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MPSTME

PFE

PROGRAMMING FOR EVERYONE

18TH | 19TH | 20TH SEP

Introduction to C

C is a powerful, high-performance programming language that's widely used in system embeddings, software development, including game development, and applications requiring high performance.

Key features of C:

LOW-LEVEL MANIPULATION: IT ALLOWS FOR DIRECT MANIPULATION OF HARDWARE AND MEMORY, WHICH IS USEFUL FOR SYSTEM-LEVEL PROGRAMMING.

PERFORMANCE: C IS KNOWN FOR ITS PERFORMANCE AND EFFICIENCY, MAKING IT IDEAL FOR APPLICATIONS WHERE SPEED AND RESOURCE MANAGEMENT ARE CRITICAL.

Header Files in C

- Header files contain predefined functions and macros that can be used in programs.
- They save time by allowing reuse of common code.
- Always included at the top of a C program using #include.

Common Header Files:

- <stdio.h> → Standard Input/Output (e.g., printf, scanf).
- <string.h> → String handling (e.g., strcpy, strlen).
- <math.h> → Mathematical functions (e.g., sqrt, pow).
- <stdlib.h> → Utility functions (e.g., malloc, free, atoi).

```
#include <header_file_name>
#include <stdio.h>
#include <sting.h>
#include <math.h>
#include <stdlib.h>
```

Execution

SOURCE → PREPROCESSOR → COMPILER → LINKER → EXECUTABLE

Stages of Execution in C:

Source File (.c)

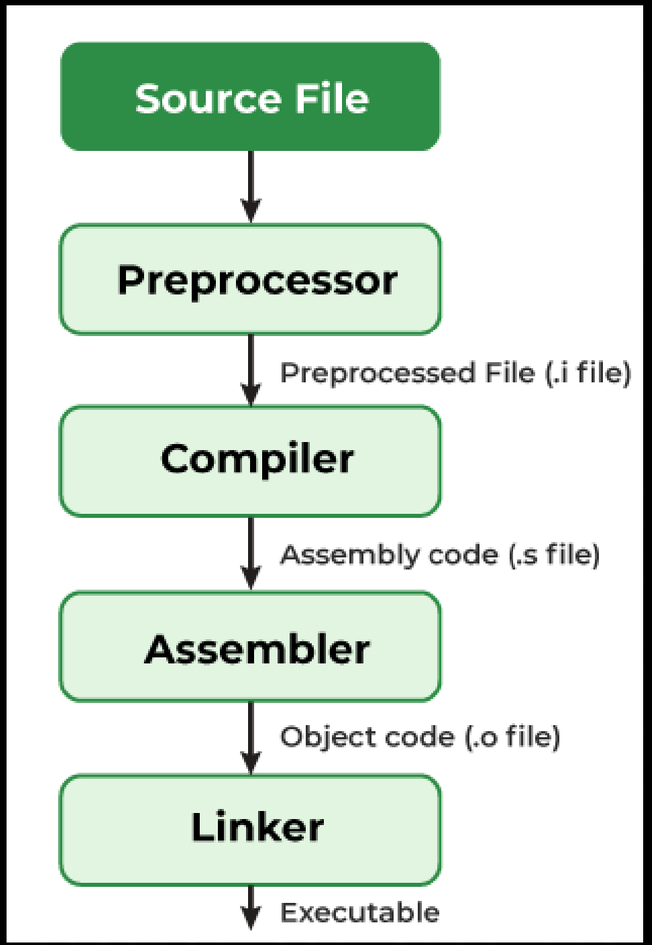
- This is your code written in C.
- Example: program.c

Preprocessor

- Handles all preprocessor directives (#include, #define, macros).
- Output: Preprocessed file (.i)

Compiler

- Converts the preprocessed code into assembly language.
- Checks for syntax errors.
- Output: Assembly file (.s)



Execution

`SOURCE → PREPROCESSOR → COMPILER → LINKER → EXECUTABLE`

Stages of Execution in C:

Assembler

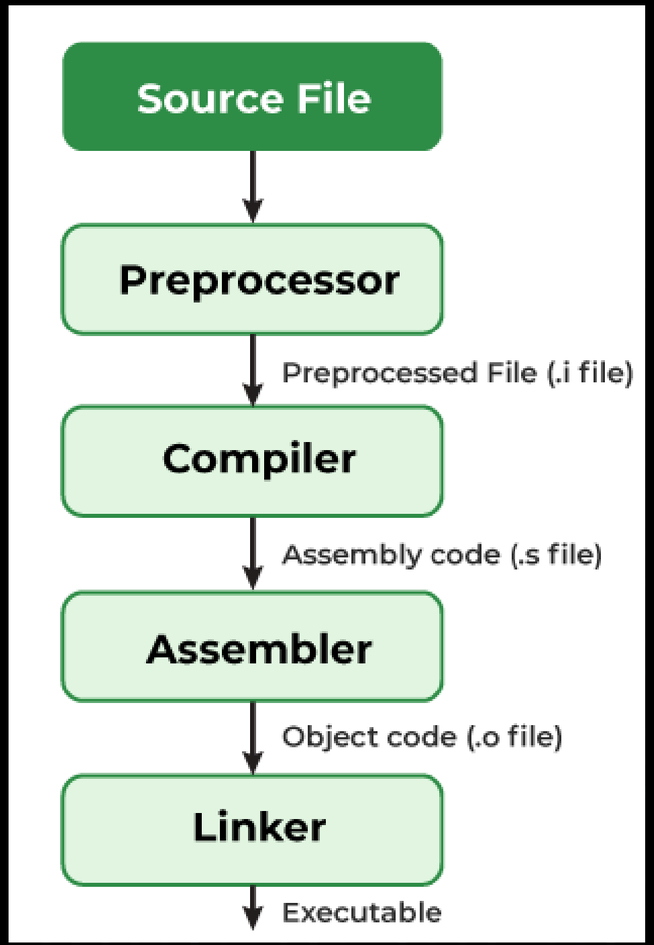
- Translates assembly code into machine code (binary).
- Creates an object file (.o).

Linker

- Combines one or more object files with required libraries.
- Resolves external references (like printf from stdio.h).
- Output: Executable file

Executable

- The final program you can run.



