Module 2 – Introduction to Programming

1. Overview of C Programming

O THEORY EXERCISE:

Q. Write an essay covering the history and evolution of C programming. Explain its importance and why it is still used today.

→ C programming is a powerful and widely used programming language known for its simplicity and versatility. Developed in the early 1970s by Dennis Ritchie at Bell Labs, C has since become one of the most influential programming languages in the world.

→ C became famous because it was used to build the **UNIX operating system**. Before that, operating systems were written in assembly language, which was very hard. C made it easier, faster, and more powerful.

→ Evolution of C: -

In **1978**, **Brian Kernighan and Dennis Ritchie** wrote a book called *The C Programming Language*. This book made C even more popular.
Later, C was given official standards to keep it the same everywhere:

- **ANSI C (1989)**
- **C99 (1999) • C11 (2011)**
- **C18 (2018)**

→ Importance of C

C is called the **mother of programming languages** because many languages like **C++, Java, and Python** came from it.

C is important because:

- It is **fast** and uses **less memory**.
- It is **portable** (same code works on different computers).
- It helps programmers understand how computers really work.
- It is used in **operating systems** (Windows, Linux, etc.).
- It is used in **embedded systems** (mobiles, cars, machines).

→ Why C is Still Used

Even after 50 years, C is still used today because it is simple, powerful, and close to hardware. It is perfect for building software that needs **speed and control**.

1. Setting Up Environment

Q. Describe the steps to install a C compiler (e.g., GCC) and set up an Integrated Development Environment (IDE) like Dec++, VS Code, or Code Blocks.

→ Step 1: Install GCC Compiler

- Download **MinGW** (Minimalist GNU for Windows) from its official website.
- Run the installer.
- In the setup, tick **"mingw32-gcc-g++"** (this is the C/C++ compiler).
- After installation, add MinGW's bin folder path (like C:\MinGW\bin) to **Environment Variables PATH**.

→ This step lets Windows find the compiler.

- To check if it works:
- Open **Command Prompt** ○ gcc –version → **Step 2:**

Choose and Install an IDE

Option 1: **DevC++**

- Download DevC++ from the official site.
- Install it like normal software (Next → Next → Finish).
- Open DevC++ → New Project → Console Application → Choose **C Language**.
- Write your C code → Press **F11** to run.
- DevC++ already comes with a compiler, so it's easiest for beginners.

→ Option 2: **Visual Studio Code (VS Code)**

- Download and install **VS Code**.
- Open VS Code → Go to Extensions → Install **C/C++ by Microsoft**.
- Make sure **MinGW (GCC)** is installed and added to PATH (Step 1).
- Create a new file hello.c → Write your C program. • Open **Terminal inside VS Code** → Run commands:

→ **Easiest way (for beginners):** Use **DevC++** because it comes with a built-in compiler. → **Better for projects:** Use **Code: Blocks** or **VS Code** for more features.

2. Basic Structure of a C Program

Q. Explain the basic structure of a C program, including headers, main function, comments, data types, and variables. Provide examples.

→ **Basic Structure of a C Program**

Every C program follows a standard structure. The main parts are:

- **Header Files**
- **Main Function**
- **Comments**
- **Data Types**
- **Variables** **1) Header file: -**

 These are special files that contain built-in functions (like printf for output, scanf for input).
Declared at the top using #include.

Example: -

```
#include <stdio.h> // Standard input-output header
```

2) Main Function: -

 Every C program must have a main () function.
Program execution starts from here.

Example: -

```
int
main () {
   // Code goes here
   return 0; // End of program
}
```

3) Comments: -

- Notes for programmers, ignored by the compiler.
- Two types:
  - **Single-line:** // comment here
  - **Multi-line:** /* comment here */
- Example: -

```
#include<stdio.h>
Main()
{
// This is a single-line comment
/* This is
   a multi-line comment */ return
0;
```

}

4) **Data Type: -**
   - Data types are used to define the type of data that a variable can store.
   - Basic Data type: -
     - int → integers (10, -5, 100)
     - float → decimal numbers (3.14, -2.5)
     - char → single character ('A', 'b')
     - double → larger decimal numbers

5) **Variables: -**
   - Variable are fundamental elements used to store and manipulate data.
   - They act as named container that hold different types of values, such as integer, floatingpoint numbers, characters, and pointer.

