C++ Notes

Part 2-1

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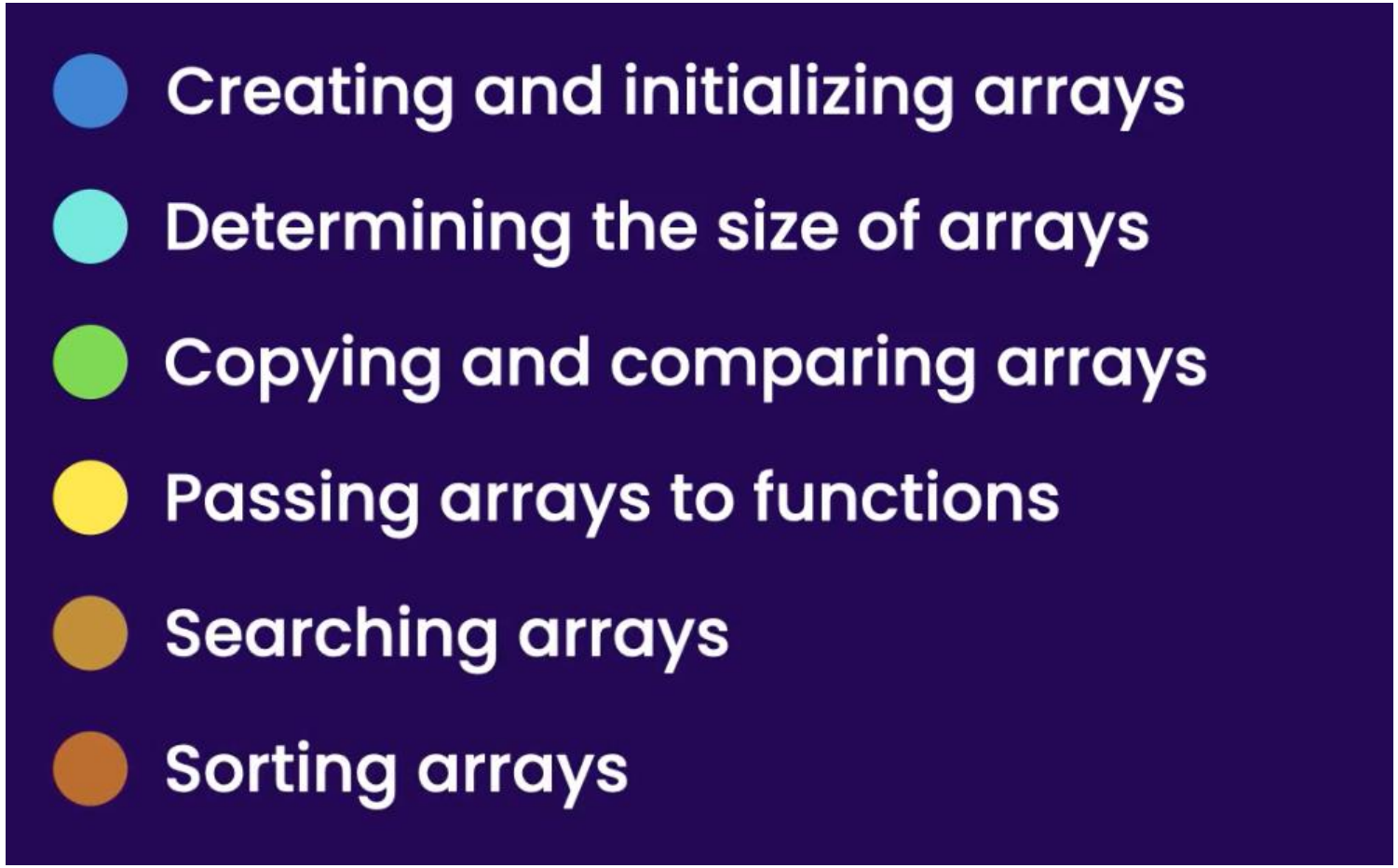
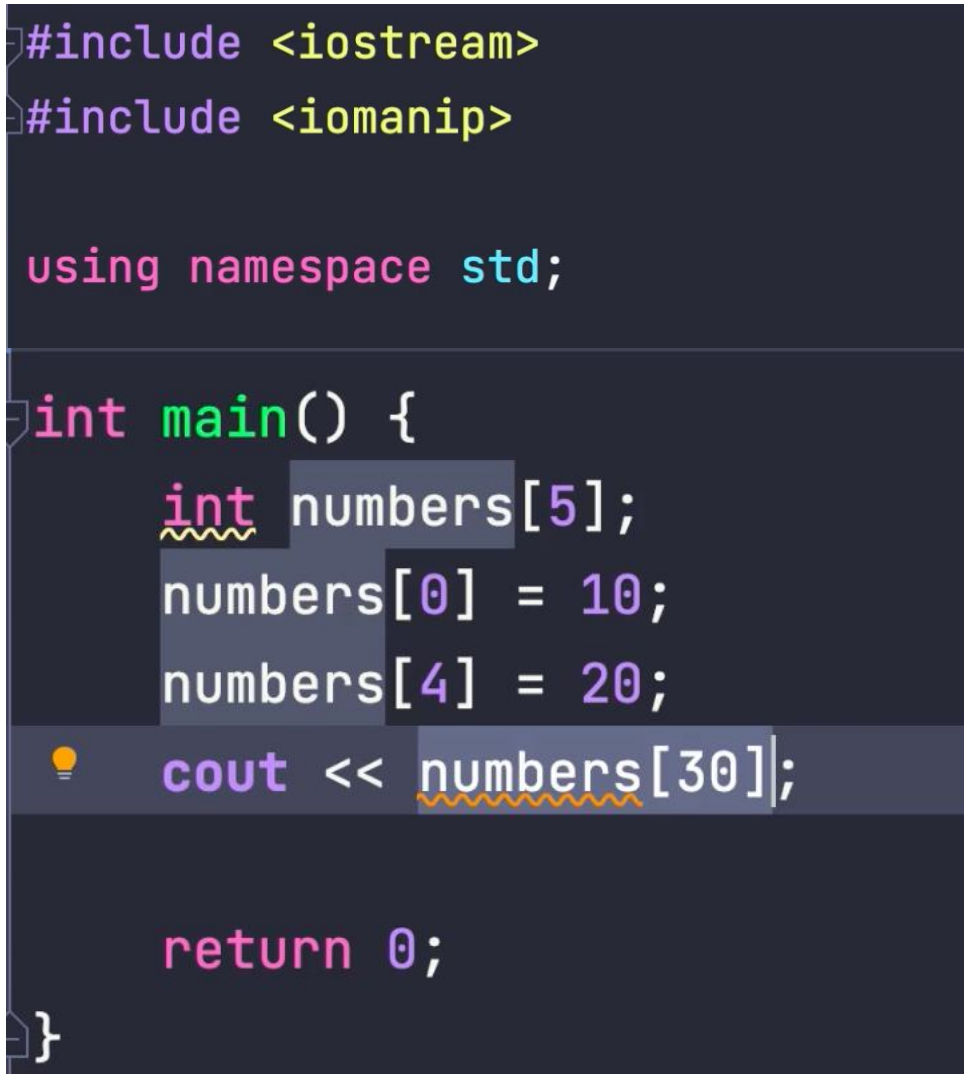
Topics Covered

Arrays


Creating and initializing arrays
Determining the size of arrays
Copying and comparing arrays
Passing arrays to functions
Searching arrays
Sorting arrays

Creating and Initializing Arrays



```cpp
#include <iostream>
#include <iomanip>

using namespace std;

int main() {
    int numbers[5];
    numbers[0] = 10;
    numbers[4] = 20;
    cout << numbers[30];

    return 0;
}
```

