Introduction to Core C++ Concepts

Chapter One

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Overview of Topics

1.4 C++ Program Structure

1.5 Data Types, Variables and Constants

1.6 Insertion and Extraction Operators

1.7 Type Conversion

1.8 Structure in C++

1.9 Dynamic memory allocation : new and delete operator

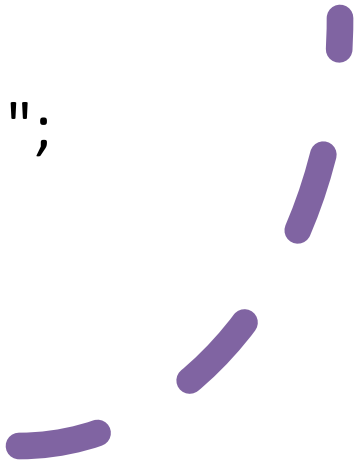
Basic C++ Program Structure

A typical C++ program includes:

- Preprocessor directives
- Main function
- Statements and expressions inside curly braces

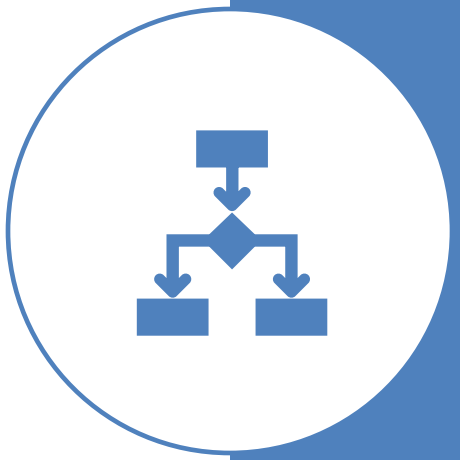
Example:

```
#include <iostream>
int main() {
   std::cout << "Hello, World!";
   return 0;
}
```



Preprocessor Directive

- A **preprocessor directive** in C++ is a command that starts with a # symbol and is processed **before the actual compilation** of the code begins.
- It tells the **C++ preprocessor** to perform specific actions like including files, defining constants, or conditionally compiling code.



Preprocessor Directives

- Begin with '#'
- Commonly used: #include, #define
- #include <iostream> includes standard input/output stream library
- #define is used for macros , compile time constant (#define PI 3.14159)

Common Preprocessor Directives

Directive	Purpose
#include	Includes the content of another file (usually header files).
#define	Defines macros or symbolic constants.
#undef	Undefines a macro defined with #define.
#ifdef / #ifndef	Checks if a macro is defined or not.
#if, #else, #elif, #endif	Conditional compilation.

Main Function and Execution Flow

- Entry point of every C++ program: int main()
- Code within main() executes sequentially
- Return value 0 signifies successful execution

Namespaces in C++

- A **namespace** is a way to group **related variables, functions, classes, etc.** under a single name to avoid **name conflicts** in large projects.
- Suppose two libraries have a function called `print()`. Without namespaces, the compiler won't know which one you mean. Namespaces **help avoid conflicts**.

Namespace

Defining

```
namespace MyNamespace {
    int value = 100;

    void show() {
        std::cout << "Value: " << value <<
std::endl;
    }
}
```

Using

1. Using Scope Resolution Operator : :

```
MyNamespace::show();
std::cout << MyNamespace::value;
```

2. Using Directive (`using namespace`)

```
using namespace MyNamespace;

show();        // No need to prefix with namespace
std::cout << value;
```

NameSpace (Function example)

```
#include <iostream>

namespace English {
    void greet() {
        std::cout << "Hello!" << std::endl;
    }
}

namespace Spanish {
    void greet() {
        std::cout << "¡Hola!" << std::endl;
    }
}

int main() {
    English::greet();  // Outputs: Hello!
    Spanish::greet();  // Outputs: ¡Hola!
    return 0;
}
```

Sample Program

```
#include <iostream>
using namespace std;

int main() {
    cout << "Welcome to C++";
    return 0;
}
```

- Include necessary library
- Uses namespace to avoid std::
- Outputs message using cout

Comments

Comments are used to explain code.

They do not affect the execution of the program.

Help improve code readability.

Single-line Comment:

Syntax: `// comment`

`Example: // This is a comment`

Multi-line Comment:

Syntax:

/* This is multi line comment */

Comments Best Practice

1

Use comments to explain *why* the code exists.