Example: -
int age = 20; // integer variable float pi =
3.14; // floating point variable char
grade = 'A'; // character variable

Example: -

```
#include <stdio.h>   // Header file


// This program shows the basic structure of C int
main () {
   // Variable declaration
int age = 20;     float
height = 5.8;     char
grade = 'A';


   // Printing values
printf("Age: %d\n", age);
printf("Height: %.1f\n", height);
```

```
printf("Grade: %c\n", grade);
return 0;  // End of program
}
```

3. Operators in C

Q. Write notes explaining each type of operator in C: arithmetic, relational, logical, assignment, increment/decrement, bitwise, and conditional operators.

- **Operator: -**
  Operators are **symbols** used to perform operations on values and variables.
  Example: +, -, *, /

1. Arithmetic Operators

Used for **mathematical calculations**.

- + → addition
- - → subtraction
- * → multiplication
- / → division
- % → remainder (modulus)

Example: - #include<stdio.h>

Main() {

Int a=10, b=5;

Printf (“%d”, a+b); //15

Printf (“%d”, a-b); //5

Printf (“%d”, a*b); //50

Printf (“%d”, a/b); //2

Printf (“%d”, a%b); //0

Return 0;

}

2. Relational Operators

Used to **compare two values**.

- == → equal to
- != → not equal to
- > → greater than
- < → less than
- >= → greater or equal
- <= → less or equal Example: - #include<stdio.h>

  Main() {

  Int a=10, b=5;

  Printf (“%d”, a==b); //false

  Printf (“%d”, a! =b); //true

  Printf (“%d”, a>b); //true

  Printf (“%d”, a<b); //false

  Printf (“%d”, a>=b); //true

  Printf (“%d”, a<=b); //false

  Return 0;

  }

3. Logical Operator

Used to combine **conditions**.

- && → AND (true if both are true)
- || → OR (true if one is true)
- ! → NOT (reverse the result)

Example: - #include<stdio.h>
Main()
{
int a = 5, b = 10; printf("%d", (a < b &&
b > 0)); // 1 (true) printf("%d", !(a < b));
// 0 (false)
printf(“%d”, (a==5 || b==5); // 1 (true)
}

4. Assignment Operators

Used to **store values** in variables.

- = → assign
- += → add and assign
- -= → subtract and assign
- *= → multiply and assign
- /= → divide and assign Example: - #include <stdio.h> int main() { int a; // =

(assign) a = 10;

printf("a = %d\n", a); // Output: 10 //

+= (add and assign) a += 5; // a = a + 5

→ 10 + 5 = 15 printf("a += 5 → %d\n",

a); // Output: 15

```
    // -= (subtract and assign)     a -= 3;   //
a = a - 3 → 15 - 3 = 12     printf("a -= 3 →
%d\n", a);   // Output: 12

    // *= (multiply and assign)     a *= 2;   // a
= a * 2 → 12 * 2 = 24     printf("a *= 2 →
%d\n", a);   // Output: 24

    // /= (divide and assign)     a /= 4;   // a
= a / 4 → 24 / 4 = 6     printf("a /= 4 →
%d\n", a);   // Output: 6

    return 0;
}
```

4. Increment / Decrement Operators

- Used to **increase or decrease** value by 1.

- **++** → increment
- -- → decrement There

are **two types**:

1. **Pre-increment / Pre-decrement** → Changes the value first, then uses it.
2. **Post-increment / Post-decrement** → Uses the value first, then changes it.

Example: - #include

<stdio.h>

int main() {

int a = 5, b;

// Pre-increment (++a) b = ++a; // a is

increased first, then assigned printf("Pre-

increment: a = %d, b = %d\n", a, b);

// Post-increment (a++) b = a++; // value of a is

assigned first, then increased printf("Post-increment:

a = %d, b = %d\n", a, b);

// Pre-decrement (--a) b = --a; // a is

decreased first, then assigned printf("Pre-

decrement: a = %d, b = %d\n", a, b);

// Post-decrement (a--)

b = a--; // value of a is assigned first, then decreased printf("Post-

decrement: a = %d, b = %d\n", a, b);

```
    return 0;
}
```

Output: -

Pre-increment: a = 6, b = 6

Post-increment: a = 7, b = 6

Pre-decrement: a = 6, b = 6

Post-decrement: a = 5, b = 6

6. Bitwise Operators

Work at the **bit (0/1) level**.