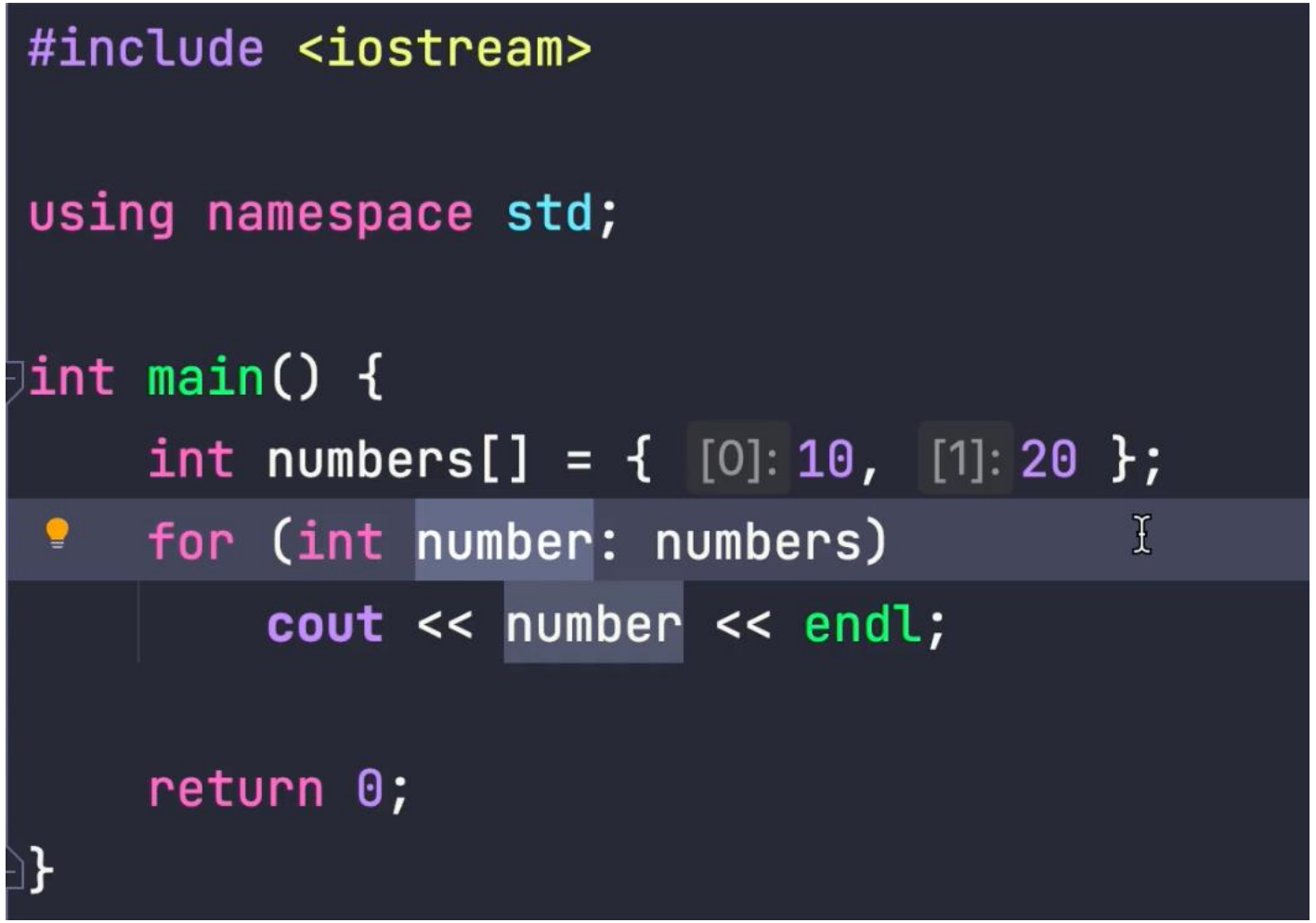
- Array indices start from 0 (zero).
- Assigning a value to an index outside of the index range will not cause any compile issue, but it will produce a garbage value.

Creating and Initializing Arrays

```cpp
#include <iostream>
#include <iomanip>

using namespace std;

int main() {
    int numbers[] = { [0]: 10, [1]: 20 };

    cout << numbers;

    return 0;
}
```

- We do not need to specify the array size if we initialize the array with values.
- The compiler determines the size based on the values provided.

Determining the Size of Arrays



```cpp
#include <iostream>

using namespace std;

int main() {
    int numbers[] = { [0]: 10, [1]: 20 };
    for (int number: numbers)
        cout << number << endl;

    return 0;
}
```

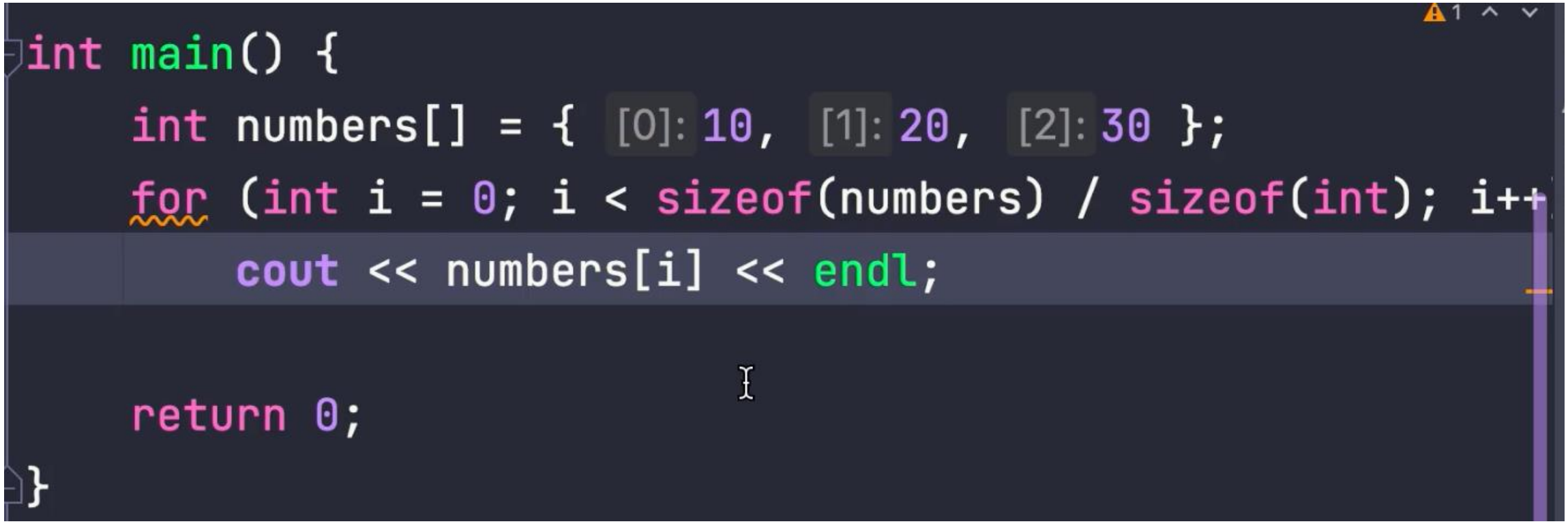
- Range-based for loop.
- The variable number will be assigned the array elements one-by-one.

Determining the Size of Arrays

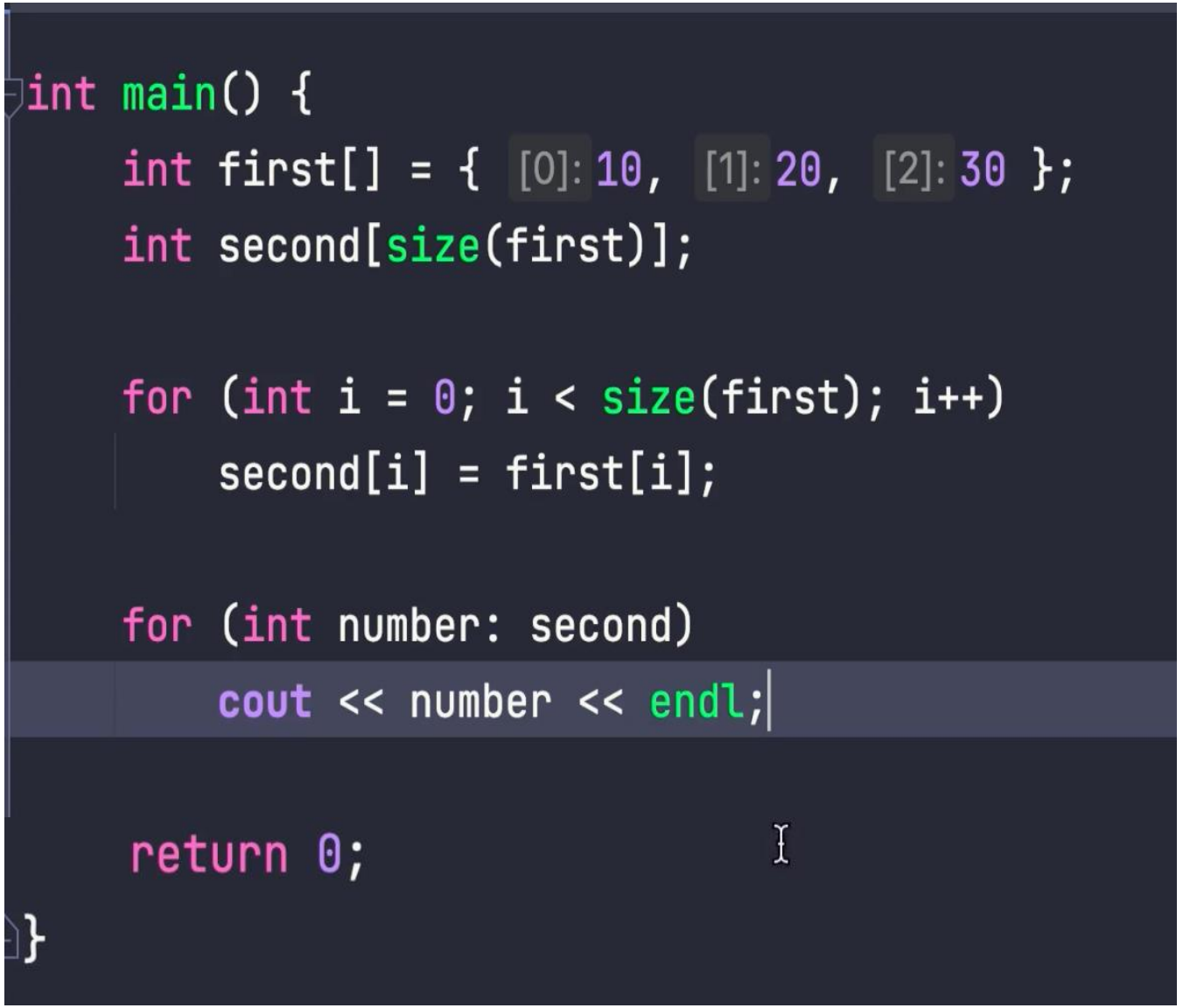
```cpp
#include <iostream>

using namespace std;

int main() {
    int numbers[] = { [0]: 10, [1]: 20 };
    for (auto number : int : numbers)
        cout << number << endl;

    return 0;
}
```

- Using **auto** in the for loop, the compiler determines the type of the variable “number” from the values in the array.