2

Avoid obvious comments.

3

Keep comments updated with code changes.

Data Types

A **data type** in programming defines **what kind of data** a variable can hold and **how much memory** it occupies.

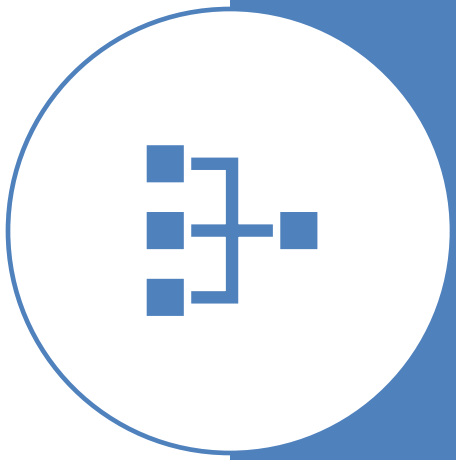
Why are Data Types Important?

- They tell the computer **how to interpret the bits** stored in memory.
- They help the compiler **check for errors** and **optimize memory use**.
- Different data types support **different operations** (e.g., math on numbers, or characters in text).

Built-in Data Types

C++ provides the following fundamental data types:

- int: Integer values (e.g., 10)
- float: Floating point numbers (e.g., 3.14)
- double: Double precision floating point
- char: Single character (e.g., 'A')
- bool: Boolean values (true or false)



Integer Data Types

Type	Size (Bytes)	Range
short	2	-32,768 to 32,767
unsigned short	2	0 to 65,535
int	4	-2,147,483,648 to 2,147,483,647
unsigned int	4	0 to 4,294,967,295
long	4 or 8	Platform-dependent
unsigned long	4 or 8	Platform-dependent
long long	8	-9,223,372,036,854,775,808 to 9,223,372,036,854,775,807
unsigned long long	8	0 to 18,446,744,073,709,551,615

Floating Point Dat Types

Type	Size (Bytes)	Range (Approx.)
float	4	$\pm 1.2 \times 10^{-38}$ to $\pm 3.4 \times 10^{38}$ (6 digits precision)
double	8	$\pm 2.3 \times 10^{-308}$ to $\pm 1.7 \times 10^{308}$ (15 digits)
long double	8 or 16	Platform-dependent (higher precision)

Character and Boolean Types

Type	Size (Bytes)	Range
char	1	-128 to 127 (signed)
unsigned char	1	0 to 255
wchar_t	2 or 4	Wide character (Unicode)
char16_t	2	UTF-16 character
char32_t	4	UTF-32 character
bool	1	true (1) or false (0)

Variable

A **variable** is a **named storage** that holds data which can **change** during program execution.

You must **declare** the variable's **data type** before using it.

Variable names must follow identifier rules (e.g., no spaces, no starting with numbers)

Syntax

dataType variableName = value;

int age = 25;

float temperature = 36.6;

char grade = 'A';

You can **change** the value of a variable later:

age = 30; // age now holds 30

Constant

A **constant** is like a variable, but its value **cannot change** after initialization.

Declared using the `const` keyword.

Helps prevent accidental changes to important values.

Syntax

const dataType constantName = value;

const double PI = 3.14159;

const int DAYS_IN_WEEK = 7;

Trying to change a constant will cause a **compile-time error**:

PI = 3.14; // Error! Cannot assign to a constant

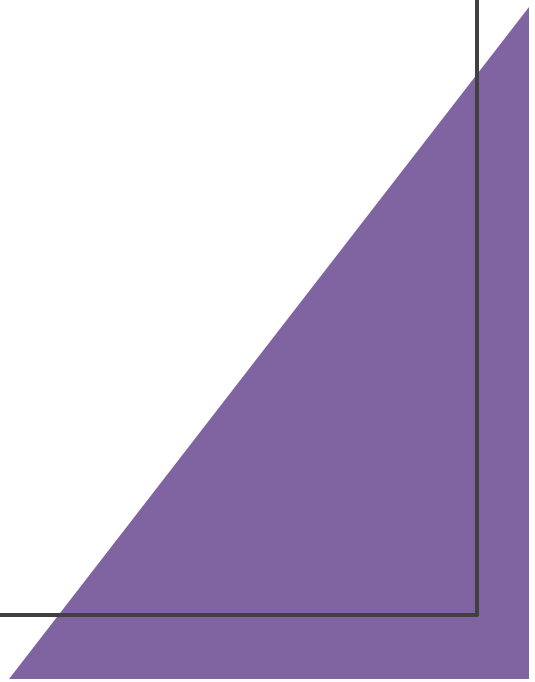
Constants in C++

- const keyword: const int size = 10;
- #define macro: #define SIZE 10
- Constants cannot be changed during execution
- Use constants to improve code readability and maintenance