- & → AND
- | → OR
- ^ → XOR (exclusive OR)
- ~ → NOT (flip bits)
- << → left shift
- >> → right shift Example: - int a = 5, b = 3; // 5 = 101, 3 = 011

(binary) printf("%d", a & b); // 1 (001) printf("%d", a | b); // 7 (111)

7. Conditional (Ternary) Operator

Shortcut for **if-else**.

- Syntax: condition? value_if_true: value_if_false

Example: - #include

<stdio.h>

```
int main() {     int num;
printf("Enter a number: ");
scanf("%d", &num);
    // Ternary operator (? :)
    (num % 2 == 0)
        ? printf("%d is Even\n", num)
        : printf("%d is Odd\n", num);

    return 0;
}
```

5. Control Flow Statements in C

Q. Explain decision-making statements in C (if, else, nested if-else, switch). Provide examples of each.

1. **if statement**

- Used when you want to run some code **only if a condition is true**.

Syntax: - **if (condition) {**

// code runs if condition is true

}

Example: -

```
#include <stdio.h> int main() {     int age = 20;     if (age >=
18) {   // condition          printf("You are an Adult.\n");  // runs
only if condition true
    }
    return 0;
}
```

2. if-else statement

- Used when you want to choose between **two options**.

Syntax: -

```
if (condition) {
    // code runs if condition is true
} else {
    // code runs if condition is false
}
```

Example: -

```
#include
<stdio.h> int
main() {     int
num = 5;

    if (num % 2 == 0) {
printf("Even number\n");
    } else {         printf("Odd
number\n");
```

```
    }

    return 0;

}
```

3. nested if-else

- Means using **if inside another if**. Used when there are **multiple conditions**.
  Syntax: -
```
if (condition1) {
    // code if condition1 is true
if (condition2) {
        // code if condition2 is also true
    } else {
        // code if condition2 is false
    }
} else {
    // code if condition1 is false
}
```

Example: -

```
#include <stdio.h> int

main() {

   int a = 10, b = 20, c = 15;


   if (a > b) {

if (a > c) {

        printf("a is the biggest\n");

    } else {

        printf("c is the biggest\n");

    }

   } else {

if (b > c) {

        printf("b is the biggest\n");

    } else {

        printf("c is the biggest\n");

    }
```

```
    }

    return 0;
}
```

4. switch statement

- Used when you want to compare **one variable** with **many possible values** (instead of writing many ifelse).

Syntax: -

```
switch (condition) {
case value1:
// code        break;
case value2:
// code        break;
    ...
default:
        // code if no case matches
}
```

Example: -

```
#include <stdio.h>
int main() {     int
choice;

    printf("Enter a number (1-3): ");
scanf("%d", &choice);

    switch (choice) {         case 1:
printf("You chose ONE\n");
break;         case 2:
printf("You chose TWO\n");
break;         case 3:
printf("You chose THREE\n");
break;         default:
            printf("Invalid choice!\n");
    }
```

```
    return 0;
}
```

 if → check 1 condition. if**-else** →

choose between 2 conditions.

 nested **if-else** → check multiple conditions step by step.

switch → better when one variable has many possible values.

6. Looping in C

Q. Compare and contrast while loops, for loops, and do-while loops. Explain the scenarios in which each loop is most appropriate.

1. **while loop**

- Condition is checked **before** the loop runs. • If condition is **true**, loop runs. If false, it stops immediately.

Syntax: - while (condition) { // code to repeat }

Example: -

```
#include <stdio.h>
int main() {  int i = 1;  while (i <= 5) {
printf("%d\n", i);
        i++;
    }
    return 0;
}
```

2. for loop

- Used when you **know exactly how many times** you want to repeat.
- Initialization, condition, and update are written in one line.