Determining the Size of Arrays



Copying Arrays



Determining the Size of Arrays

```cpp
using namespace std;

int main() {
    int first[] = { [0]: 10, [1]: 20, [2]: 30 };
    int second[] = { [0]: 10, [1]: 20, [2]: 30 };

    if (first == second)
        cout << "Equal";

    return 0;
}
```

- ❑ We cannot compare arrays using their names directly.
- ❑ We need to compare each element individually.
- ❑ Array names store their address in the memory.

Determining the Size of Arrays

```cpp
int main() {
    int first[] = { [0]: 10, [1]: 20, [2]: 30 };
    int second[] = { [0]: 10, [1]: 20, [2]: 30 };

    cout << first << endl;
    cout << second << endl;

    return 0;
}
```

- We cannot compare arrays using their names directly.
- We need to compare each element individually.
- Array names store their address in the memory.

```
0x7ffee74a18fc
0x7ffee74a18f0
```

Array addresses in the memory

Determining the Size of Arrays

```cpp
int main() {
    int first[] = { [0]: 10, [1]: 20, [2]: 30 };
    int second[] = { [0]: 10, [1]: 20, [2]: 30 };

    bool areEqual = true;
    for (int i = 0; i < size(first); i++)
        if (first[i] != second[i]) {
            areEqual = false;
            break;
        }

    cout << boolalpha << areEqual;

    return 0;
}
```

- We cannot compare arrays using their names directly.
- We need to compare each element individually.
- Array names store their address in the memory.

Passing Arrays to Functions

```cpp
#include <iostream>

using namespace std;

void printNumbers(int numbers[]) {
    for (int number: numbers)
        cout << number;
}
```

```cpp
// int[] -> int*
void printNumbers(int numbers[]) {
    for (int i = 0; i < size(numbers); i++)
        cout << numbers[i];
}
```

- Integer array number, when passed as an argument, represents a number which is the address of the array in memory.
- It is a pointer.
- We cannot use range loop in this case.

- **size(numbers)** will not work, because numbers is just an address (hexadecimal number)

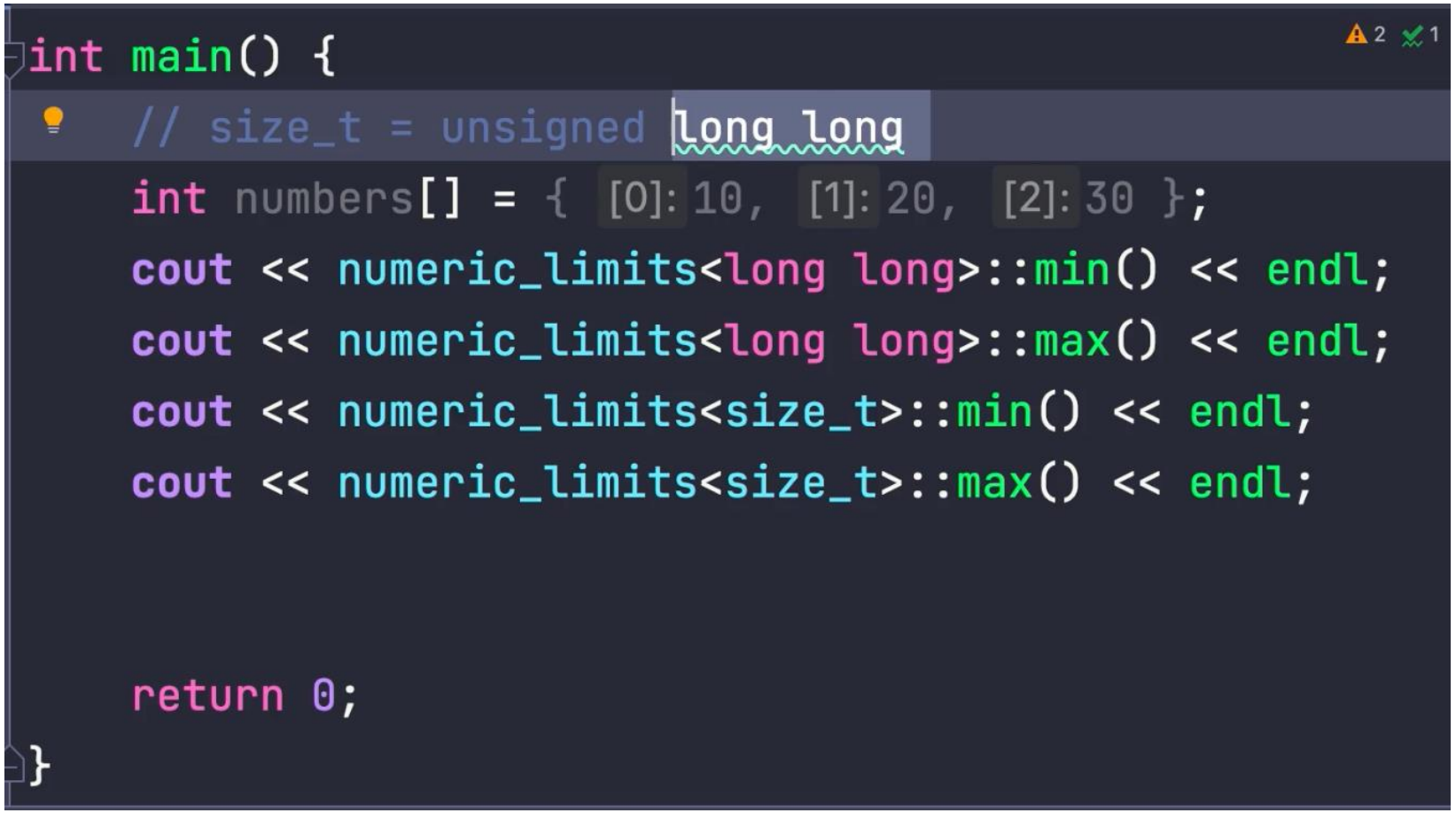
Passing Arrays to Functions

```cpp
#include <iostream>

using namespace std;

// int[] -> int*
void printNumbers(int numbers[], int size) {
    for (int i = 0; i < size; i++)
        cout << numbers[i];
}
int main() {
    int numbers[] = { [0]: 10, [1]: 20, [2]: 30 };
    printNumbers(numbers, size: size(numbers));

    return 0;
}
```

Solution

- We need to pass the size of the array too.

size_t()



- It is another data type.
- size_t is used in C++ primarily for representing the size of objects in memory.
- It can hold the size of the largest object the system can handle.
- It is an unsigned integer type that is guaranteed to be large enough to hold the size of any object.

Unpacking Arrays

```cpp
int main() {
    int values[3] = { [0]: 10, [1]: 20, [2]: 30 };
    auto [x : int , y : int , z : int ] = values;
    cout << x << ", " << y << ", " << z;


    return 0;
}
```

Equivalent

```cpp
//     int x = values[0];
//     int y = values[1];
//     int z = values[2];
```

- ❑ C++: structured binding
- ❑ JavaScript: destructuring
- ❑ Python: unpacking

Searching Arrays (Linear Search)

```cpp
#include <iostream>

using namespace std;

int find(int numbers[], int size, int target) {
    for (int i = 0; i < size; i++)
        if (numbers[i] == target)
            return i;
    return -1;
}

int main() {
    int numbers[] = { [0]: 10, [1]: 20, [2]: 30 };
    cout << find(numbers, size: size(numbers), target: 10);

    return 0;
}
```

