Module 2 – Introduction to Programming

1. Overview of C Programming

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

ANS:

C programming is one of the most powerful and popular programming languages in computer science. It is often called the "mother of all modern programming languages" because many other languages like C++, Java, and Python are influenced by it. To understand its importance, we should look at its history, evolution, and why it is still used even today.

History and Evolution

The story of C programming starts in the early 1970s at Bell Laboratories (Bell Labs) in the United States. A computer scientist named **Dennis Ritchie** developed C between **1969 and 1973**. Before C, programmers used languages like **Assembly** and **B**, but these languages had many limitations. Assembly language was fast but very hard to learn, while B language was simple but weak in features.

Dennis Ritchie created C by improving the B language and adding more features like data types, control structures, and functions. The first version of C was used to develop the **UNIX operating system**, which became very successful. Because UNIX was written in C, the language spread quickly across the world.

In **1983**, the American National Standards Institute (**ANSI**) started working on a standard version of C to make sure it was the same everywhere. This standard, called **ANSI C (or C89/C90)**, became the base for modern C compilers. Later, new versions such as **C99**, **C11**, and **C18** added features like inline functions, better memory management, and multi-threading support.

Importance of C Programming

C became famous because it combines the power of Assembly with the simplicity of higher-level languages. Some key reasons for its importance are:

1. **Portability** – C programs can run on different machines with little or no change.
2. **Efficiency** – C gives direct access to memory and system resources, so it is very fast.
3. **Foundation for other languages** – Many popular languages like C++, Java, and Python are built using concepts of C.
4. **System programming** – Operating systems, device drivers, and embedded systems are often written in C.
5. **Structured language** – C allows breaking a program into functions, making it easier to write, test, and maintain.

Why C is Still Used Today

Even after more than 50 years, C has not lost its value. It is still used today because:

- Most **operating systems (like Windows, Linux, macOS)** are based on C.
- **Embedded systems** (like washing machines, cars, medical devices) use C because it is close to hardware.
- It is the best choice when **speed and memory management** are very important.
- Learning C helps students understand how computers really work, which makes learning other languages easier.

2. Setting Up Environment

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

ANS:

To write and run programs in C, we need two main things:

1. A **C compiler** – which converts our C code into machine code that the computer understands. (Example: **GCC – GNU Compiler Collection**)
2. An **Integrated Development Environment (IDE)** – which provides a friendly interface for writing, running, and debugging code. (Examples: **DevC++, Code::Blocks, VS Code**)

Step 1: Installing a C Compiler (GCC)

1. **Download GCC**:
    - On **Windows**, GCC is usually available through *MinGW* or *TDM-GCC*. You can download it from the official MinGW website.
    - On **macOS**, GCC can be installed using *Xcode Command Line Tools*.
2. **Install the compiler**:
    - Run the installer and follow the on-screen instructions.
    - Select the installation directory (usually C:\MinGW or similar).
3. **Set environment variable (PATH)**:
    - Go to *System Properties → Environment Variables*.
    - Add the bin folder path of GCC (for example: C:\MinGW\bin) to the PATH variable.
    - This allows you to run gcc command from anywhere in the command prompt.
4. **Verify installation**:

- Open *Command Prompt* and type:
- gcc --version
- If GCC is installed correctly, it will show the compiler version.

Step 2: Setting Up an IDE

An IDE makes programming easier by providing features like code highlighting, auto-completion, and debugging tools.

(a) DevC++

1. Download DevC++ setup file from the official site.
2. Install it by following the instructions.
3. Open DevC++ → Create a new project → Select "C Project".
4. Write your program and click "Run" or press **F11** to compile and execute.

(b) Code::Blocks

1. Download Code::Blocks with MinGW compiler included.
2. Install it and launch the IDE.
3. Go to *Settings* → *Compiler* and ensure GCC is selected.
4. Create a new project, write code, and press **Build & Run**.

(c) Visual Studio Code (VS Code)

1. Download and install VS Code from Microsoft's website.
2. Install the **C/C++ extension** from the Extensions tab.
3. Install GCC (MinGW) separately if not already done.
4. Configure VS Code by creating a tasks.json file to link with GCC.
5. Write your C code and press **Run** to execute.