Syntax: - for (initialization; condition; modification) {
    // code to repeat

```
}
```

Example: -

```
#include <stdio.h>
int main() {
    for (int i = 1; i <= 5; i++) {
printf("%d\n", i);
    }
    return 0;
}
```

3. do-while loop

- Runs the loop **at least once**, even if condition is false. • Condition is checked **after** running the loop.

Syntax: - do

```
{
    // code to repeat
} while (condition);
```

Example: - #include <stdio.h> int main() { int i = 1; do { printf("%d\n", i); i++; } while (i <= 5); return 0; }

Feature	while loop	for loop	do-while loop
Condition check	Before loop body	Before loop body	After loop body
Guaranteed execution	✗ Not guaranteed	✗ Not guaranteed	✅ At least once
Best for	Unknown iterations	Known/finite iterations	Must run at least once
Example use case	Reading file until EOF	Iterating through array indexes	Menu system, input prompt

7. Loop Control Statements

Q. Explain the use of break, continue, and goto statements in C. Provide examples of each.

1. break – Stop the loop

- **Easy words:** If the loop is running, break will **stop it immediately**.

Example:

```
#include <stdio.h> int

main() {

   for (int i = 1; i <= 5; i++) {

if (i == 3) {

            break;  // Stop the loop

        }

        printf("%d\n", i);

    }

    return 0;

}
```

Output: -

1

2

2. continue – Skip this turn

- **Easy words:** continue will **skip the current number** and go to the next one.

Example:

```
#include <stdio.h> int main() {
for (int i = 1; i <= 5; i++) {         if (i
== 3) {             continue;  // Skip
number 3
        }
printf("%d\n", i);
    }
    return 0;
}
```

Output: -

1

2

4

5

3. goto – Jump to a label

- **Easy words:** goto lets you **jump to a specific part of the program**.

Example:

```
#include     <stdio.h>
int main() {      int i =
1; start:  // label      if
(i       <=       3)       {
printf("%d\n",         i);
i++;          goto start;
```

```
// Jump back to
"start"
    }
    return 0;
}
```

8. Functions in C

Q. What are functions in C? Explain function declaration, definition, and how to call a function. Provide examples

- A **function** in C is a **block of code** that performs a specific task.
  It helps to **divide a big program into smaller parts**, making the program **easy to understand and reuse**.

There are **3 main parts** of a function:

1. Function Declaration (Prototype)

- Tells the compiler about the function name, return type, and parameters (if any).
- It's usually written **before the main()** function. Syntax: - return_type function_name(data_type parameter1, data_type parameter2); Example: -

```
int add(int a, int b);
```

2. Function Definition

- This is where we **actually write the code** of the function — what it will do. Syntax: - return_type function_name(data_type parameter1, data_type parameter2) {

```
// code to perform task
return value;
}
```

Example: -

```
int add(int a, int b) {
int sum = a + b;
return sum;
}
```

3. Function Call

- To **use** the function, we call it inside the main() function. Syntax: - function_name(arguments); Example: - int result = add(5, 3); example: -

```
#include <stdio.h>

// Function Declaration int
add(int a, int b);

int main() {     int
x, y, result;     x
= 5;     y = 3;

   //     Function     Call
result    =    add(x,    y);
printf("Sum     =     %d",
result);     return 0;
}

// Function Definition
int add(int a, int b) {
```

```
int sum = a + b;

return sum;

}
```

9. Arrays in C

Q. Explain the concept of arrays in C. Differentiate between one-dimensional and multi-dimensional arrays with examples.

- An **array** is a **collection of similar data items** stored at **continuous memory locations**. It is used to **store multiple values** of the **same data type** using a **single name**. Example: - int marks[5];

There are two main types:

1. One-Dimensional Array

- It stores data in a **single row (line)**.
- Syntax: - data_type array_name[size];

2. Multi-Dimensional Array

- It stores data in **rows and columns** (like a table).The most common is the **two-dimensional array**.
- Syntax: - **data_type array_name[rows][columns];**

Feature	One-Dimensional Array	Multi-Dimensional Array
Structure	Single row (line)	Table-like (rows & columns)
Syntax	int a[5];	int a[2][3];
Example	int marks[5] = {10, 20, 30, 40, 50};	int mat[2][3] = {{1,2,3},{4,5,6}};
Access element	marks[2]	mat[1][2]
Use	Store list of items	Store data in matrix or table form