Syntax / Structure

Every C program has these:

- Headers
- The ‘Main’ Function
- Statements and Expressions
- Declaring variables and using various data types for them

Syntax / Structure

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

int main(void) // 'Main' Function
{
    printf("Hello World!");
    return 0;
}
```

printf() – Output Function

printf()

- Used to display output on the screen.
- Defined in <stdio.h>.

Format Specifiers:

- %d → integer
- %f → float
- %c → character
- %s → string
- %lu → length

```c
#include <stdio.h>

int main() {
    int age = 20;
    float height = 5.9;
    char grade = 'A';
    char name[] = "Alice";

    printf("Name: %s\n", name);
    printf("Age: %d\n", age);
    printf("Height: %f\n", height);
    printf("Grade: %c\n", grade);

    return 0;
}
```

```
Name: Alice
Age: 20
Height: 5.900000
Grade: A
```

scanf() – Input Function

scanf()

- Used to take input from the user.
- Defined in <stdio.h>.

Format Specifiers:

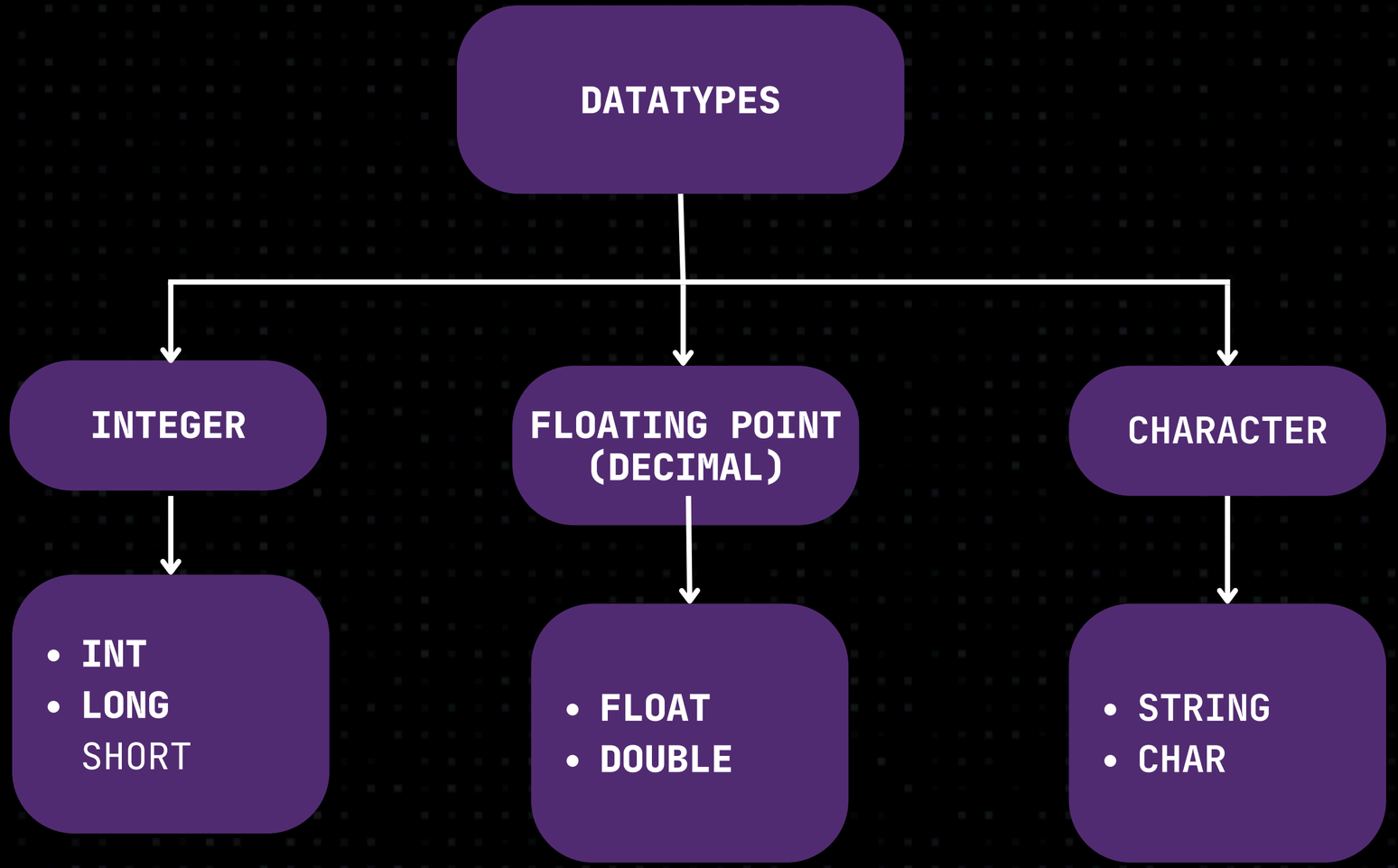
- %d → integer
- %f → float
- %c → character
- %s → string

```c
#include <stdio.h>

int main() {
    int age;
    float height;
    char grade;
    char name[20];

    printf("Enter Name, Age, Height, Grade:\n");
    scanf("%s %d %f %c", name, &age, &height, &grade);

    printf("Name: %s\n", name);
    printf("Age: %d\n", age);
    printf("Height: %.2f\n", height);
    printf("Grade: %c\n", grade);

    return 0;
}
```

```
Enter Name, Age, Height, Grade:
soham
19
5.10
A
Name: soham
Age: 19
Height: 5.10
Grade: A
```

Data Types

A data type gives the type of date any variable can store. For example, numbers, characters, decimals, etc.



Data Types

- int - stores integers (whole numbers), without decimals, such as 123 or -123
- long - (–2,147,483,648 to 2,147,483,647 (32-bit) / much bigger (64-bit)
- short (–32,768 to 32,767)
- float - holds floating values up to 7 digits.
- double - that is used to store floating-point values up to 15 digits
- char - stores single characters, such as 'a' or 'B'. Char values are surrounded by single quotes
- string - stores text, such as "Hello World". String values are surrounded by double quotes
- bool - stores values with two states: true or false

Data Types

```c
int myNum = 15; // Integer variable
float myFloat = 9.8; // Floating-point variable
double myDouble = 3.1415926535897793; // Double variable
char myLetter = 'A'; // Character variable
char myText[] = "Welcome to PFE!"; // Character Array (String) variable
```