3. Basic Structure of a C Program

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

ANS:

A C program is made up of different parts that together tell the computer what to do. Every program has a specific structure that includes **headers, main function, comments, data types, and variables**. Let's understand each part one by one.

---

1. Header Files

- Header files contain predefined functions and libraries that help us in programming.
- They are included at the beginning of the program using the #include directive.
- Example:

```
#include <stdio.h>  // Standard input-output functions
#include <conio.h>  // Console input-output functions
```

---

2. Main Function

- Every C program must have a main() function.
- It is the starting point of execution.
- Syntax:

```
int main() {
   // code statements
   return 0;
```

}

---

3. Comments

- Comments are notes written in the code to explain it.
- They are ignored by the compiler.
- Two types:
    - **Single-line comment**: // This is a comment
    - **Multi-line comment**:

/* This is a

multi-line comment */

---

4. Data Types

- Data types define the kind of data a variable can store.
- Common data types in C:
    - int → stores integers (e.g., 10, -5)
    - float → stores decimal numbers (e.g., 3.14, 5.6)
    - char → stores single character (e.g., 'A', 'b')
    - double → stores large decimal numbers

---

5. Variables

- Variables are names given to memory locations where data is stored.
- We must declare variables before using them.
- Example:

int age = 20; // integer variable

float price = 99.5; // float variable

```
    char grade = 'A';   // character variable
```

Example Program

```
#include <stdio.h>   // Header file for input-output functions


// This is a simple C program
int main() {
   int age = 20;       // integer variable
   float marks = 85.5;  // float variable
   char grade = 'A';    // character variable

   printf("Age: %d\n", age);
   printf("Marks: %.2f\n", marks);
   printf("Grade: %c\n", grade);

   return 0; // end of program
}
```

Output:

```
Age: 20
Marks: 85.50
Grade: A
```

4. Operators in C

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

ANS:

Operators are special symbols used in C programming to perform operations on variables and values. They help in calculations, comparisons, and decision-making.

---

1. Arithmetic Operators

- Used for mathematical calculations.
- Examples:
    - + (addition) → a + b
    - - (subtraction) → a - b
    - * (multiplication) → a * b
    - / (division) → a / b
    - % (modulus/remainder) → a % b
- Example:

```
int a=10, b=3;
printf("%d", a % b);
```

Output: 1

---

2. Relational Operators

- Used to compare two values.

- They return **true (1)** or **false (0)**.
- Examples:
    - == (equal to)
    - != (not equal to)
    - > (greater than)
    - < (less than)
    - >= (greater than or equal to)
    - <= (less than or equal to)
- Example:

```
int a=5, b=8;
printf("%d", a < b);
```

Output: 1 (true)

---

3. Logical Operators

- Used for combining conditions.
- Examples:
    - && (AND) → true if both conditions are true
    - || (OR) → true if at least one condition is true
    - ! (NOT) → reverses the result
- Example:

```
int a=5, b=8;
printf("%d", (a<10 && b>5));
```

Output: 1 (true)

---

4. Assignment Operators

- Used to assign values to variables.
- Examples:
    - = (simple assignment) → a = 10
    - += (add and assign) → a += 5 (same as a = a+5)
    - -= (subtract and assign)
    - *= (multiply and assign)
    - /= (divide and assign)
    - %= (modulus and assign)

---

5. Increment and Decrement Operators

- Used to increase or decrease the value of a variable by 1.
- Examples:
    - ++ (increment)
    - -- (decrement)
- Can be used in two ways:
    - **Pre-increment**: ++a → value increases before use
    - **Post-increment**: a++ → value increases after use
- Example:

int a=5;

printf("%d", ++a);

Output: 6

---

6. Bitwise Operators

- Work on binary (bits) of numbers.
- Examples:

- & (AND)
- | (OR)
- ^ (XOR)
- ~ (NOT)
- << (left shift)
- >> (right shift)

- Example:

```
int a=5, b=3;  // binary: 101 and 011
printf("%d", a & b);
```

Output: 1

---

7. Conditional (Ternary) Operator

- Shorthand for **if-else** statement.
- Syntax:
- condition ? expression1 : expression2;
- Example:

```
int a=10, b=20;
int max = (a>b) ? a : b;
printf("%d", max);
```

Output: 20

5. Control Flow Statements in C

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

ANS:

In C programming, **decision-making statements** are used to control the flow of a program. They allow the program to make choices based on conditions. The main decision-making statements are **if, else, nested if-else, and switch**.