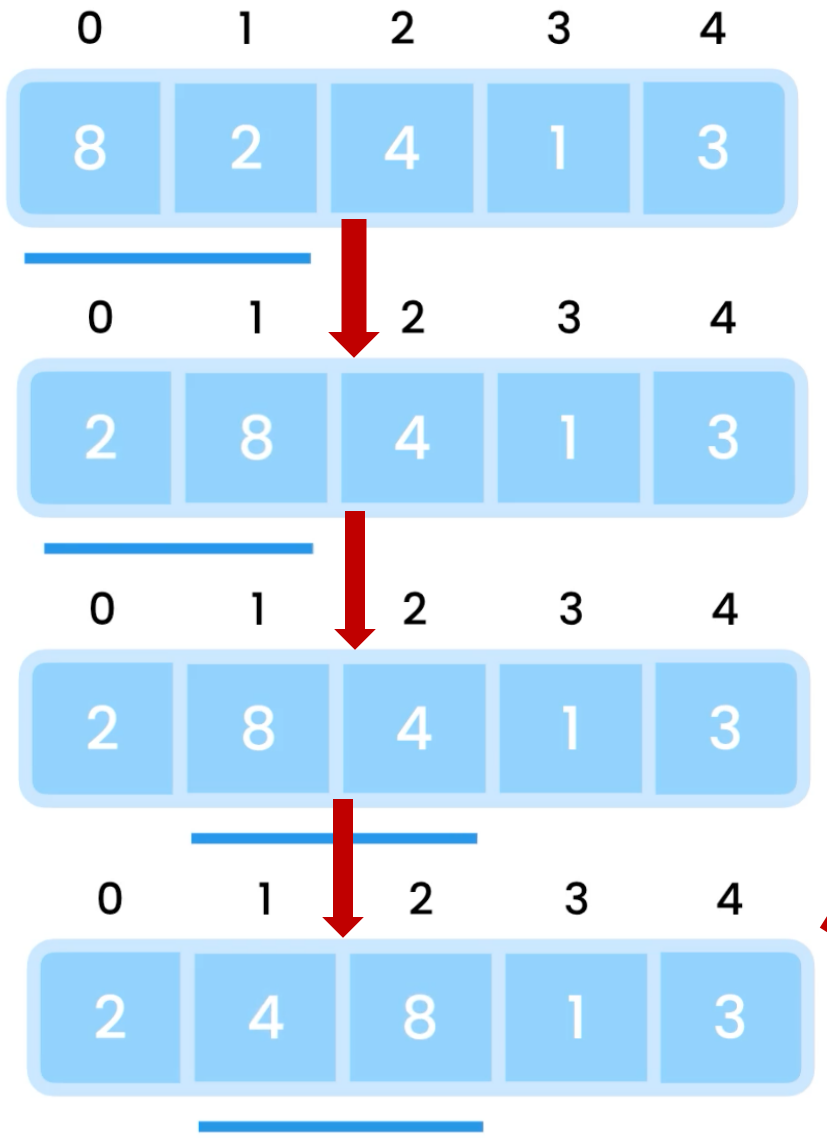
- Create a function for finding a value in an array.
- If the target value exists, return its index; otherwise return -1.

Sorting Arrays

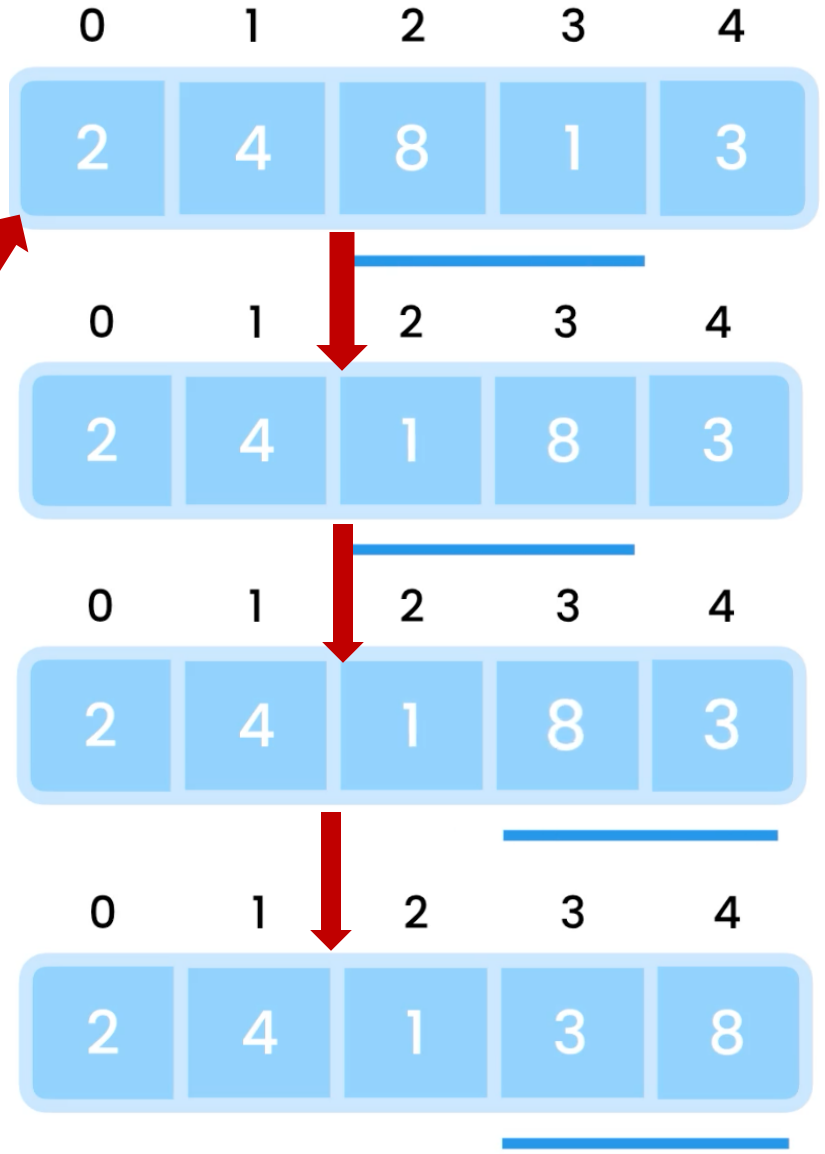
Common Algorithms

- ❑ Bubble sort
- ❑ Selection sort
- ❑ Insertion sort
- ❑ Merge sort
- ❑ Quick sort

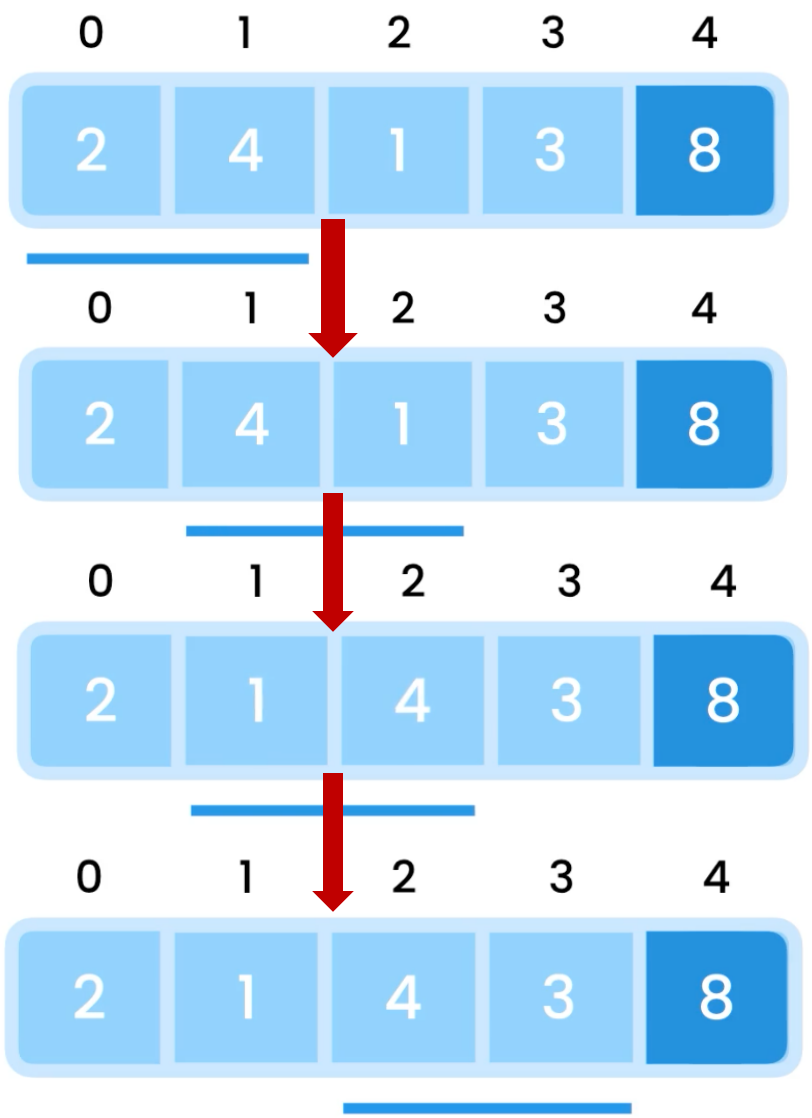
Bubble Sort



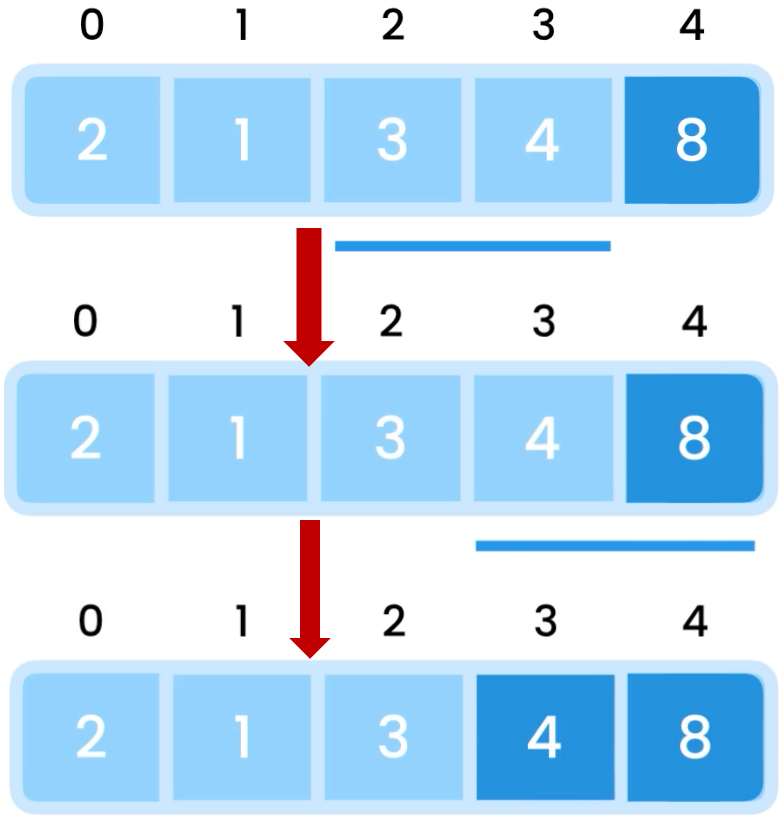
First iteration (first pass)