```c
#include <stdio.h>

int main() {
    printf("Size of short = %lu bytes\n", sizeof(short));
    printf("Size of int = %lu bytes\n", sizeof(int));
    printf("Size of long = %lu bytes\n", sizeof(long));
    printf("Size of long long = %lu bytes\n", sizeof(long long));
    printf("Size of float = %lu bytes\n", sizeof(float));
    printf("Size of double = %lu bytes\n", sizeof(double));
    printf("Size of long double = %lu bytes\n", sizeof(long double));
    return 0;
}
```

ASCII

(AMERICAN STANDARD CODE FOR INFORMATION INTERCHANGE)

- Definition: A character encoding standard used in computers and communication devices.
- Purpose: Represents text and control characters using numbers.
- Developed: In 1963 by ANSI (American National Standards Institute).

7 bits = 7 binary digits

- Example: 1001011 (this is a 7-bit binary number).

Key Features

- Uses 7 bits to represent characters (128 unique codes: 0–127).
- Includes:
  - Control Characters (0–31, 127) → e.g., newline, tab, backspace.
  - Printable Characters (32–126) → letters, digits, symbols.
- Extended ASCII uses 8 bits (256 codes), adding more symbols and graphical characters.

- 1000001 (binary 65) → A
- 1100001 (binary 97) → a

Why Important?

- Foundation of text encoding in early computers.
- Still forms the basis for Unicode and other modern encodings.

Decimal	Hex	Char	Decimal	Hex	Char	Decimal	Hex	Char	Decimal	Hex	Char
0	00	[NULL]	32	20	[SPACE]	64	40	@	96	60	`
1	01	[START OF HEADING]	33	21	!	65	41	A	97	61	a
2	02	[START OF TEXT]	34	22	"	66	42	B	98	62	b
3	03	[END OF TEXT]	35	23	#	67	43	C	99	63	c
4	04	[END OF TRANSMISSION]	36	24	$	68	44	D	100	64	d
5	05	[ENQUIRY]	37	25	%	69	45	E	101	65	e
6	06	[ACKNOWLEDGE]	38	26	&	70	46	F	102	66	f
7	07	[BELL]	39	27	'	71	47	G	103	67	g
8	08	[BACKSPACE]	40	28	(	72	48	H	104	68	h
9	09	[HORIZONTAL TAB]	41	29	)	73	49	I	105	69	i
10	0A	[LINE FEED]	42	2A	*	74	4A	J	106	6A	j
11	0B	[VERTICAL TAB]	43	2B	+	75	4B	K	107	6B	k
12	0C	[FORM FEED]	44	2C	,	76	4C	L	108	6C	l
13	0D	[CARRIAGE RETURN]	45	2D	-	77	4D	M	109	6D	m
14	0E	[SHIFT OUT]	46	2E	.	78	4E	N	110	6E	n
15	0F	[SHIFT IN]	47	2F	/	79	4F	O	111	6F	o
16	10	[DATA LINK ESCAPE]	48	30	0	80	50	P	112	70	p
17	11	[DEVICE CONTROL 1]	49	31	1	81	51	Q	113	71	q
18	12	[DEVICE CONTROL 2]	50	32	2	82	52	R	114	72	r
19	13	[DEVICE CONTROL 3]	51	33	3	83	53	S	115	73	s
20	14	[DEVICE CONTROL 4]	52	34	4	84	54	T	116	74	t
21	15	[NEGATIVE ACKNOWLEDGE]	53	35	5	85	55	U	117	75	u
22	16	[SYNCHRONOUS IDLE]	54	36	6	86	56	V	118	76	v
23	17	[END OF TRANS. BLOCK]	55	37	7	87	57	W	119	77	w
24	18	[CANCEL]	56	38	8	88	58	X	120	78	x
25	19	[END OF MEDIUM]	57	39	9	89	59	Y	121	79	y
26	1A	[SUBSTITUTE]	58	3A	:	90	5A	Z	122	7A	z
27	1B	[ESCAPE]	59	3B	;	91	5B	[	123	7B	{
28	1C	[FILE SEPARATOR]	60	3C	<	92	5C	\	124	7C	|
29	1D	[GROUP SEPARATOR]	61	3D	=	93	5D	]	125	7D	}
30	1E	[RECORD SEPARATOR]	62	3E	>	94	5E	^	126	7E	~
31	1F	[UNIT SEPARATOR]	63	3F	?	95	5F	_	127	7F	[DEL]

Global and Local Variables

1. Local Variables

- A local variable is declared inside a function, block, or method and is accessible only within that scope.
- It is created when the block or function is called and destroyed when the block or function finishes execution.
- Scope: Limited to the function or block where it is declared.
- Lifetime: Exists only during the function or block execution.

Global and Local Variables

2. Global Variables

- A global variable is declared outside of all functions and is accessible from any function within the same program after its declaration.
- Scope: Available throughout the entire program, starting from the point of declaration.
- Lifetime: Exists for the entire duration of the program (from start to end).

Global and Local Variables

1. Local Variables

```c
void display(){
    int num = 10; //Local variable to the display() function
    printf("Inside display: %d\n", num);
}

int main(){
    int num = 5; //Local variable to main() function
    printf("Inside main: %d\n", num);

    display();
    return 0;
}
```

Output:

```
Inside main: 5
Inside display: 10
```

Global and Local Variables

2. Global Variables

```c
int globalVar = 100;

int func1(){
    printf("Global Variable inside func1: %d\n", globalVar);
}

int main()
{
    printf("Global Variable inside main: %d\n", globalVar);

    globalVar = 200;
    func1();

    return 0;
}
```

Output:

```
Global Variable inside main: 100
Global Variable inside func1: 200
```

STRUCTURES

In C, a structure is a user-defined data type that groups together different types of data under a single name. These data elements, called members or fields, can be of different types (int, float, char, etc.).

Key points:

1. Structure definition: It defines the blueprint of the structure.
2. Structure variable: A structure variable holds data based on the defined structure.
3. Accessing members: Members are accessed using the dot (.) operator.

Benefits:

- You can store different types of data together.
- Makes your code more organized and readable.

Syntax:

```
1    struct StructureName {
2        data_type member1;
3        data_type member2;
4        // more members
5    };
```

Example:

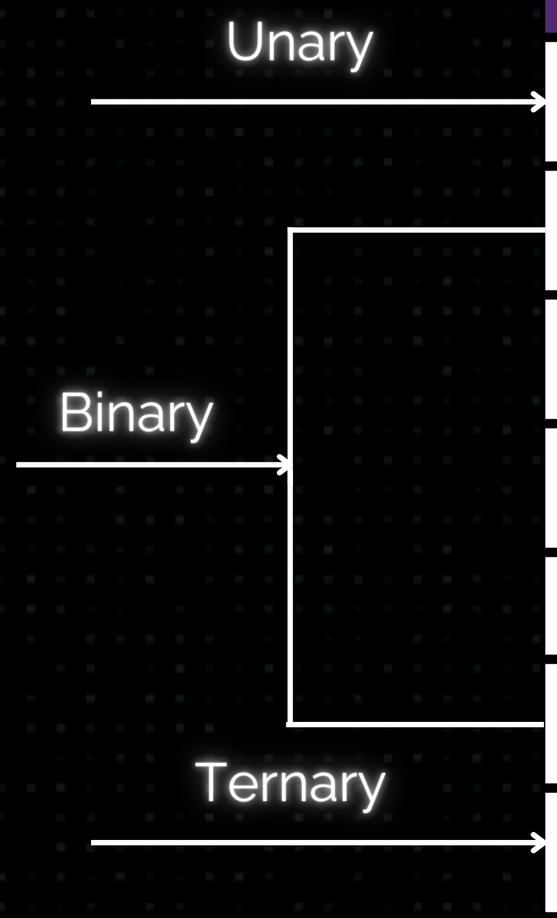
```
 9    struct Person {
10        char name[50];
11        int age;
12        float height;
13    };
```

STRUCTURES