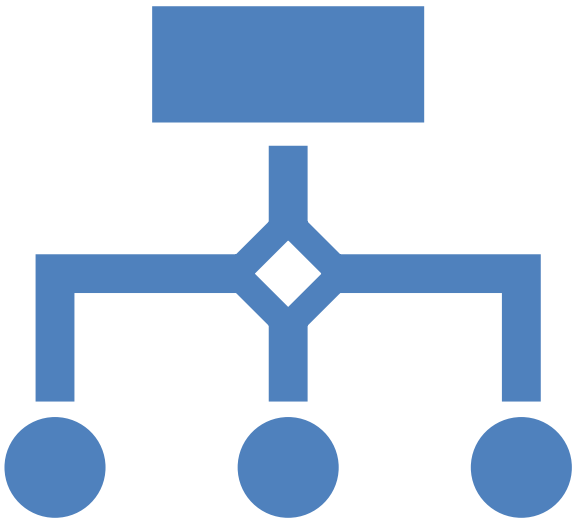
Example: Variables and Constants

```
const float PI = 3.14;
int radius = 5;
float area = PI * radius * radius;
cout << "Area: " << area;
```

- PI is a constant
- Variables used to compute area



Operators in C++



Operators are symbols that tell the compiler to perform specific mathematical, logical, or relational operations.

Types of Operators

- Arithmetic
- Relational
- Logical
- Assignment
- Incremental

Arithmetic Operator

Used to perform basic math calculations.

Operator	Meaning	Example	Result
+	Addition	5 + 3	8
-	Subtraction	5 - 3	2
*	Multiplication	5 * 3	15
/	Division	6 / 3	2
%	Modulus (remainder)	5 % 3	2

Relational Operator

- Used to compare two values, results in `true` or `false`.

OPERATOR	MEANING	EXAMPLE	RESULT
==	Equal to	5 == 3	false
!=	Not equal to	5 != 3	true
>	Greater than	5 > 3	true
<	Less than	5 < 3	false
>=	Greater or equal	5 >= 5	true
<=	Less or equal	3 <= 5	true

Logical Operators

- Used to combine multiple conditions.

Operator	Meaning	Example	Result
&&	Logical AND	(5 > 3) && (2 < 4)	true
`		`	Logical OR
!	Logical NOT	!(5 == 3)	true

Assignment Operators

Used to assign values to variables.

Operator	Meaning	Example	Result
=	Assign	x = 5	x = 5
+=	Add and assign	x += 3	x = x + 3
-=	Subtract and assign	x -= 2	x = x - 2
*=	Multiply and assign	x *= 4	x = x * 4
/=	Divide and assign	x /= 2	x = x / 2
%=	Modulus and assign	x %= 3	x = x % 3

Increment and Decrement Operators

Operator	Meaning	Example	Result
++	Increment by 1	x++ or ++x	x = x + 1
--	Decrement by 1	x-- or --x	x = x - 1

Escape Sequence

- Sometimes, you want your program to display special characters or format the text output in a certain way. Since you can't type these special commands directly in strings, C++ uses **escape sequences** to handle this.

- They are **special codes** inside strings that start with a backslash (\).
- They tell the program to perform an action or insert a special character.
- For example, moving to a new line, adding tabs, or printing quotes.

Common Escape Sequence

ESCAPE CODE	DESCRIPTION	EXAMPLE	OUTPUT
\n	Inserts a **new line**	cout << "Hi\nThere";	Hi There
\t	Inserts a **tab space**	cout << "A\tB";	A B
\\	Prints a **backslash**	cout << "\\";	\
\"	Prints a **double quote**	cout << "\"Hello\"";	"Hello"
\'	Prints a **single quote**	cout << "It\'s OK";	It's OK
\a	Produces a **beep sound**	cout << "\a";	(Beep sound if supported)
\b	Deletes the **previous character**	cout << "ABC\bD";	ABD
\r	Returns cursor to **start of line**	cout << "12345\rABC";	ABC45 (ABC overwrites start)

Why to use Escape Sequence

TO **FORMAT YOUR OUTPUT** CLEARLY (NEW LINES, TABS).

