"Advanced C Programming"

Preprocessor

Compilation Phases

1.preprocessing:

gcc –E code.c

2.assembly code generation:

gcc -S code.c

3.obj file generation:

gcc –c code.c

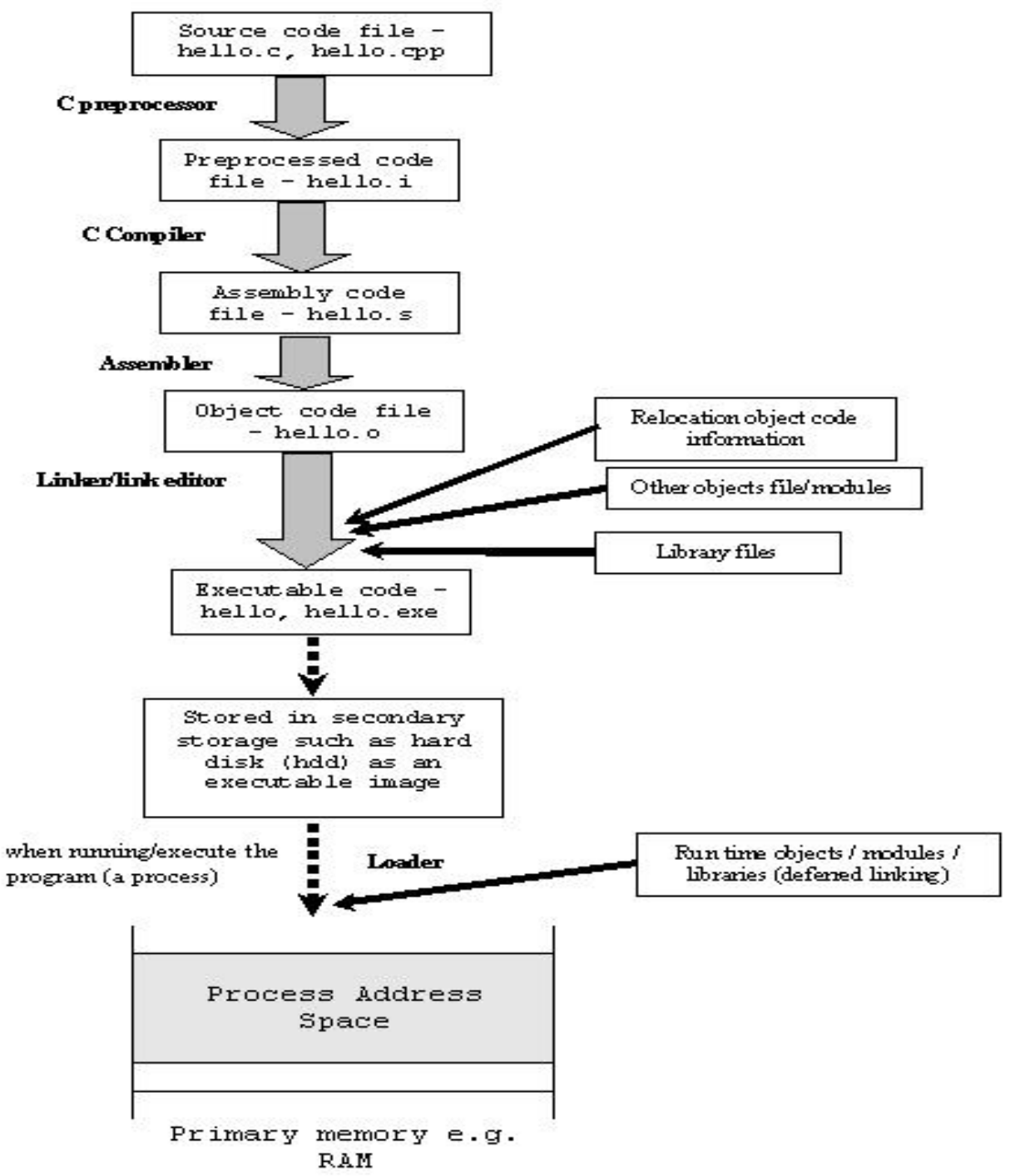
4.executable generation:

gcc code.c

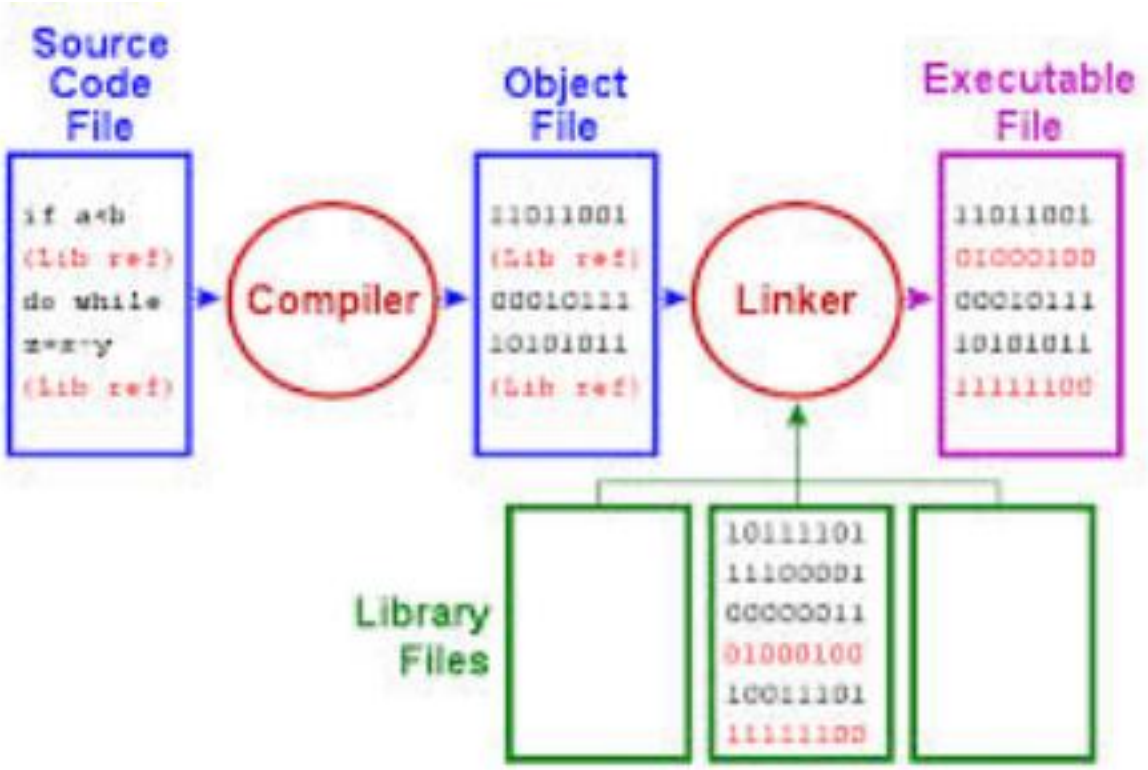
[gcc code.c –o myexe]

from obj files:

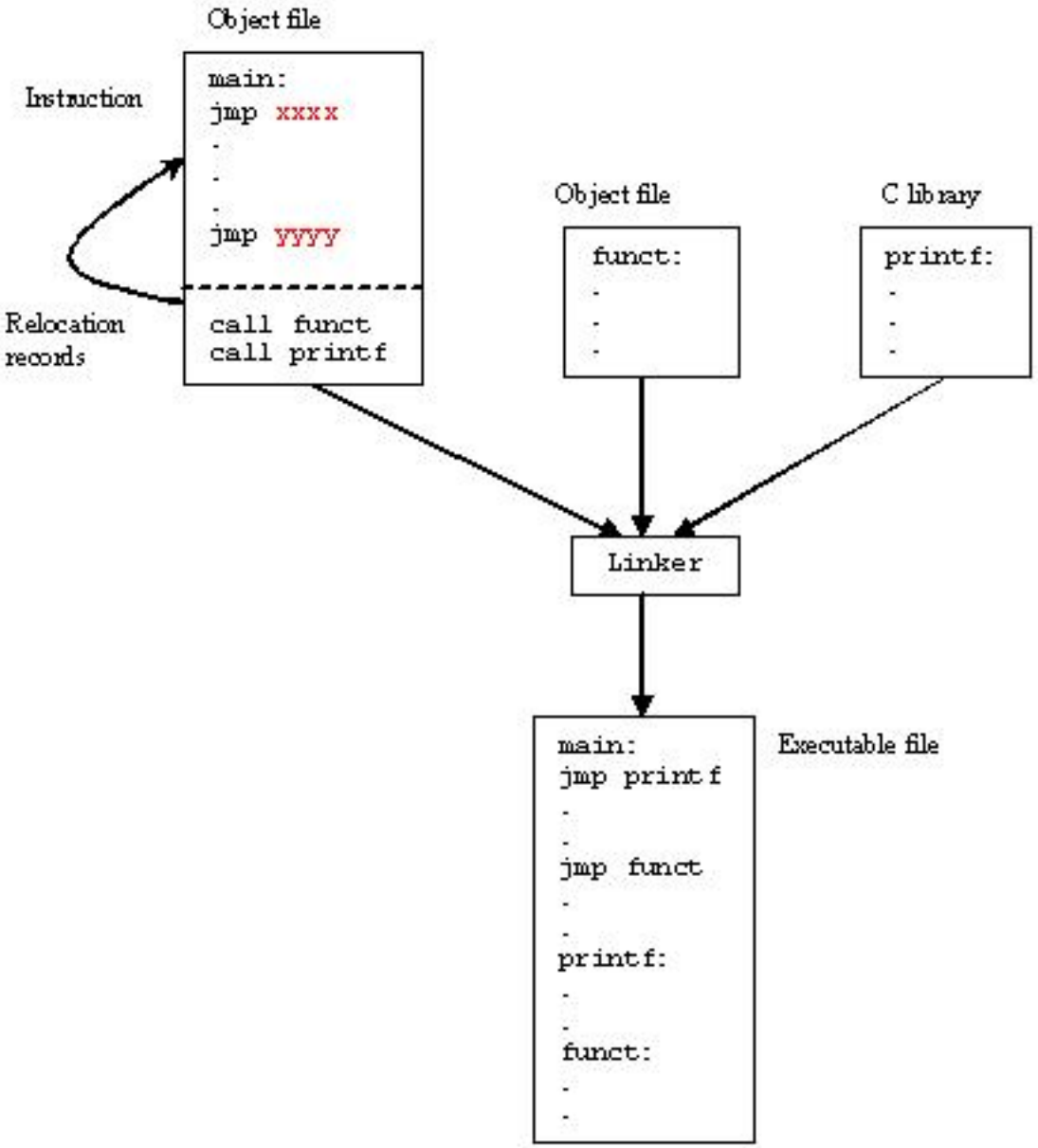
gcc -o myexe code.o

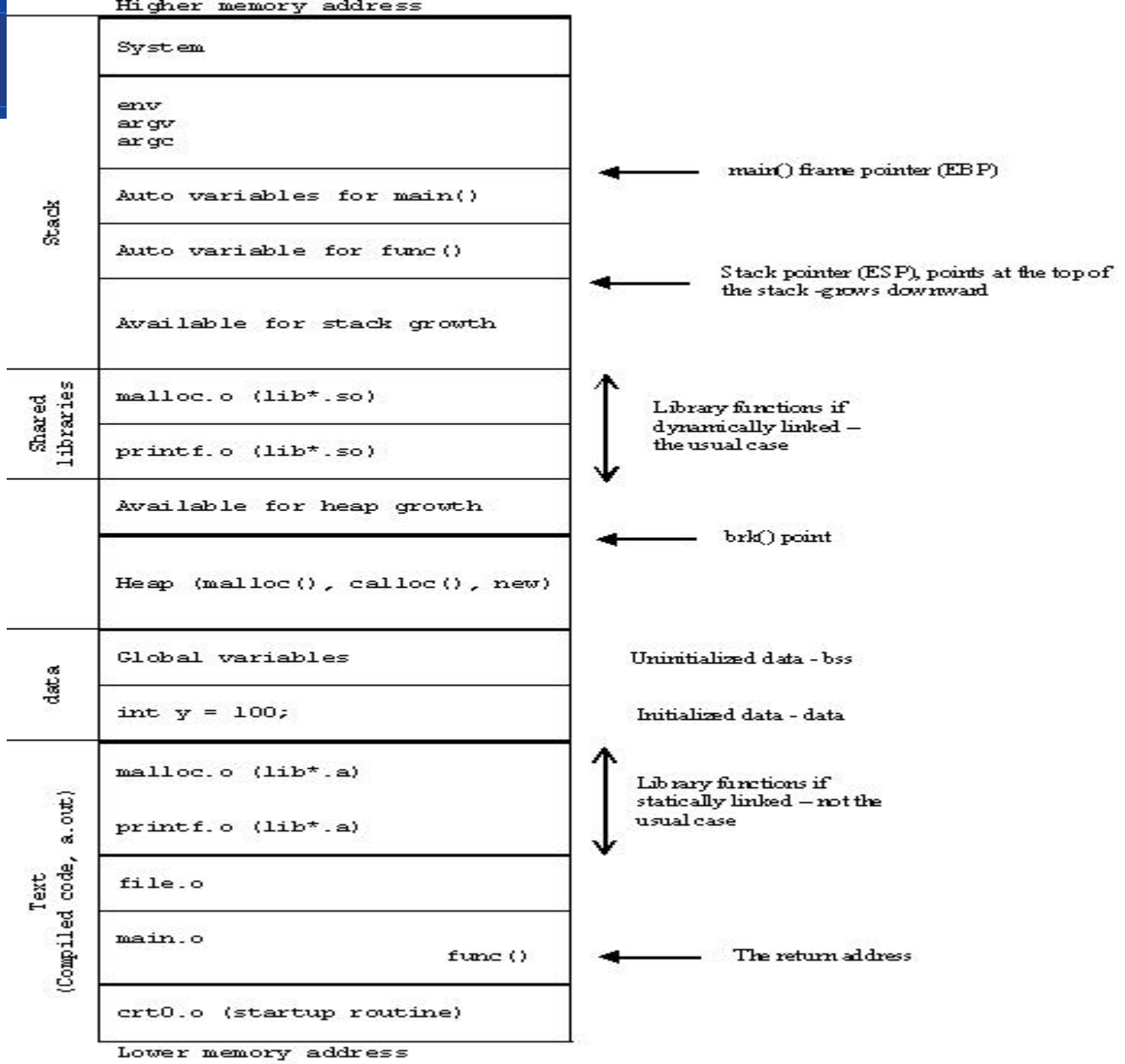


Compilation Phases



Compiling and running C programs




Higher memory address
Stack
System
env
argv
argc
Auto variables for main()
Auto variable for func()
Available for stack growth
main() frame pointer (EBP)
Stack pointer (ESP), points at the top of the stack -grows downward
Shared libraries
malloc.o (lib*.so)
printf.o (lib*.so)
Library functions if dynamically linked – the usual case
Available for heap growth
brk() point
Heap (malloc(), calloc(), new)
data
Global variables
Uninitialized data - bss
int y = 100;
Initialized data - data
Text (Compiled code, a.out)
malloc.o (lib*.a)
printf.o (lib*.a)
Library functions if statically linked – not the usual case
file.o
main.o
func()
The return address
crt0.o (startup routine)
Lower memory address

Introduction

Definition and Features:

Pre-processing is conceptually a separate first step in the compilation. It performs the following actions before the compilation process:

- Inclusion of other files
- Definition of symbolic constants and macros
- Conditional compilation of program code
- Conditional execution of preprocessor directives

Operators: Two operators are available in standard C

- **#** - Used to replace the text token to a string surrounded by quotes
- **##** - Used to **concatenate** two tokens (Token Pasting)

File Inclusion (#include)

The #include Preprocessor Directive

- Used to include the copy of a specified file in place of the directive

Syntax:

Type 1: #include <filename>

- **It searches standard library** for the file
- Use for standard library files

Type 2: #include "filename"

- First, **It searches the current directory** for the file, if not found, then it searches the standard library
- Used for user-defined files

File Inclusion (#include)…

The #include Preprocessor Directive

- **Uses**
  - Loading header files
    - **#include<stdio.h>**
  - Programs with **multiple source files** to be compiled together
  - **Header file** - has common declarations and definitions (Structures, Unions, function prototypes)

Symbolic Constants (#define)

The #define Preprocessor Directive

Preprocessor directive used to create **symbolic constants** and **macros**. When program compiled, all occurrences of symbolic constant replaced with replacement text. (Also called as **Object-Like Macros**)

Syntax:

#define identifier replacement-text

Example:

#define PI 3.14159

- Every thing written right side of the identifier will be replaced.
- **Cannot redefine** symbolic constants with more **`#define`** statements

Macros (#define)

Macros: The #define Preprocessor Directive

- A macro is **a fragment of code** which has been **given a name**. Whenever the name is used, it is replaced by the contents of the macro. **(GNU C Definition)**
- By convention, macro names are written in uppercase to increase the readability. People can differentiate between a normal variable and a symbolic constant.

Types of Macros:

a) Object like macros (Symbolic Constants)

b) Function like macros

a) Object like Macros

Object like macros – Macros without arguments are treated like Symbolic Constants and called as object like macros

Examples:

```
#define BUFFER_SIZE 1024
foo = (char *) malloc (BUFFER_SIZE);
```

Symbolic Constants (#define)

The #define Preprocessor Directive

```
#include<stdio.h>
#define UPPER 25

void main( )
{
        int i ;
        for ( i = 1 ; i <= UPPER ; i++ )
        printf( "%d\n",i);
}
```

```
#include <stdio.h>
#define PI 3.1415
int main(){
    int radius;
    float area;
    printf("Enter the radius: ");
    scanf("%d",&radius);
    area=PI*radius*radius;
    printf("Area=%.2f",area);
    return 0;
}
```

b) Function like Macros

Function like macros – To define a function like macro, use the same directive "#define", but put a pair of parentheses immediately after the macro name.

Examples:

Before preprocessing

```
#define PI 3.14159
#define CIRCLE_AREA( x ) ( PI * ( x ) * ( x ) )
area = CIRCLE_AREA(4);
```

After preprocessing

```
area = ( 3.14159 * ( 4 ) * ( 4 ) );
```

A function like macro is only expanded if its name appears with a pair of parentheses after it.

b) Function like Macros…

- Without parentheses – Incorrect expansion

Before preprocessing

```
#define CIRCLE_AREA( x )  PI *  x *  x
area = CIRCLE_AREA( c + 2 );
```

After preprocessing

```
area = 3.14159 * c + 2 * c + 2;
```

- Multiple arguments

Before preprocessing

```
#define RECTANGLE_AREA( x, y ) ( ( x ) * ( y ) )
rectArea = RECTANGLE_AREA( a + 4, b + 7 );
```

After preprocessing

```
rectArea = ( ( a + 4 ) * ( b + 7 ) );
```

Macros

```
#include <stdio.h>

#define MAX(x,y) ((x) > (y) ? (x) : (y))

int main(void)
{
   printf("Max between 10 and 20 is %d\n", MAX(10, 20));
   return 0;
}
```

Macros

```
#define MUL(X,Y) X*Y
void main()
{
printf("value %d",MUL(3,4));
printf("value %d",MUL(3+2,4+2));
}
```

Macros - Exercise

- **Write a program to compute the area of a rectangle using macros**

Function .vs. Macro

No	Macro	Function
1	Macro is **Preprocessed**	Function is **Compiled**
2	**No Type Checking**	**Type Checking** is Done
3	**Code** Length **Increases**	**Code** Length remains **Same**
4	Use of macro can lead to **side effect**	No **side Effect**
-		
5	Speed of Execution is **Faster**	Speed of Execution is **Slower**
6	Before Compilation macro name is replaced by macro value	During function call , Transfer of Control takes place
7	Useful where small code appears many time	Useful where large code appears many time
8	Generally Macros do not extend beyond one line	Function can be of any number of lines
9	Macro does not Check **Compile Errors**	Function Checks **Compile Errors**