Bubble Sort

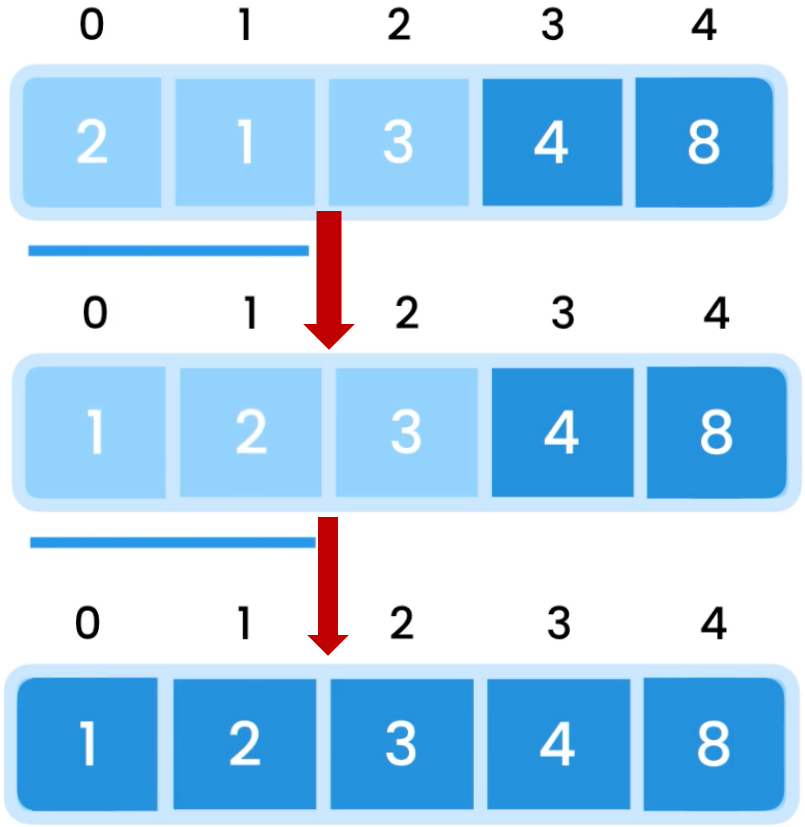


Second iteration (second pass)



Bubble Sort

Third iteration (third pass)



Bubble Sort

```cpp
#include <iostream>

using namespace std;

void swap(int numbers[], int i, int j) {
    int temp = numbers[i];
    numbers[i] = numbers[j];
    numbers[j] = temp;
}
```

```cpp
void sort(int numbers[], int size) {
    for (int pass = 0; pass < size; pass++) {
        for (int i = 1; i < size; i++)
            if (numbers[i] < numbers[i - 1])
                swap(numbers, i, j: i - 1);
    }
}
```

```cpp
int main() {
    int numbers[] = { [0]: 30, [1]: 20, [2]: 10 };
    sort(numbers, size: size(numbers));
    for (int number: numbers)
        cout << number << endl;

    return 0;
}
```

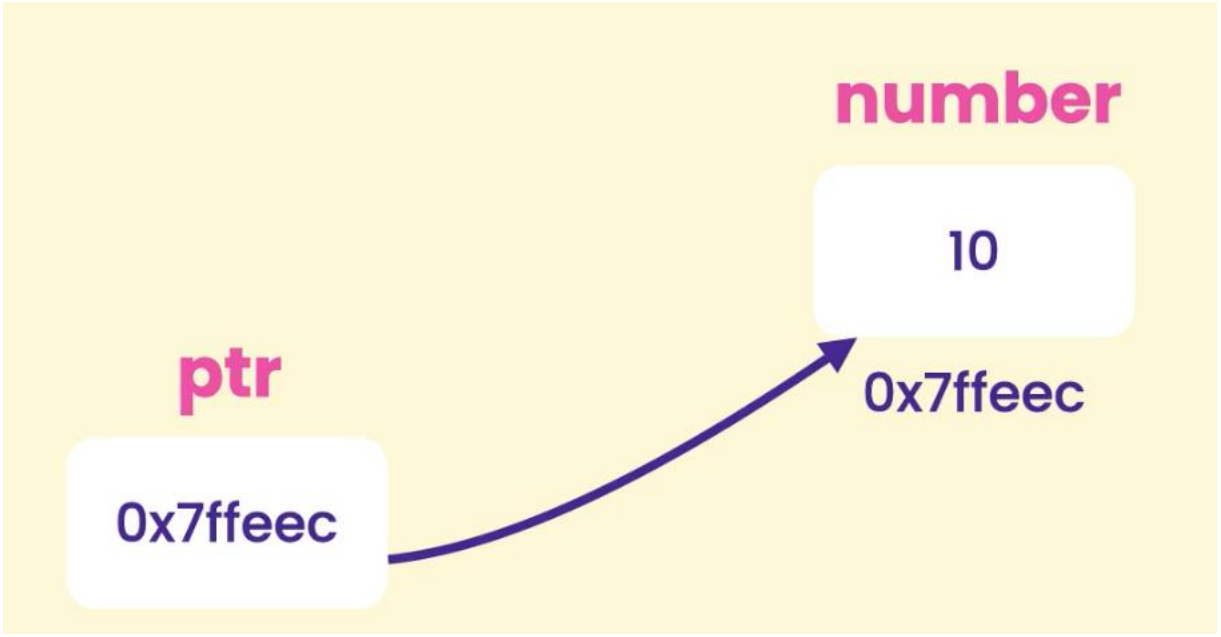
```cpp
int main() {
    const int rows = 2;
    const int columns = 3;

    // 2x3
    int matrix[rows][columns] = {
            [0]: { [0]: 11,  [1]: 12,  [2]: 13},
            [1]: { [0]: 21,  [1]: 22,  [2]: 23}
    };

    for (int row = 0; row < rows; row++) {
        for (int col = 0; col < columns; col++)
            cout << matrix[row][col] << endl;
    }

    return 0;
}
```

Multi-dimentional Arrays

```cpp
using namespace std;

const int rows = 2;
const int columns = 3;

void printMatrix(int matrix[rows][columns]) {
    for (int row = 0; row < rows; row++) {
        for (int col = 0; col < columns; col++)
            cout << matrix[row][col] << endl;
    }
}
int main() {
    // 2x3
    int matrix[rows][columns] = {
            [0]: { [0]: 11,  [1]: 12,  [2]: 13},
            [1]: { [0]: 21,  [1]: 22,  [2]: 23}
    };
    printMatrix(matrix);

    return 0;
}
```

Multi-dimensional Arrays

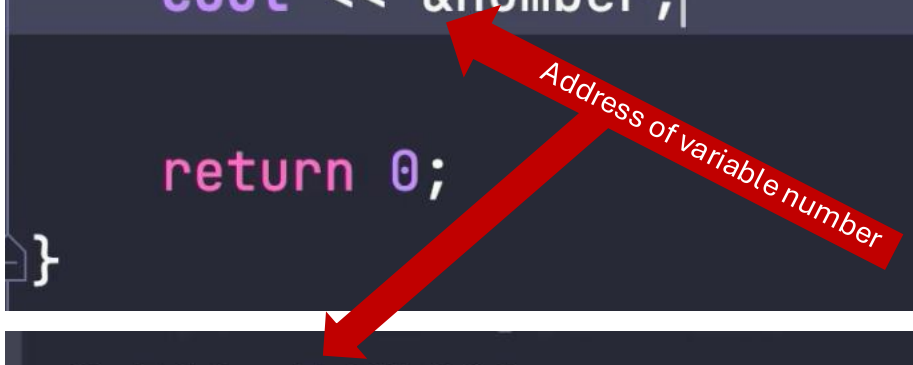
Pointers



- A pointer holds the address of another variable in memory.
- Reasons for using pointers
  - Efficiently passing large objects.
  - Dynamic memory allocation.
  - Enabling polymorphism.