```c
struct Person {
    char name[50];
    int age;
    float height;
};

int main() {
    // Array of structures
    struct Person group[3] = {
        {"Alice", 20, 5.5},
        {"Bob", 22, 5.9},
        {"Charlie", 25, 6.1}
    };

    // Accessing members
    printf("First person's name: %s\n", group[0].name);
    printf("Second person's age: %d\n", group[1].age);
    printf("Third person's height: %.2f\n", group[2].height);

    return 0;
}
```

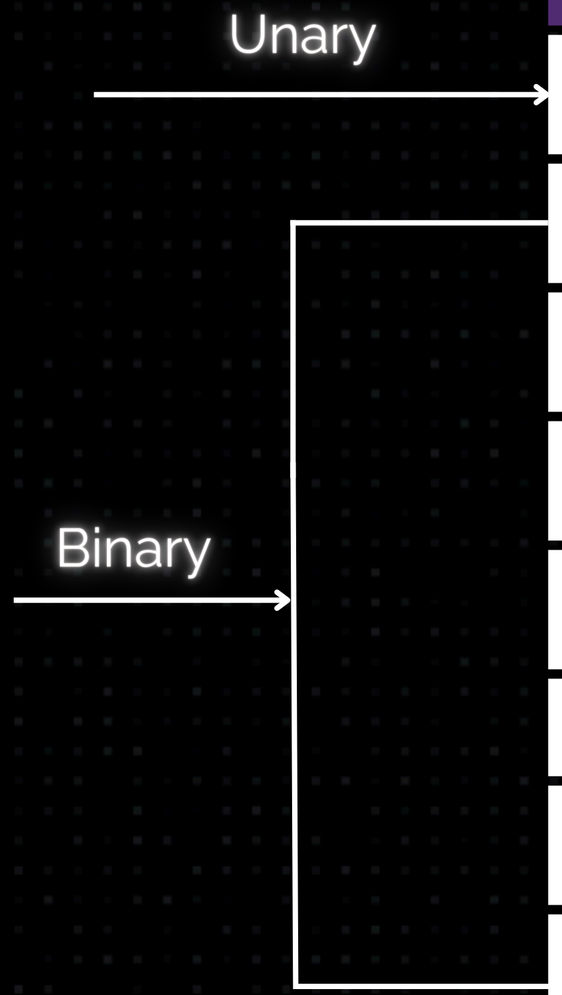
- group[0] → refers to the first structure in the array.
- group[0].name → accesses the name field of the first person.
- Similarly group[1].age → age of the second person.

Operators



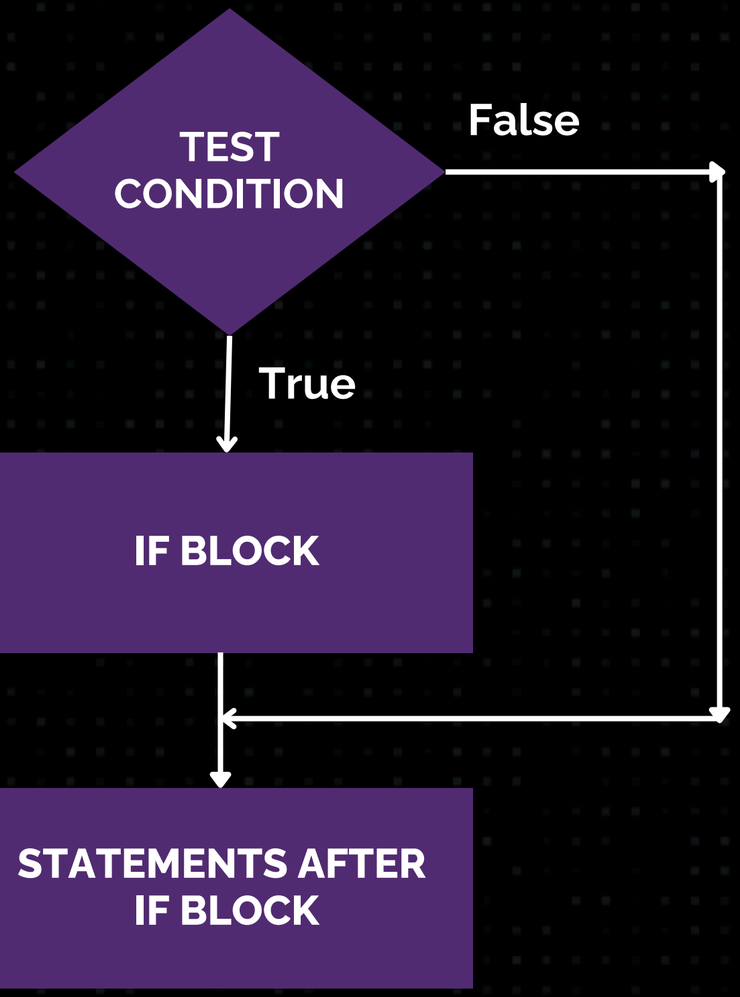
OPERATOR	Type
++, --	Unary Operator
+, -, *, /, %	Arithmetic Operator
<, <=, >, >=, ==, !=	Relational Operator
&&, ||, !	Logical Operator
&, |, <<, >>, -, ^	Bitwise Operator
=, +=, -=, *=, %=	Assignment Operator
?:	Ternary Operator

Operators Precedence



OPERATOR	Precedence
++, --	First
*,/,%	Second
+, -	Third
<, <=, >, >=	Fourth
==, !=	Fifth
&&	Sixth
||	Seventh
=	Last

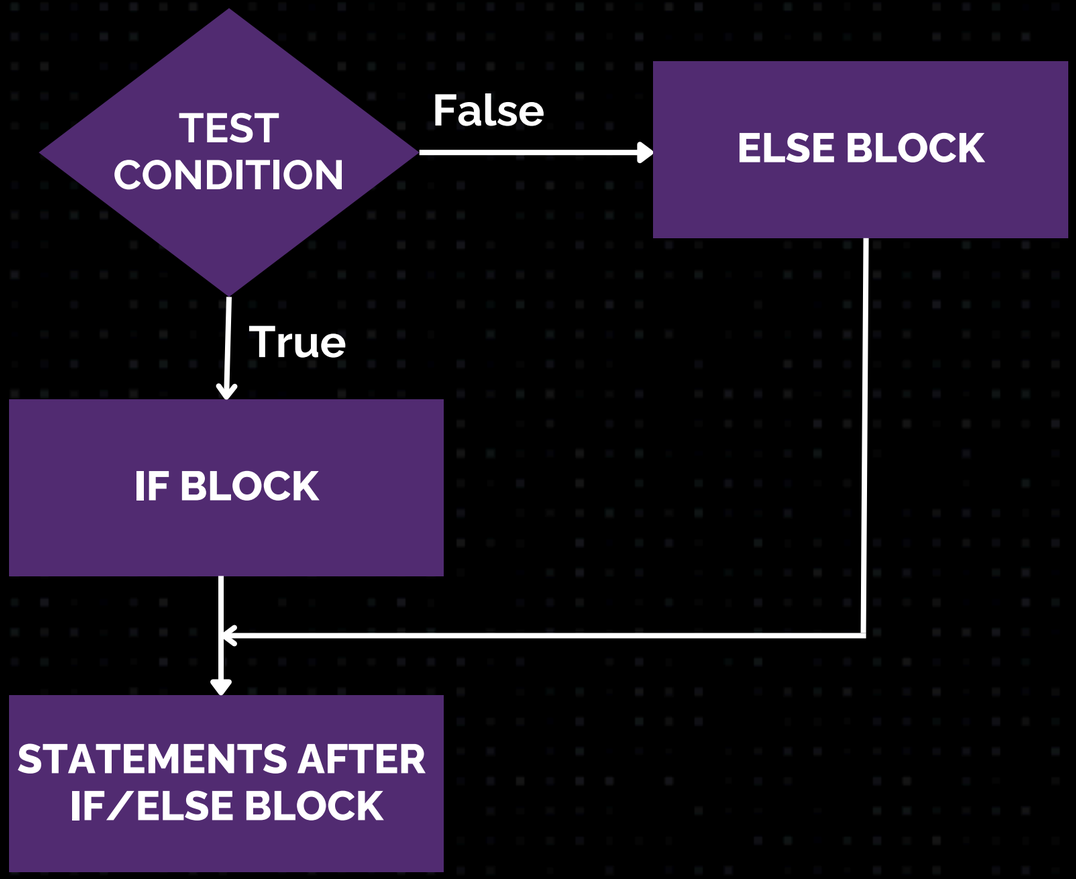
If Statments



If Statments