TO **INCLUDE SPECIAL CHARACTERS** IN YOUR TEXT.

TO MAKE YOUR PROGRAM'S OUTPUT **EASIER TO READ AND UNDERSTAND**.

Input/Output in C++

- cin: Standard input (keyboard)
- cout: Standard output (screen)
- Requires iostream library
- Used with insertion (<<) and extraction (>>) operators

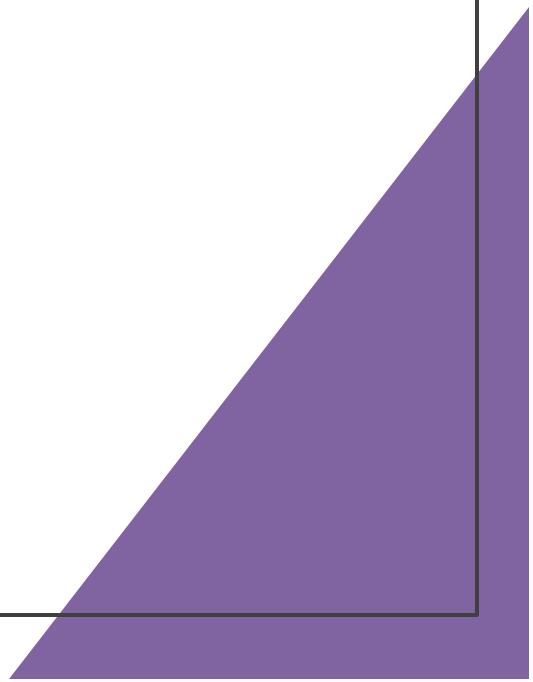
Insertion and Extraction Operators

<< : Outputs data to console (cout)

>> : Accepts input from user (cin)

Example:

```
int age;
cin >> age;
cout << "Age is: " << age;
```



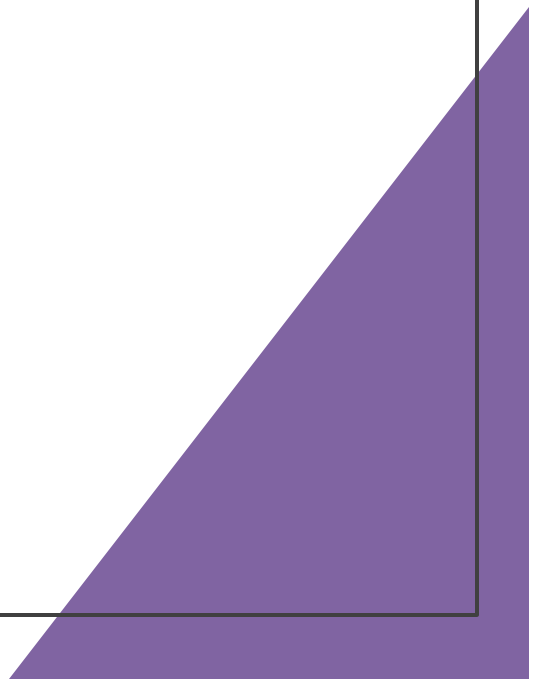
I/O Example Program

```
#include <iostream>
using namespace std;

int main() {
   int num;
   cout << "Enter a number: ";
   cin >> num;
   cout << "You entered: " << num;
   return 0;
}
```

What is Type Conversion?

- Converting data from one type to another
- Implicit: Done automatically by compiler
- Explicit: Manual casting by programmer



Implicit Type Conversion

- Occurs automatically during expressions
- Lower to higher type: int to float
- Example: int x = 10; float y = x; // x is promoted

Explicit Type Conversion

Also called type casting

Syntax: (data_type)variable;

Example: float a = 10.5; int b = (int)a; // b = 10

Type Conversion Example

```
int a = 5, b = 2;
float result = (float)a / b;
cout << "Result: " << result;
```

Casts a to float to get decimal result

endl

- `endl` stands for **end line**.
- It is used with **`cout`** to **insert a newline** character.
- It also **flushes the output buffer**, meaning it forces the output to be printed immediately.