Declaring and Using Pointers

```cpp
#include <iostream>

using namespace std;

int main() {
    int number = 10;
    cout << &number;

    return 0;
}
```

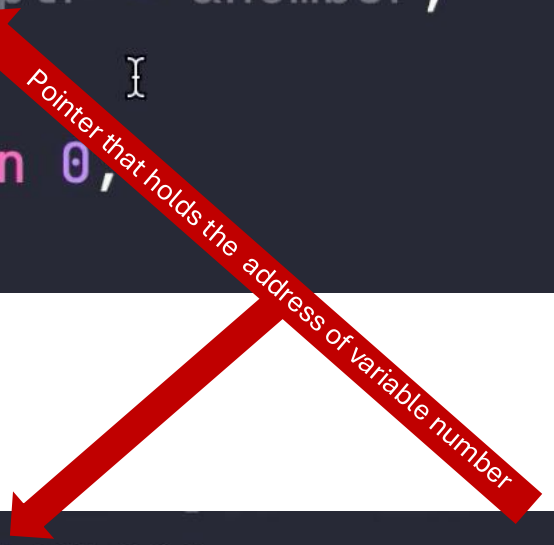



```
0x7ffee3d1b908
Process finished with exit code 0
```

- A pointer holds the address of another variable in memory.
- Output of the cout statement.

Declaring and Using Pointers

```
int main() {
    int number = 10;
    cout << &number;

    int* ptr = &number;

    return 0;
}
```



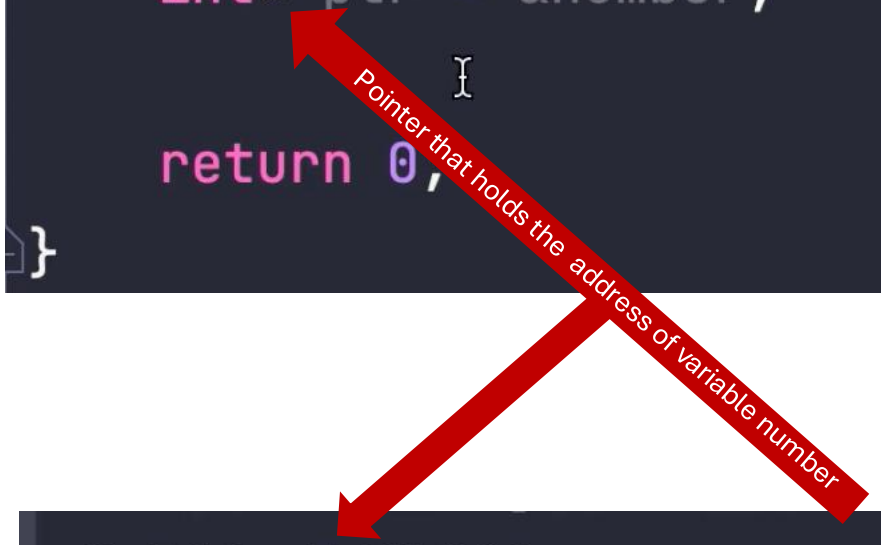

```
0x7ffee3d1b908
Process finished with exit code 0
```

- A pointer holds the address of another variable in memory.
- A * symbol after the type represents a pointer.
- Pointer type and viable type should match.

- Output of the cout statement.

Declaring and Using Pointers

```
int main() {
    int number = 10;
    cout << &number;

    int* ptr = &number;

    return 0;
}
```




```
0x7ffee3d1b908
Process finished with exit code 0
```

- A pointer holds the address of another variable in memory.
- A * symbol after the type represents a pointer.
- Pointer type and viable type should match.
- Pointers should be initialized. Otherwise, we might access a part of the memory that we are not supposed to.

- Output of the cout statement.

Declaring and Using Pointers

```
int main() {
    int number = 10;

    int* ptr;
    cout << ptr;

    return 0;
}
```

Pointer not initialized

- Pointers should be initialized. Otherwise, we might access a part of the memory that we are not supposed to.
- Program may terminate and give “memory access violation” error.

```
int main() {
    int number = 10;

    int* ptr = nullptr;
    cout << ptr;

    return 0;
}
```

Initialized to null pointer

Declaring and Using Pointers

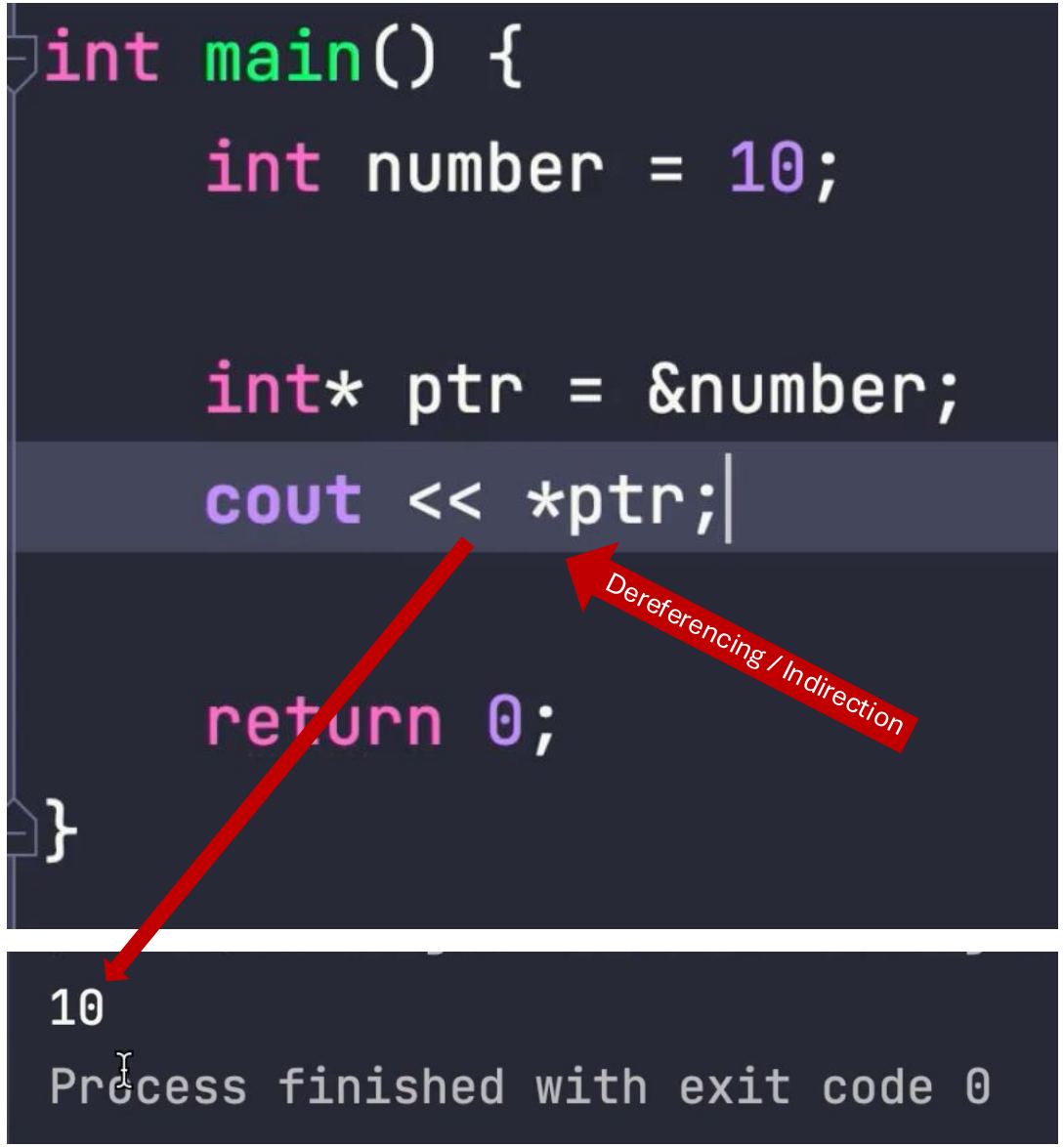
- Pointers should be initialized. Otherwise, we might access a part of the memory that we are not supposed to.
- Program may terminate and give “memory access violation” error.

```
int main() {
    int number = 10;

    int* ptr = nullptr;
    cout << ptr;

    return 0;
}
```

Initialized to null pointer

```
int main() {
    int number = 10;

    int* ptr = nullptr;
    if (ptr != nullptr)
    cout << ptr;

    return 0;
}
```

Pointers



- * in front of the pointer is called “dereferencing” or “indirection”.
- It is used to access the value that pointer points to.

- Output of the cout statement.

Pointers

```
int main() {
    int number = 10;

    // The address-of operator
    int* ptr = &number;
    // Indirection (de-referencing) operator
    *ptr = 20;

    cout << number;

    return 0;
}
```

- * in front of the pointer is called “dereferencing” or “indirection”.
- It is used to access the value that pointer points to.

Pointers

```c
int main() {
    int x = 10;
    int y = 20;
    int* ptr = &x;
    *ptr *= 2;
    ptr = &y;
    *ptr *= 3;

    return 0;
}
```

- **Exercise:** Determine the values printed on the terminal.

Pointers and Constants

Pointers and Constants

Case 1: Data is Constant

```
int main() {
    const int x = 10;
    int* ptr = &x;

    return 0;
}
```

- This declaration will give an error.
- Since the x is constant int, then the pointer should be constant int.
- Types should match.

```
int main() {
    const int x = 10;
    const int* ptr = &x;

    return 0;
}
```

Pointers and Constants

Case 1: Data is Constant

```
int main() {
    const int x = 10;
    const int* ptr = &x;

    *ptr = 20;

    return 0;
}
```

- *ptr = 20 statement will give a compilation error.
- The variable x is declared as constant and cannot be changed.