10. Pointers in C

Q. Explain what pointers are in C and how they are declared and initialized. Why are pointers important in C?

- A **pointer** is a **special variable** that **stores the address of another variable**. Instead of storing a value directly, it stores **where the value is kept in memory**.
- A **variable** store a value.
- A **pointer** stores the **address** of that variable. Syntax: - data_type *pointer_name;

Example: - int a = 10; // normal variable int *p; // pointer variable p = &a; // store address of 'a' in pointer 'p'

Example: - #include

<stdio.h>

```
int main() {     int a = 10;     int *p;
// pointer declaration     p = &a;
// pointer initialization


    printf("Value of a: %d\n", a);
printf("Address of a: %p\n", &a);
printf("Pointer p stores: %p\n", p);
printf("Value pointed by p: %d\n", *p);


    return 0;
}
```

Output: - Value

of a: 10

Address of a: 0x7fffb2b3a5c

Pointer p stores: 0x7fffb2b3a5c

Value pointed by p: 10

Reason	Explanation
1 Access memory directly	You can read/write data using memory addresses
2 Dynamic memory	Used in malloc(), calloc(), and free()
3 Faster and efficient	Helps pass large data (like arrays) without copying
4 Function arguments	Functions can modify variables outside their scope
5 Data structures	Used in linked lists, trees, stacks, queues, etc.

11. Strings in C

Q. Explain string handling functions like strlen(), strcpy(), strcat(), strcmp(), and strchr(). Provide examples of when these functions are useful

- A **string** in C is a **collection of characters** stored in an array and **ends with a null character** ('\0').

Example: - char name[] = "Rana";

Here, the string "Rana" is actually stored as:
'R' 'a' 'n' 'a' '\0'

Common String Handling Functions (in <string.h>)

These functions are built into C for working with strings. You must include the header file:

#include <string.h>

1. strlen() – Find Length of a String

- **Use:** Returns the **number of characters** in a string

(excluding '\0'). Syntax: - int strlen(char str[]);

2. strcpy() – Copy One String to Another

- **Use:** Copies the content of one string into another.

Syntax: -

strcpy(destination, source);

3. strcat() – Join Two Strings

- **Use:** Combines (concatenates) two strings together.

Syntax: -

strcat(string1, string2);

4. strcmp() – Compare Two Strings

- **Use:** Compares two strings **character by character**.

Syntax: - strcmp(string1, string2);

5. strchr() – Find Character in a String

- **Use:** Finds the **first occurrence** of a character in a string. Syntax: - strchr(string, character);

Function	Meaning	Example	Use
strlen()	Finds string length	strlen("Hello") → 5	Count characters
strcpy()	Copies one string to another	strcpy(b, a)	Copy names, messages
strcat()	Joins two strings	strcat(a, b)	Combine text
strcmp()	Compares two strings	strcmp(a, b)	Compare input (like passwords)
strchr()	Finds a character	strchr("apple",'p')	Search characters

Example: - #include

<stdio.h>

#include <string.h>

int main() { char

str1[50] = "Hello"; char

str2[50] = "World"; char

```
str3[50];     char *ptr;
int len, cmp;

   // 1. strlen() - Find length of string
len = strlen(str1);     printf("Length of
str1 = %d\n", len);

   // 2. strcpy() - Copy str1 into str3
strcpy(str3, str1);     printf("After strcpy,
str3 = %s\n", str3);

   // 3. strcat() - Join str1 and str2
   strcat(str1, str2);     printf("After
strcat, str1 = %s\n", str1);

   // 4. strcmp() - Compare str1 and
str2     cmp = strcmp(str1, str2);
if(cmp == 0)         printf("str1 and str2
are equal\n");     else if(cmp > 0)
printf("str1 is greater than str2\n");
else         printf("str1 is smaller than
str2\n");

   // 5. strchr() - Find character in string     ptr = strchr(str1, 'o');
if(ptr)         printf("Character 'o' found at position: %ld\n", ptr -
str1 + 1);     else         printf("Character not found\n");

   return 0;
}
```

12. Structures in C

Q. Explain the concept of structures in C. Describe how to declare, initialize, and access structure members.

- A **structure** is a **user-defined data type** that lets you **combine different types of data** under one name.
  It's like a box that can hold **different types of variables** together.