---

1. if Statement

- The if statement checks a condition.
- If the condition is **true**, the block of code inside it is executed.
- If the condition is **false**, nothing happens.

Syntax:

```
if (condition) {
   // statements
}
```

Example:

```
int age = 18;
if (age >= 18) {
   printf("You are eligible to vote.");
}
```

Output:

You are eligible to vote.

---

2. if-else Statement

- Provides two choices.
- If the condition is **true**, the if block runs.
- If the condition is **false**, the else block runs.

Syntax:

```
if (condition) {
```

```
    // statements if true
} else {
    // statements if false
}
```

Example:

```
int num = 5;
if (num % 2 == 0) {
    printf("Even number");
} else {
    printf("Odd number");
}
```

Output:

Odd number

---

3. Nested if-else

- An if-else statement inside another if or else.
- Used when multiple conditions need to be checked.

Syntax:

```
if (condition1) {
    if (condition2) {
        // statements
    } else {
        // statements
    }
} else {
```

```
    // statements
}
```

Example:

```
int marks = 75;
if (marks >= 60) {
    if (marks >= 90) {
        printf("Grade: A");
    } else {
        printf("Grade: B");
    }
} else {
    printf("Grade: C");
}
```

Output:

```
Grade: B
```

---

4. switch Statement

- Used when there are multiple options to choose from.
- Instead of writing many if-else, we use switch.
- Each case is checked, and when it matches, that block runs.

Syntax:

```
switch (expression) {
    case value1:
        // statements
        break;
```

```
    case value2:
        // statements
        break;
    default:
        // statements
}
```

Example:

```
int day = 3;
switch (day) {
    case 1: printf("Monday"); break;
    case 2: printf("Tuesday"); break;
    case 3: printf("Wednesday"); break;
    default: printf("Invalid day");
}
```

Output:

Wednesday

6. Looping in C

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

ANS:

In C programming, **loops** are used to repeat a block of code multiple times. The three main types of loops are **while loop, for loop, and do-while loop**. Each loop has its own style and usage.

---

1. While Loop

- The condition is checked **before** the loop executes.
- If the condition is true, the loop body runs; otherwise, it does not run at all.
- Best used when the number of iterations is **not known in advance**.
- Appropriate Scenarios: When reading input until a condition is met (e.g., reading a file until EOF)

Syntax:

```
while (condition) {
   // code
}
```

Example:

```
int i = 1;
while (i <= 5) {
   printf("%d ", i);
   i++;
}
```

Output: 1 2 3 4 5

---

2. For Loop

- All loop elements (initialization, condition, increment/decrement) are written in one line.
- Mostly used when the number of iterations is **known in advance**.
- Easy to use for counting loops.
- Appropriate Scenarios: When repeating a block of code a fixed number of times (e.g., printing numbers 1–100).

Syntax:

```
for (initialization; condition; increment) {
   // code
}
```

Example:

```
for (int i = 1; i <= 5; i++) {
   printf("%d ", i);
}
```

Output: 1 2 3 4 5

---

3. Do-While Loop

- The loop body executes **at least once**, even if the condition is false.
- Condition is checked **after** execution.
- Best used when we need the loop to run at least one time.
- Appropriate Scenarios: When the loop must run at least once (e.g., menu-driven programs where options are shown at least once).

Syntax:

```
do {
   // code
} while (condition);
```

Example:

```
int i = 1;
do {
   printf("%d ", i);
   i++;
```

} while (i <= 5);

Output: 1 2 3 4 5

7. Loop Control Statements

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

ANS:

In C programming, sometimes we need to change the normal flow of loops or code execution. For this purpose, C provides three important control statements: **break, continue, and goto**.