```c
#include <stdio.h>

int main(){
    if (condition){
        // Executes only if the condition is TRUE
    }

    return 0;
}
```

If Else Statments

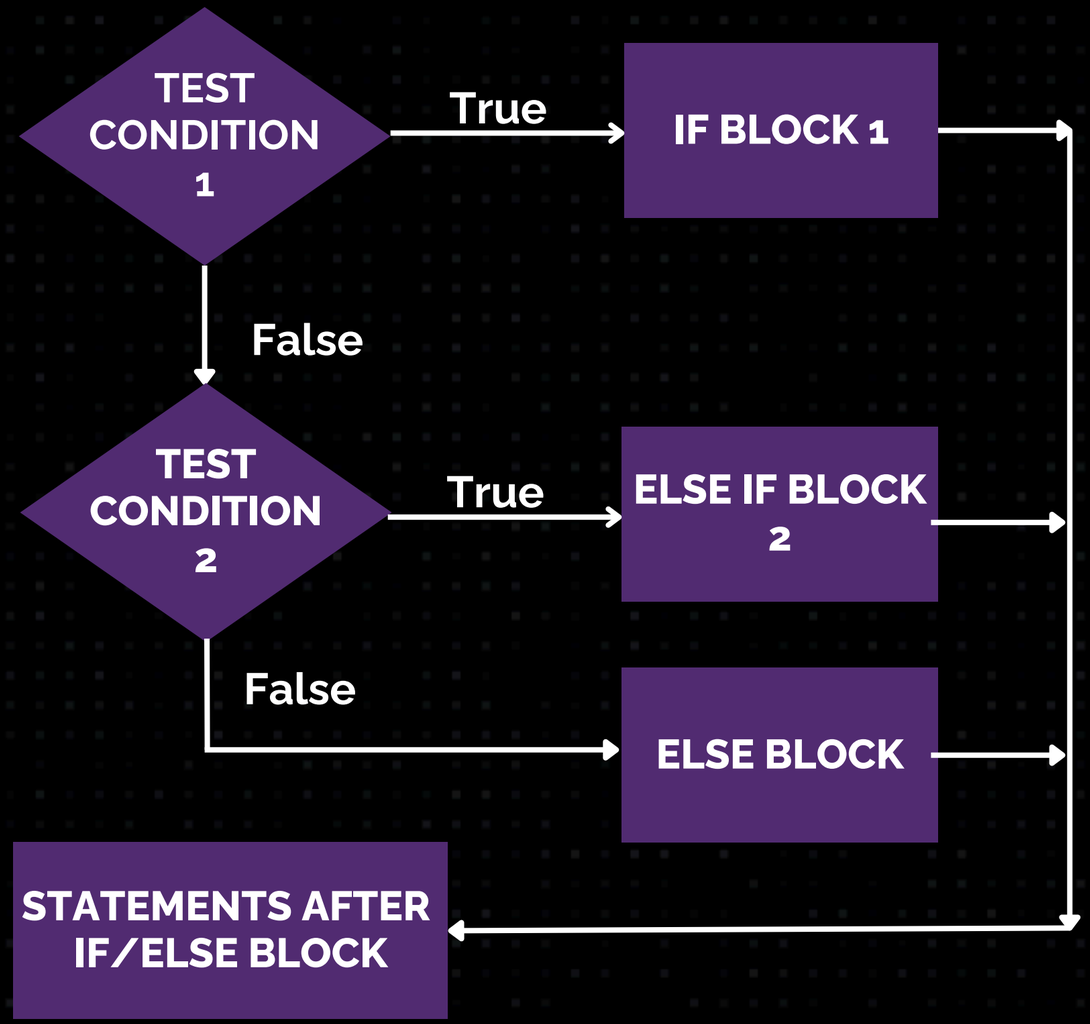


If Else Statments

Conditional choice between two actions