Pointers and Constants

Case 1: Data is Constant

```
int main() {
    const int x = 10;
    const int* ptr = &x;

    int y = 20;
    ptr = &y;

    return 0;
}
```

- *ptr = 20 statement will give a compilation error.
- The variable x is declared as constant and cannot be changed.
- The pointer ptr is not constant, it can be set the address of y later on.

Pointers and Constants

Case 2: Pointer is Constant

```
int main() {
    int x = 10;
    int* const ptr = &x;

    int y = 20;
    ptr = &y;

    return 0;
}
```

Compilation error

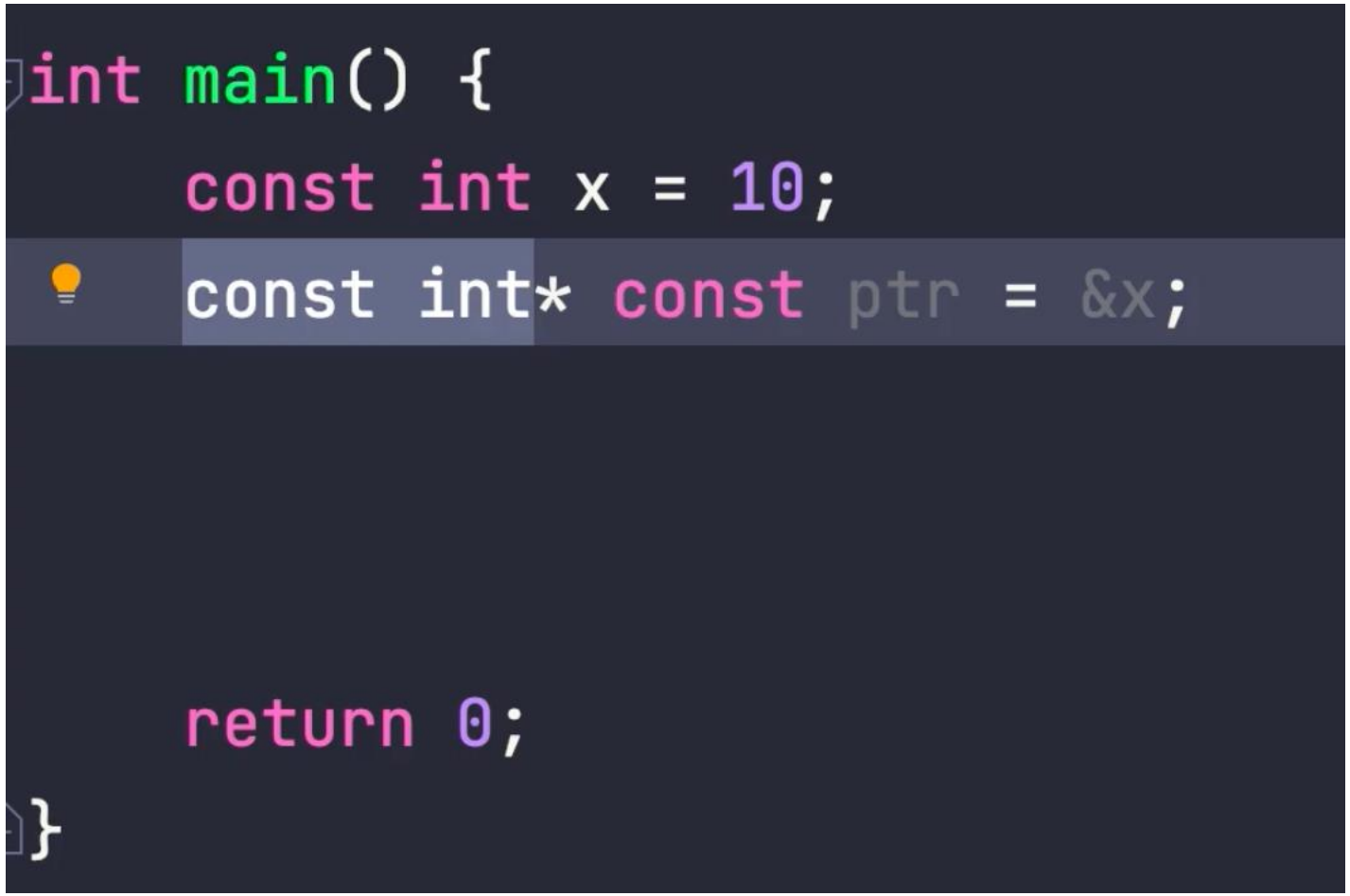
- The pointer ptr is constant.
- It cannot be changed.
- It has to be initialized during the declaration.

```
int main() {
    int x = 10;
    int* const ptr;

    return 0;
}
```