Example

```
#include <iostream>
using namespace std;

int main() {
    cout << "Hello World" << endl;  // Moves to next line after printing
    cout << "Welcome to C++" << endl;
    return 0;
}
```

Structure Definition

Collection of related variables under one name

Syntax:

```
struct Student {
    int id;
    char name[50];
    float marks;
};
```

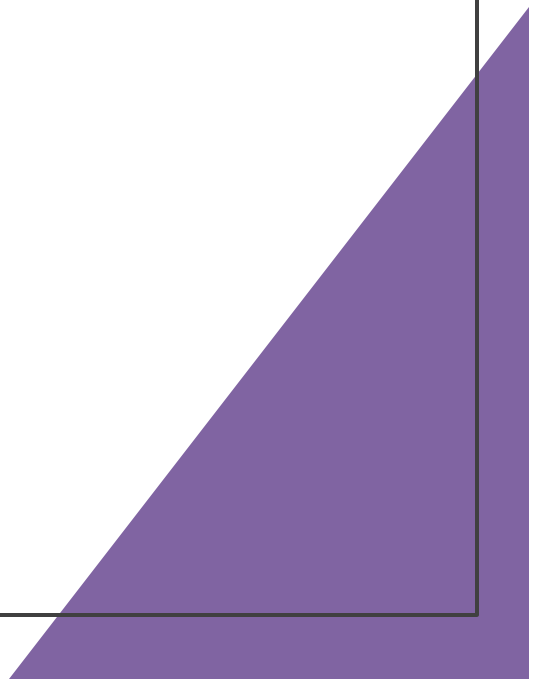
User-defined and Derived Types

User-defined types:

- struct: Combines variables under one type
- enum: Enumerated constants

Derived types:

- Arrays, pointers, references



Accessing Structure Members

Use dot operator (.) with variable

Example:

```
Student s1;
s1.id = 1;
cout << s1.id;
```

Structure Example Program

```
struct Book {
    int id;
    char title[50];
};

int main() {
    Book b1 = {1, "C++ Basics"};
    cout << "ID: " << b1.id << ", Title: " << b1.title;
    return 0;
}
```

What is Dynamic Memory Allocation?

- Memory is allocated at runtime (heap)
- Useful when size is unknown at compile-time
- new and delete operators are used

new Operator

- Allocates memory and returns pointer

Example:

```
int* p = new int;
*p = 10;
cout << *p;
```

delete Operator

- Frees dynamically allocated memory
- Must be used to avoid memory leaks

Example:

- delete p; // p was allocated with new

Dynamic Arrays

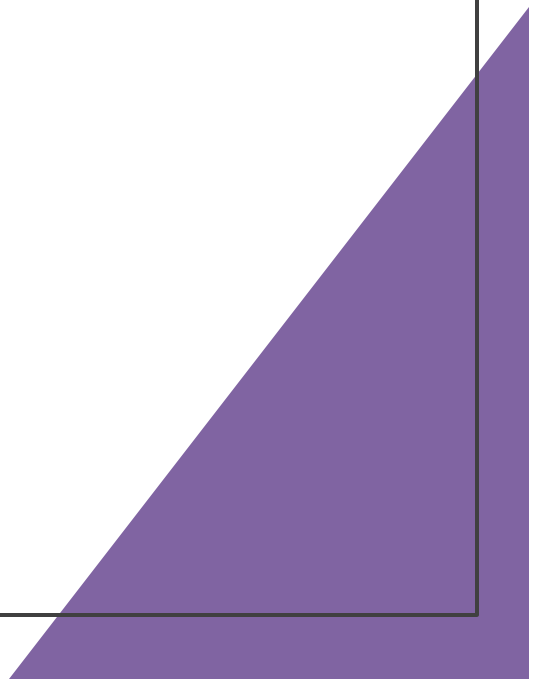
Allocate arrays dynamically

```
int* arr = new int[5];
for (int i = 0; i < 5; i++)
 arr[i] = i * 2;
delete[] arr; // Use delete[] for arrays
```

Dynamic Memory Example

```
int* num = new int(25);
cout << "Value: " << *num;
delete num;
```

- Shows allocation, usage, and deallocation



Summary of Topics

- C++ program starts with main()
- Variables and constants store data
- cin/cout used for I/O
- Type conversion changes data type
- Structures group related data
- Dynamic memory helps manage heap memory