```c
#include <stdio.h>

int main(){
    int score = 50;     //int variable score set to 50

    if(score <= 50){    //condition to check whether score is <= 50
        printf("Score is less than or equal to 50");//output this if true
    }

    else{
        printf("Score is greater than 50");         //output this if its not
    }

    return 0;
}
```

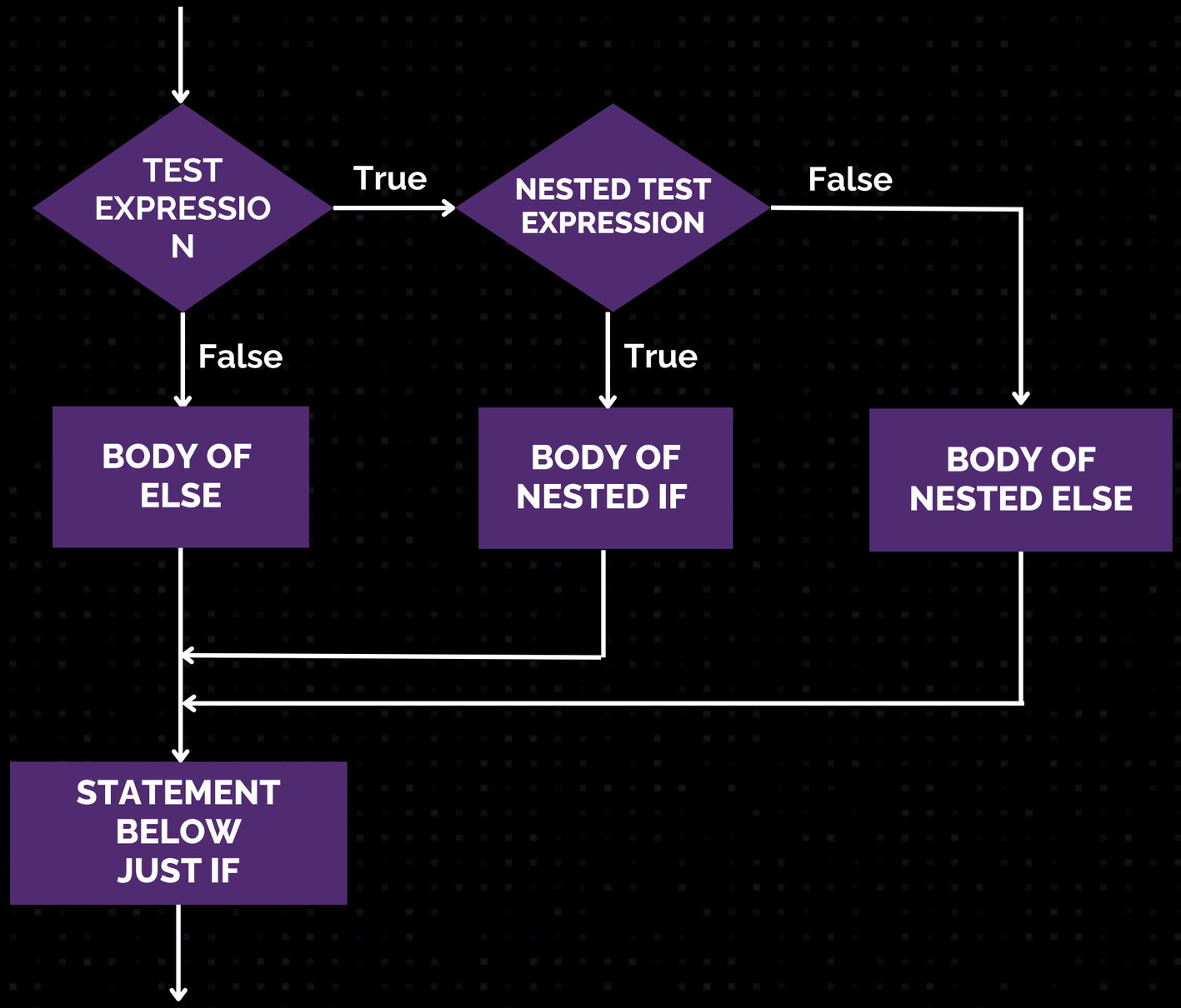
Else If Statments



Else If Statments

```c
int main()
{
    int score = 50;

    if (score < 50)
    { // If score is less than 50
        printf("Score is less than 50\n");
    }
    else if (score == 50)
    { // If score equals 50
        printf("Score is equal to 50\n");
    }
    else
    { // If score is greater than 50
        printf("Score is greater than 50\n");
    }

    return 0;
}
```

Nested If Statments



Nested If Statments

```c
#include <stdio.h>

int main(){

    if (condition){
        // executes only if the above condition is true

        if (condition){
            // executes only if both parents and child conditions are true
        }

        else (condition){
            // executes if above child condition is false, but the parent one was true
        }

    else{
        // executes if the parent condition is false
    }
    }

}
```

Switch Case

It is an alternative to using multiple if-else statements when you need to compare a variable against different constant values.

Note: Only int, char and enum can be used in switch-case

```c
int main()
{
    int variable = 1; // Example value for the variable

    switch (variable)
    {
    case 1: // Statement for case 1
        // Statement1
        break;
    case 2: // Statement for case 2
        // Statement2
        break;
    default: // Executed if none of the other statements are matching
        // StatementDefault
        break;
    }

    return 0;
}
```

Switch Case (Fall-through Behaviour)

If you omit the break statement, the code will "fall through" to the next case, which means multiple case blocks can be executed in sequence.

```c
#include <stdio.h>

int main() {
    int number = 2;

    switch (number) {
        case 1:
            printf("One\n");
            break;
        case 2:
            printf("Two\n");
            break;
        case 3:
            printf("Three\n");
            break;
        default:
            printf("Invalid number\n");
            break;
    }

    return 0;
}
```

Output:

```
TwoThree
```

Calculator With Switch Case:

```c
#include <stdio.h>

int main() {
    char op;
    int num1, num2;

    printf("Enter an operator (+, -, *, /): ");
    scanf(" %c", &op);

    printf("Enter two numbers: ");
    scanf("%d %d", &num1, &num2);

    switch (op) {
        case '+':
            printf("%d + %d = %d\n", num1, num2, num1 + num2);
            break;
        case '-':
            printf("%d - %d = %d\n", num1, num2, num1 - num2);
            break;
        case '*':
            printf("%d * %d = %d\n", num1, num2, num1 * num2);
            break;
        case '/':
            printf("%d / %d = %d\n", num1, num2, num1 / num2);
            break;
        default:
            printf("Error: Invalid operator\n");
    }

    return 0;
}
```

Arrays and Strings

Arrays

In C, an array is a data structure that allows you to store multiple elements of the same data type in a contiguous block of memory. The following are the properties of arrays:

Arrays have a fixed size, which means the number of elements they can hold is determined when the array is created and cannot be changed during runtime.

Indexed: Elements in the array can be accessed via their index, which starts at 0 for the first element and goes up to (size - 1) for the last element.

Homogeneous: All elements in the array must be of the same type (e.g., all integers, all floats).

Arrays


```c
int main()
{
    // Declaration
    int nums[5]; // Declare an array 'nums' with 5 elements