---

1. break Statement

- The break statement is used to **immediately exit** from a loop or switch case.
- Once break is executed, control moves to the statement **after the loop/switch**.
- Commonly used in **switch statements** and to stop a loop when a condition is met.

Syntax:

```
break;
```

Example (using in loop):

```
for (int i = 1; i <= 5; i++) {
   if (i == 3) {
      break;   // exit loop when i = 3
   }
   printf("%d ", i);
}
```

Output:

1 2

---

2. continue Statement

- The continue statement is used to **skip the current iteration** of a loop and move to the **next iteration**.
- It does not exit the loop, only skips the code below it for that iteration.

Syntax:

```
continue;
```

Example:

```
for (int i = 1; i <= 5; i++) {
   if (i == 3) {
      continue;   // skip printing 3
   }
   printf("%d ", i);
}
```

Output:

1 2 4 5

---

3. goto Statement

- The goto statement is used to **jump** from one part of the program to another.
- It uses a **label** as a reference point.
- Although it can make code less readable, it is useful in certain cases like **error handling**.

Syntax:

```
goto label;
// some code
label:
  // code to jump here
```

Example:

```
int i = 1;
start:
if (i <= 3) {
   printf("%d ", i);
   i++;
   goto start;   // jump back to label
}
```

Output:

1 2 3

8. Functions in C

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

ANS:

A **function** in C is a block of code that performs a specific task. Instead of writing the same code again and again, we can put it inside a function and reuse it whenever needed.

Functions make programs:

- **Modular** (divided into parts)
- **Readable**
- **Reusable**

In C, there are two types of functions:

1. **Library functions** – predefined (e.g., printf(), scanf(), sqrt()).
2. **User-defined functions** – created by the programmer.

---

1. Function Declaration (Prototype)

- Tells the compiler about the function name, return type, and parameters.
- Written before the main() function.

Syntax:

```
return_type function_name(parameter_list);
```

Example:

```
int add(int a, int b);   // function declaration
```

---

2. Function Definition

- Contains the actual code of the function.
- Defines what the function will do.

Syntax:

```
return_type function_name(parameters) {
   // body of function
   return value;
}
```

Example:

```
int add(int a, int b) {
   return a + b;   // function definition
}
```

---

3. Calling a Function

- A function is executed when it is **called** inside main() or another function.
- We pass required values (arguments) to it.

Syntax:

function_name(arguments);

Example:

int result = add(5, 3); // function call

Complete Example Program

```
#include <stdio.h>

// function declaration
int add(int a, int b);

int main() {
   int x = 5, y = 10, sum;

   sum = add(x, y);  // function call

   printf("Sum = %d", sum);
   return 0;
}

// function definition
```

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

Output:

Sum = 15

9. Arrays in C

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

ANS:

An **array** in C is a collection of elements of the **same data type** stored in **contiguous memory locations**.

- Instead of declaring many variables (int a, b, c...), we can store multiple values in a single array.
- Each element in an array is accessed using an **index** (position number).
- In C, array indexing starts from **0**.

Syntax:

```
data_type array_name[size];
```

Example:

```
int marks[5] = {90, 85, 78, 92, 88};
printf("%d", marks[0]);  // Output: 90
```

---

1. One-Dimensional Array

- It is a **single row/line** of elements.
- Used when we need to store values like marks, salaries, temperatures, etc.

Syntax:

```
data_type array_name[size];
```

Example:

```
#include <stdio.h>
int main() {
   int marks[5] = {90, 85, 78, 92, 88};

   for(int i=0; i<5; i++) {
      printf("%d ", marks[i]);
   }
   return 0;
}
```

Output:

```
90 85 78 92 88
```

---

2. Multi-Dimensional Array

- An array having **more than one dimension** (like a table or matrix).
- The most common is the **two-dimensional (2D) array**.
- Used for storing data in rows and columns, e.g., matrices, game boards.