Think of it like this:
If you want to store a student's details — name, roll number, and marks — you can use a **structure** instead of separate variables.

- To **group related information** of different data types.
- Makes code cleaner and easier to manage.
- Useful for **real-world data** (like student, employee, book, etc.).

1. Declaring a Structure

Synatx: - struct

structure_name {

data_type member1;

data_type member2;

...

};

Example: - struct

Student {

int roll;

char name[50];

float marks;

};

2. Declaring Structure Variables struct Student s1, s2;

3. Initializing a Structure

Example: - struct

Student s2;

s2.roll = 2;

strcpy(s2.name, "Vrujal"); // use strcpy() for strings s2.marks

= 92.0;

4. Accessing Structure Members

Use the **dot operator (.)** to access members. Example:

-

printf("Roll: %d\n", s1.roll);
printf("Name: %s\n", s1.name); printf("Marks:

%.2f\n", s1.marks);

Example: - #include

<stdio.h>

#include <string.h>

// Structure Declaration struct

Student {

int roll;

char name[50];

float marks;

};

int main() {

// Structure Initialization struct

Student s1 = {1, "Rana", 88.5};

// Another way to assign values

struct Student s2; s2.roll = 2;

```
strcpy(s2.name, "Vrujal");
s2.marks = 92.0;

   // Displaying Data
printf("Student 1:\n");
   printf(" Roll: %d\n Name: %s\n Marks: %.2f\n\n", s1.roll, s1.name, s1.marks);

   printf("Student 2:\n");     printf(" Roll: %d\n Name: %s\n Marks: %.2f\n",
s2.roll, s2.name, s2.marks);     return 0;
}
```

13. File Handling in C

Q. Explain the importance of file handling in C. Discuss how to perform file operations like opening, closing, reading, and writing files.

- **File handling** in C allows you to **store data permanently** on your computer (in files), so that data is **not lost when the program ends**.

Without file handling — data disappears when the program closes.
With file handling — data can be **saved, read, or modified** anytime.

Reason	Explanation
1 Permanent storage	Keeps data safe even after program ends
2 Data sharing	Files can be shared between programs
3 Easy access	Read/write large data easily
4 Record keeping	Used in databases, reports, and logs

All file handling functions are found in the **<stdio.h>** library.

Function	Purpose
fopen()	Opens a file
fclose()	Closes a file
fprintf()	Writes formatted data to a file
fscanf()	Reads formatted data from a file
fgets()	Reads a line from a file
fputs()	Writes a line to a file

fgetc()	Reads a character
fputc()	Writes a character

1. Declare a File Pointer

```
FILE *fp;
```

2. Open a File using fopen() fp =

```
fopen("data.txt", "w");
```

Mode	Meaning	Description
"r"	Read	Opens existing file for reading
"w"	Write	Creates new file (deletes old one)
"a"	Append	Adds data at the end of file
"r+"	Read + Write	Opens existing file for both
"w+"	Write + Read	Creates new file for both

3. Perform Read/Write Operations 4.

Close the File using fclose()

```
fclose(fp);
```

Example 1: Writing to a File

```
#include <stdio.h>

int main() {     FILE *fp;     fp = fopen("example.txt",
"w");  // open for writing

   if(fp == NULL) {
printf("Error opening file!");
return 1;
   }
```

```
    fprintf(fp, "Hello, this is a test file.\n");
fprintf(fp, "Writing data using fprintf().");

    fclose(fp); // close file     printf("Data
written successfully!\n");     return 0;
}
```

Output: -

Data written successfully!

Content in “example.txt”:

Hello, this is a test file.

Writing data using fprintf().

Example 2: Reading from a File

```
#include <stdio.h>

int main() {
FILE *fp;
char ch;

    fp = fopen("example.txt", "r"); // open for reading
if(fp == NULL) {         printf("File not found!");
return 1;
    }

    printf("File content:\n");
while((ch = fgetc(fp)) != EOF) {
printf("%c", ch);
    }

    fclose(fp);
return 0;
```

```
}
```

Output:

```
File content:
Hello, this is a test file.
Writing data using fprintf().
```