    // Initialization
    for (int i = 0; i < 5; i++)
    {                   // Loop to initialize each array element
        nums[i] = i; // Assign 'i' to the 'i-th' element of the array
    }

    return 0; // Exit program
}
```

Arrays (2D)

In C, a 2D array (also known as a two-dimensional array or matrix) is essentially an array of arrays. It is used to store data in a tabular format with rows and columns.

2D Array Properties

Fixed size: The number of rows and columns is specified when the array is created and cannot be changed.

Indexed: Elements in the array can be accessed via their index as follows: array[Row index][Col index]
For example: int a[1][2]

Rows and columns: You need two indices to access an element — one for the row and one for the column.

Arrays (2D)

Declaration and Initialization

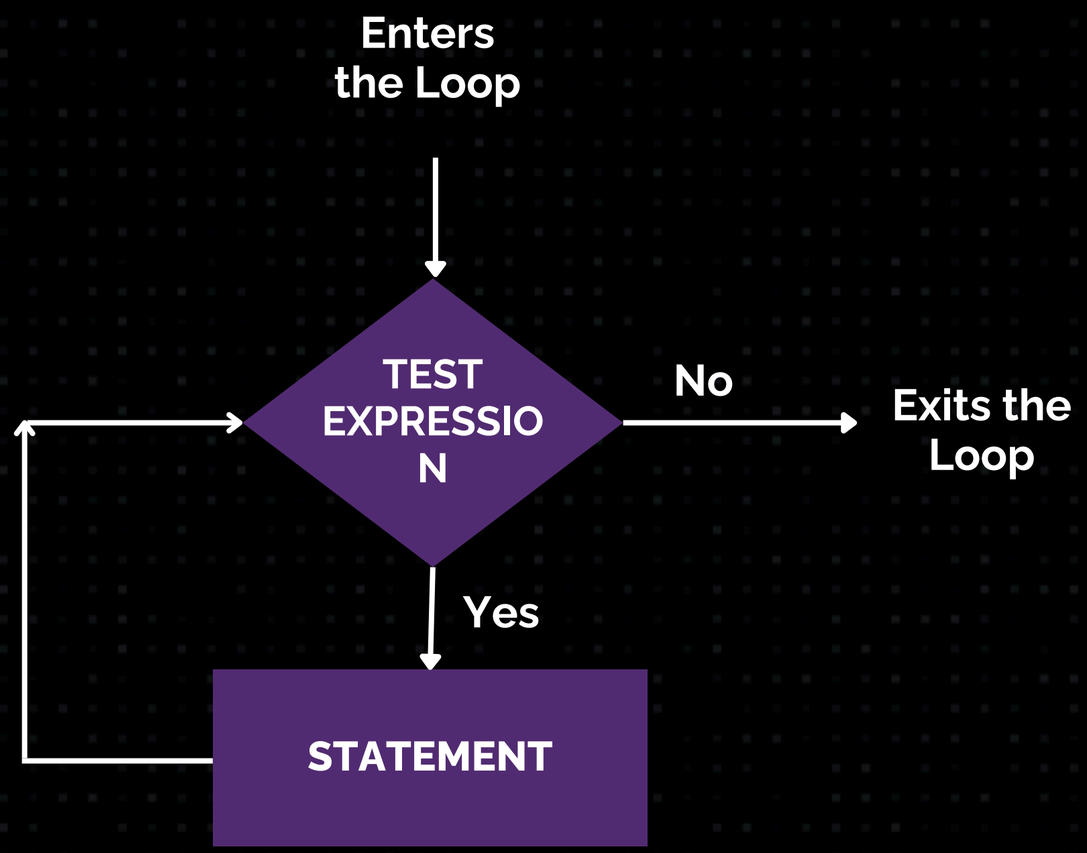
```c
int array[3][4] = {
    {1, 2, 3, 4},
    {5, 6, 7, 8},
    {9, 10, 11, 12}};
```

Accessing elements using nested loops

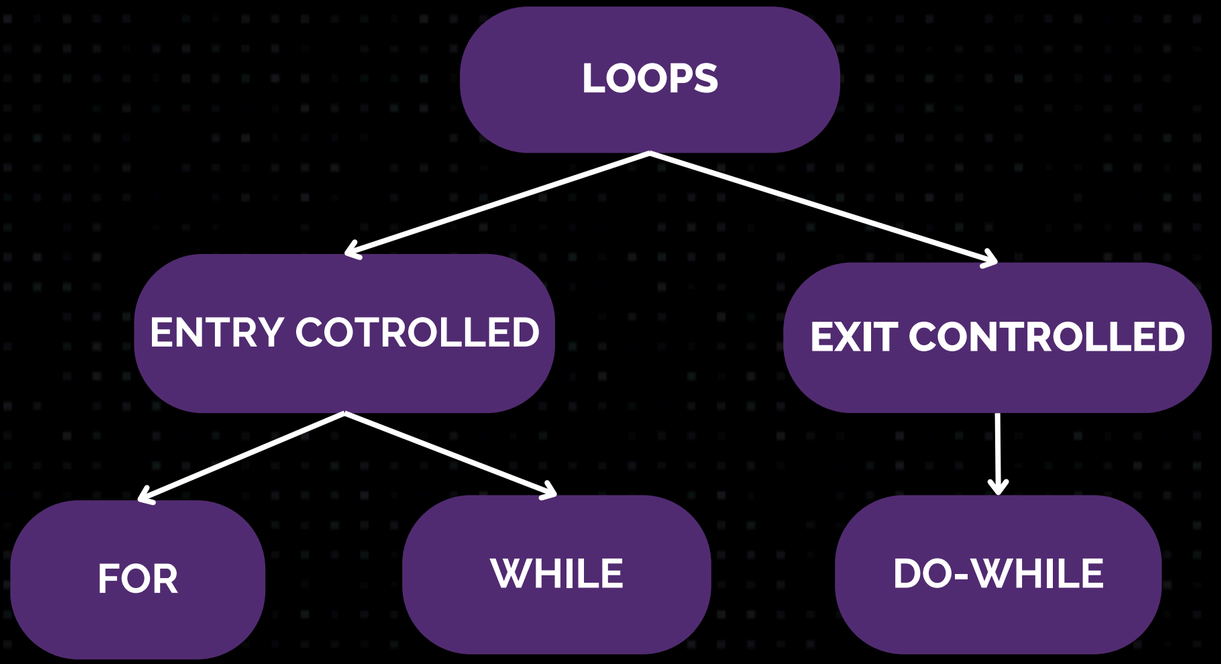
```c
for (int i = 0; i < 3; i++)
{
    // Loop through columns
    for (int j = 0; j < 4; j++)
    {
        printf("%d ", array[i][j]); // Access each element
    }
    printf("\n"); // Print new line after each row
}
```

Loops

Loops are control structures that allow you to execute a block of code repeatedly. C provides several types of loops, each suited for different situations.



Loops



For Loops