Syntax (2D array):

```
data_type array_name[rows][columns];
```

Example (2D array):

```
#include <stdio.h>
int main() {
   int matrix[2][3] = {{1,2,3}, {4,5,6}};
```

```
    for(int i=0; i<2; i++) {
        for(int j=0; j<3; j++) {
            printf("%d ", matrix[i][j]);
        }
        printf("\n");
    }
    return 0;
}
```

Output:

1 2 3

4 5 6

Feature	**One-Dimensional Array**	**Multi-Dimensional Array**
Definition	Stores data in a single row (line)	Stores data in multiple rows & columns
Syntax	int arr[5];	int arr[3][3];
Access	arr[index]	arr[row][column]
Example Use	Marks of students, daily temperatures	Matrices, tables, game boards

10.Pointers in C

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

ANS:

A **pointer** is a special variable in C that stores the **memory address** of another variable instead of storing its value directly.

- In normal variables → we store actual values (e.g., int x = 10;).
- In pointers → we store the **location** of that value in memory (e.g., int *ptr = &x;).

Thus, a pointer is like a "link" to the variable's value.

Declaration and Initialization

Syntax:

data_type *pointer_name;

- data_type → type of variable the pointer points to.
- * → indicates it is a pointer.

Initialization:

int x = 10; // normal variable

int *ptr; // pointer declaration

ptr = &x; // initialization (store address of x in ptr)

Accessing value:

- & → address-of operator (gives address).
- * → dereference operator (gives value at that address).

Example:

#include <stdio.h>

int main() {

```
    int x = 10;
    int *p = &x;

    printf("Value of x: %d\n", x);      // 10
    printf("Address of x: %p\n", &x);   // some memory address
    printf("Value using pointer: %d\n", *p); // 10
    return 0;
}
```

Why are Pointers Important in C?

1. **Memory Access:**
    - Pointers allow **direct access to memory locations**, making C powerful and flexible.
2. **Efficient Array Handling:**
    - Arrays and strings are handled easily using pointers.
3. **Function Arguments (Call by Reference):**
    - Pointers allow functions to modify variables outside their scope.

```
void change(int *p) {
    *p = 50;
}
int main() {
    int x = 10;
    change(&x);
    printf("%d", x);  // Output: 50
}
```

4. **Dynamic Memory Allocation:**

   Functions like malloc(), calloc(), free() work with pointers to manage memory at runtime.

5. **Data Structures:**

   Pointers are the backbone of **linked lists, stacks, queues, and trees**.

10.Strings in C

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

ANS:

In C, strings are arrays of characters ending with a **null character \0**.
The <string.h> library provides many functions to work with strings.
Some important functions are:

---

1. strlen() – String Length

- **Purpose:** Returns the length of a string (number of characters excluding \0).
- **Syntax:**

```
int strlen(const char *str);
```

- **Example:**

```
#include <stdio.h>
#include <string.h>
int main() {
   char name[] = "Computer";
   printf("Length = %d", strlen(name));
```

```
    return 0;
}
```

Output: 8

- **Use:** Useful to find string size before operations like concatenation or memory allocation.

---

2. strcpy() – String Copy

- **Purpose:** Copies contents of one string into another.
- **Syntax:**

```
char* strcpy(char *destination, const char *source);
```

- **Example:**

```
char s1[20], s2[] = "Hello";
strcpy(s1, s2);
printf("%s", s1);
```

Output: Hello

- **Use:** Used when duplicating strings.

---

3. strcat() – String Concatenation

- **Purpose:** Appends one string to the end of another.
- **Syntax:**

```
char* strcat(char *destination, const char *source);
```

- **Example:**

```
char s1[20] = "Good ";
char s2[] = "Morning";
```

strcat(s1, s2);

printf("%s", s1);

Output: Good Morning

- **Use:** Useful for joining strings (like full name from first + last name).