Macros - #undef

- #undef
  - Undefines a symbolic constant or macro, which can later be redefined

```
#include <stdio.h>

#define MAX(x,y) ((x) > (y) ? (x) : (y))

int main(void)
{
   printf("Max between 10 and 20 is %d\n", MAX(10, 20));
   return 0;
}
```

Conditional Compilation

We can, if we want, have the compiler skip over part of a source code by inserting the preprocessing commands **#ifdef and #endif,**which have the general form:

```
#ifdef macroname
    statement 1 ;
    statement 2 ;
    statement 3 ;
#endif
```

If macroname has been #defined, the block of code will be processed as usual; otherwise not.

#ifdef Directives

```
#include <stdio.h>
#define RAJU 100
int main()
{
   #ifdef RAJU
   printf("RAJU is defined. So, this line will be added in " \
          "this C file\n");
   #else
   printf("RAJU is not defined\n");
   #endif
   return 0;
}
```

Compilation options: defining RAJU from outside of code

```
 gcc ifdef.c -D RAJU=100 -o ifdef
```

#ifdef Directives

```
#include <stdio.h>
int main()
{
  #define C “C Programming"

  #ifdef C
    printf(C);
  #endif

  return 0;
}
```

#ifndef Directives

- #ifndef exactly acts as reverse as #ifdef directive. If particular macro is not defined, “If” clause statements are included in source file.
- Otherwise, else clause statements are included in source file for compilation and execution.

#ifndef Directives

```
#include <stdio.h>
#define RAJU 100
int main()
{
   #ifndef SELVA
   {
      printf("SELVA is not defined. So, now we are going to define
     here\n");
      #define SELVA 300
   }
   #else
   printf("SELVA is already defined in the program");

   #endif
   return 0;

}
```

#undef Directives

```
#include <stdio.h>
#define height 100
void main()
{
   printf("First defined value for height    :
    %d\n",height);
   #undef height          // undefining variable
   #define height 600     // redefining the same for new value
   printf("value of height after undef
    redefine:%d",height);
}
```

Conditional Compilation

- **Conditional compilation**
  - Control preprocessor directives and compilation
  - **Note:** Cast expressions, **sizeof,** enumeration constants cannot be evaluated
- Structure is similar to **"if"** control structure

```
#if !defined( NULL )
        #define NULL 0
#endif
```

  - Determines if symbolic constant **NULL** defined
    - If **NULL** is defined, **defined(NULL)** evaluates to **1**
    - If **NULL** not defined, defines **NULL** as **0**
  - Every **#if** ends with **#endif**
  - **#ifdef** is the short form for **#if defined(***name***)**
  - **#ifndef** is the short from for **#if !defined(***name***)**

Conditional Compilation…

- **Other statements**

  #elif - equivalent of else if in an if structure

  #else - equivalent of else in an if structure

- **"Comment out" code**
  - Cannot use /* … */
  - **Use**

```
#if 0
    code commented out
#endif
```

  To enable the code, change 0 to 1

Conditional Compilation…

```
#include <stdio.h>
#define IOS  1
#define ANDROID  2
#define OS  IOS
int main()
{
   #if OS == IOS
   printf("this is ios device.\n");
   #elif OS == ANDROID
   printf("this is android device.\n");
   #endif
   return 0;
}
```

Conditional Compilation…

- **Debugging**

```
#define DEBUG 1
#ifdef DEBUG
   printf("Variable x = %d", x);
#endif
```

  - Defining DEBUG enables code
  - After code corrected, remove #define statement
  - Debugging statements are now ignored

Operator - Concatenation

- **## - It concatenates two tokens**

Example:

```
#define TOKENCONCAT( x, y )  x ## y

TOKENCONCAT( O, K )   becomes OK
```

```
#include<stdio.h>
#define CAT(a, b) a##b
void main() {
   printf("%d", CAT(10, 20));
}
```

Thank You