```c
int main()
{
    printf("Printing 10 numbers\n"); // Print message

    for (int i = 1; i <= 10; i++)
    { // Loop from 1 to 10
        printf("%d\n", i); // Print current number
    }

    return 0; // Exit program
}
```

While Loops

```c
int main()
{
    int i = 1;                          // Initialize i to 1
    printf("Printing 10 numbers\n"); // Print message

    while (i <= 10)
    {                           // Loop while i is less than or equal to 10
        printf("%d\n", i); // Print current number
        i++;                // Increment i
    }

    return 0; // Exit program
}
```

Do-While Loops

```c
#include <stdio.h>

int main(){
    int i = 1; // Initialize 'i' with 1
    printf("Printing 10 numbers: \n"); // print a message

    do {
        printf("%d\n", i);  // Output the current value of i
        i++;                // Increment its value by 1
    } while (i <= 10);      // Do run this code till it's value less than equal to 10

    return 0;
}
```

Loop Control Statements

1) break: Exits the loop immediately, even if the loop condition is still true.

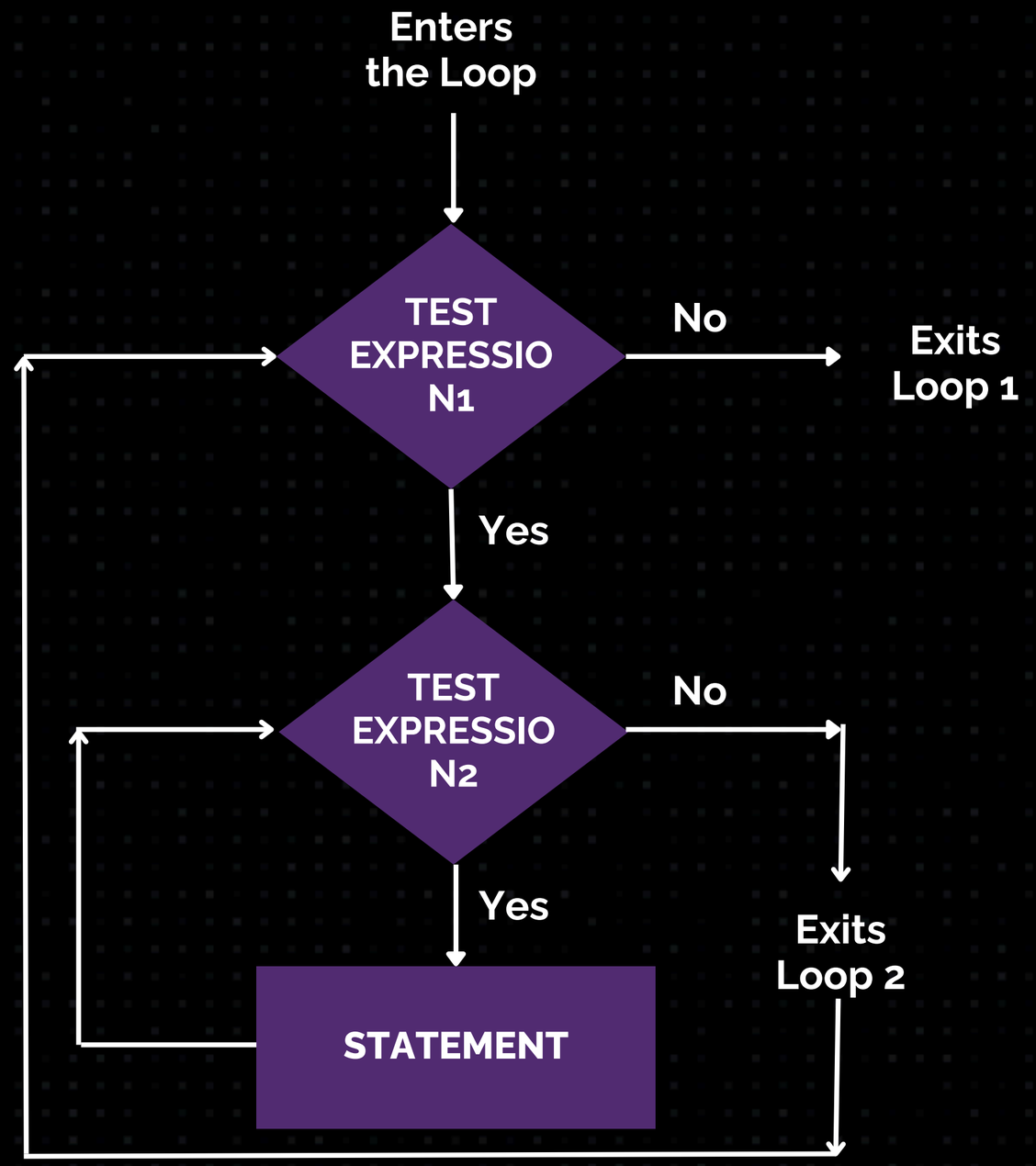
```c
for (int i = 0; i < 10; i++)
{
    if (i == 5)
    {
        break; // Exit the loop when i is 5
    }
    printf("%d ", i); // Output: 0 1 2 3 4
}
```

2) continue: Skips the rest of the loop body for the current iteration and continues with the next iteration.

```c
for (int i = 0; i < 5; i++)
{
    if (i == 2)
    {
        continue; // Skip the current iteration when i is 2
    }
    printf("%d ", i); // Output: 0 1 3 4
}
```

Nested Loops

- In C, nested loops refer to a loop inside another loop.
- The inner loop is executed completely for each iteration of the outer loop.
- This structure is useful when dealing with multi-dimensional data, such as in 2D arrays or grids, and for performing repeated tasks that require multiple levels of iteration.



Nested Loops

```c
#include <stdio.h>

int main(){
    for (int i = 0; i <=3; i++){         // Outer loop (runs 4 times from index 0 to 3)
        for (int j = 1; j <= 2; j++){    // Inner loop (runs 2 times for each run of outer loop)
            printf("i = %d, j = %d\n", i, j);
        }
    }

    return 0;
}
```

Nested Loops

Output

```
i = 1, j = 1
i = 1, j = 2
i = 2, j = 1
i = 2, j = 2
i = 3, j = 1
i = 3, j = 2
```

Clock Example

```c
#include <stdio.h>

int main() {
    int h, m, s;

    for(h = 0; h < 24; h++) {            // hours loop
        for(m = 0; m < 60; m++) {        // minutes loop
            for(s = 0; s < 60; s++) {    // seconds loop
                printf("%02d:%02d:%02d\n", h, m, s);
            }
        }
    }

    return 0;
}
```