---

4. strcmp() – String Comparison

- **Purpose:** Compares two strings **lexicographically** (like dictionary order).
- **Syntax:**

int strcmp(const char *s1, const char *s2);

- **Return Values:**
  - 0 → if strings are equal
  - <0 → if first string is smaller
  - >0 → if first string is greater
- **Example:**

char s1[] = "Apple";

char s2[] = "Banana";

printf("%d", strcmp(s1, s2));

Output: negative value

- **Use:** Useful in sorting or searching strings.

---

5. strchr() – Find Character in String

- **Purpose:** Finds the first occurrence of a character in a string.
- **Syntax:**

char* strchr(const char *str, int ch);

- **Example:**

```
char s[] = "Programming";
char *ptr = strchr(s, 'g');
printf("%s", ptr);
```

Output: gram...

- **Use:** Helpful in searching for a character in a sentence.

12. Structures in C

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

ANS:

- A **structure** in C is a **user-defined data type** that groups together variables of different data types under a single name.
- It is useful for representing real-world entities (like student, employee, book) that have multiple attributes of different types.
- Unlike arrays (same data type), structures allow storage of **heterogeneous (different) data types**.

Declaring a Structure

- **Syntax:**

```
struct StructureName {
    data_type member1;
    data_type member2;
    ...
};
```

- Example:

```
struct Student {
```

```
    int rollno;
    char name[30];
    float marks;
};
```

Defining Structure Variables

- **Syntax:**

struct StructureName variable_name;

- Example:

struct Student s1, s2;

Initializing Structures

- Structures can be initialized at the time of declaration or later by assignment.
- Example 1: **Direct Initialization**

struct Student s1 = {101, "Amit", 89.5};

- Example 2: **Assigning Values Later**

```
struct Student s2;
s2.rollno = 102;
strcpy(s2.name, "Neha");
s2.marks = 92.3;
```

Accessing Structure Members

- Members are accessed using the **dot (.) operator** with the structure variable.
- **Syntax:**

variable_name.member_name;

- Example:

printf("Roll No: %d", s1.rollno);

printf("Name: %s", s1.name);

printf("Marks: %.2f", s1.marks);

Complete Example

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

struct Student {
   int rollno;
   char name[30];
   float marks;
};

int main() {
   struct Student s1 = {101, "Amit", 89.5};  // initialization
   struct Student s2;

   // Assigning values
   s2.rollno = 102;
   strcpy(s2.name, "Neha");
   s2.marks = 92.3;
```

```
    // Accessing members
    printf("Student 1: %d, %s, %.2f\n", s1.rollno, s1.name, s1.marks);
    printf("Student 2: %d, %s, %.2f\n", s2.rollno, s2.name, s2.marks);

    return 0;
}
```

Output:

Student 1: 101, Amit, 89.50

Student 2: 102, Neha, 92.30

13. File Handling in C

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

ANS:

Importance of File Handling

- In C, normal variables and arrays are **temporary** – data is lost once the program ends.
- **File handling** allows programs to **store data permanently** on storage devices (like HDD/SSD).
- It is essential for applications like databases, text editors, compilers, and banking systems.

Advantages of File Handling

1. **Data persistence** – data is saved permanently.
2. **Large data storage** – files can store much more data than memory.

3. **Input/Output operations** – allows reading from and writing to external files.
4. **Data sharing** – multiple programs can access the same file.

File Operations in C

C provides several operations for file management using functions from the **stdio.h** library.

1. Opening a File

- A file must be opened before performing read/write operations using **fopen()**.
- **Syntax:**

FILE *fp;

fp = fopen("filename.txt", "mode");

- **Modes:**
    - "r" → open for reading
    - "w" → open for writing (creates new/overwrites existing file)
    - "a" → open for appending
    - "r+" → open for reading and writing

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2. Closing a File

- After operations, file must be closed with **fclose()**.
- **Syntax:**

fclose(fp);

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3. Writing to a File

- Functions:

- fprintf(fp, "format", data) → formatted writing
- fputs(string, fp) → write string
- fputc(char, fp) → write single character

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4. Reading from a File

- Functions:
  - fscanf(fp, "format", &data) → formatted reading
  - fgets(string, size, fp) → read string
  - fgetc(fp) → read single character