Compilation error

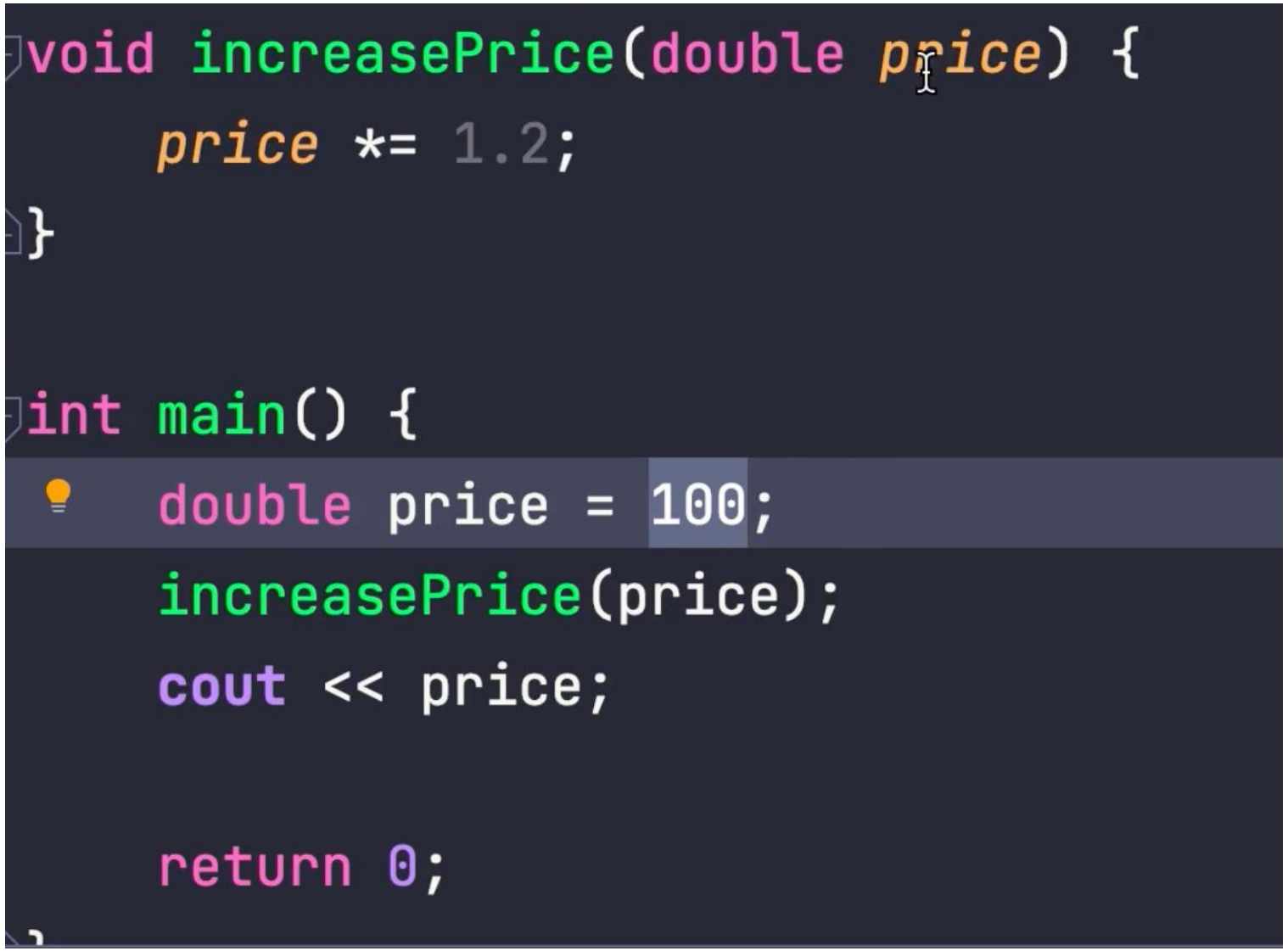
Pointers and Constants

Case 3: Both the Data and the Pointer are Constant



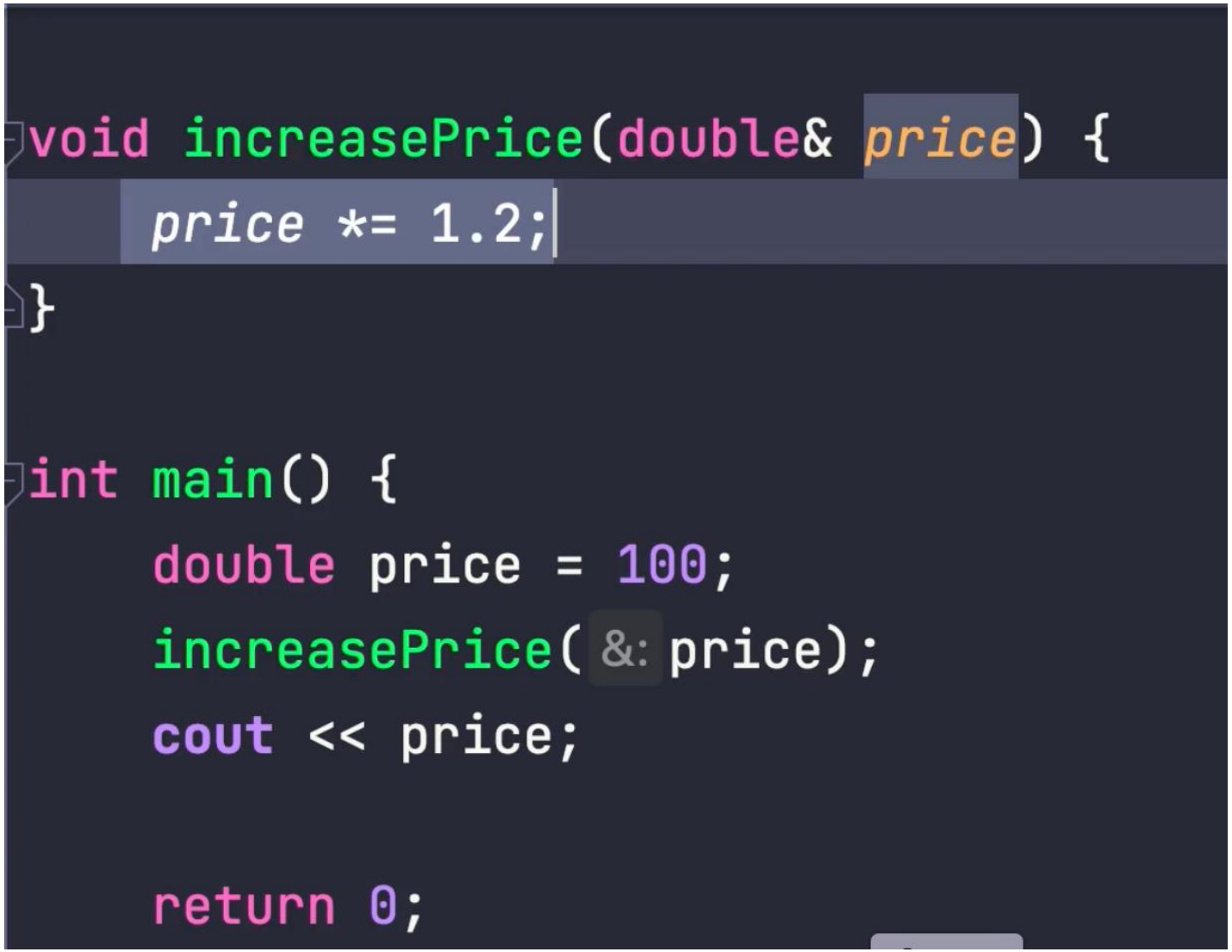
- A constant pointer, ptr, is pointing to a constant integer, x.

Passing Pointers to Functions



- The value of price is copied to the parameter price in the function.
- This is called-by-value.
- In the main function, the value of price does not change after the function call.

Passing Pointers to Functions



```
void increasePrice(double& price) {
    price *= 1.2;
}

int main() {
    double price = 100;
    increasePrice( &: price);
    cout << price;

    return 0;
```

- This is call-by-reference.
- The address of the price is passed to the argument.
- The change on the parameter price in the function changes the value in the main function.

Passing Pointers to Functions

```
void increasePrice(double* price) {
    *price *= 1.2;
}

int main() {
    double price = 100;
    increasePrice( price: &price);
    cout << price;

    return 0;
```

- This is using a pointer.
- Using call-by-reference is a better choice.

```cpp
#include <iostream>

using namespace std;

void swap(int* first, int* second) {
    int temp = *first;
    *first = *second;
    *second = temp;
}

int main() {
    int x = 10;
    int y = 20;
    swap( first: &x,  second: &y);
    cout << x << ", " << y;

    return 0;
}
```

Passing Pointers to Functions

EXERCISE

Implement the swap function for swapping two variables using pointers.

```cpp
void swap(int* first, int* second);
```

The Relationship Between Array and Pointers

```cpp
using namespace std;

int main() {
    int numbers[] = { [0]: 10, [1]: 20, [2]: 30 };
    cout << numbers;

    return 0;
}
```

- The array variable numbers is technically a pointer that points the address of the first element.

```
0x7ffeece758fc
Process finished with exit code 0
```

- Output of the cout statement.

The Relationship Between Array and Pointers

```
using namespace std;

    int numbers[] = { [0]: 10, [1]: 20, [2]: 30 };
    cout << *numbers;

    return 0;
}
```

- The array variable numbers is technically a pointer that points the address of the first element.

```
10
Process finished with exit code 0
```

- Output of the cout statement.

The Relationship Between Array and Pointers

```
using namespace std;

    int numbers[] = { [0]: 10, [1]: 20, [2]: 30 };
    int* ptr = numbers;
    cout << ptr;


    return 0;
}
```

- The array variable numbers is technically a pointer that points the address of the first element.

```
0x7ffeece758fc
Process finished with exit code 0
```

- Output of the cout statement.

The Relationship Between Array and Pointers

```
using namespace std;

    int numbers[] = { [0]: 10, [1]: 20, [2]: 30 };
    int* ptr = numbers;
    cout << *ptr;


    return 0;
}
```

- The array variable numbers is technically a pointer that points the address of the first element.

```
10
Process finished with exit code 0
```

- Output of the cout statement.

The Relationship Between Array and Pointers

```
using namespace std;

    int numbers[] = { [0]: 10, [1]: 20, [2]: 30 };
    int* ptr = numbers;
    cout << ptr[1];


    return 0;
}
```

- The array variable numbers is technically a pointer that points the address of the first element.

```
20
Process finished with exit code 0
```

- Output of the cout statement.

The Relationship Between Array and Pointers

```cpp
using namespace std;

void printNumbers(int numbers[]) {
    numbers[0] = 0;
}

int main() {
    int numbers[] = { [0]: 10, [1]: 20, [2]: 30 };
    printNumbers(numbers);
    cout << numbers[0];

    return 0;
}
```

- In C++, arrays as function parameters are always passed-by-reference for efficiency.

```
0
Process finished with exit code 0
```

- Output of the cout statement.

Pointer Arithmetic

```cpp
#include <iostream>

using namespace std;

int main() {
    int numbers[] = { [0]: 10, [1]: 20, [2]: 30 };
    int* ptr = numbers;
    ptr++;
    cout << *ptr;

    return 0;
}
```

- Pointer ptr points the first element of numbers.
- ptr++ points the second element.
- Its value is incremented by the size of the data type (by 4 in the case of int data type)

```
20
Process finished with exit code 0
```

- Output of the cout statement.

Pointer Arithmetic

```cpp
using namespace std;

int main() {
    int numbers[] = { [0]: 10, [1]: 20, [2]: 30 };
    int* ptr = numbers;
    cout << *(ptr + 1);
    cout << ptr[1];
    cout << numbers[1];

    return 0;
}
```

- All the expressions in cout statements are identical.

```
10
Process finished with exit code 0
```

- Output of the cout statement.

Pointer Arithmetic

```cpp
using namespace std;

int main() {
    int numbers[] = { [0]: 10, [1]: 20, [2]: 30 };
    int* ptr = numbers;
    cout << *(ptr + 1);
    cout << ptr[1];
    cout << numbers[1];

    return 0;
}
```

- All the expressions in cout statements are identical.
- The bracket notation ptr[1] is easy to use and follow.

```
20
Process finished with exit code 0
```

- Output of the cout statement.

Comparing Pointers

```
using namespace std;
int main() {
    int x = 10;
    int y = 20;

    int* ptrX = &x;
    int* ptrY = &x;

    if (ptrX == ptrY)
        cout << "Same";

    return 0;
```

```
Same
Process finished with exit code 0
```

- We are comparing the address of the variable x stored in pointers ptrX and ptrY.
- Output of the cout statement.

Comparing Pointers

```
using namespace std;
int main() {
    int x = 10;
    int y = 20;

    if (ptrX != nullptr)
        cout << *ptrX;

    return 0;
}
```

- It is a good practice to check if a pointer is a null pointer or not before using it.

```
10
Process finished with exit code 0
```

- Output of the cout statement.

Comparing Pointers

EXERCISE

Given this array:

```
int numbers[] = { 10, 20, 30 };
```

Create a pointer that points to the last element in this array.

Use a while loop to iterate over this array, and print the numbers in reverse order.

Comparing Pointers

```cpp
using namespace std;

int main() {
    int numbers[] = { [0]: 10, [1]: 20, [2]: 30 };
    int* ptr = &numbers[size(numbers) - 1];
    while (ptr >= numbers) {
        cout << *ptr << endl;
        ptr--;
    }

    return 0;
}
```

```
30
20
10

Process finished with exit code 0
```

EXERCISE

Given this array:

```
int numbers[] = { 10, 20, 30 };
```

Create a pointer that points to the last element in this array.

Use a while loop to iterate over this array, and print the numbers in reverse order.

- Output of the cout statement.

```cpp
using namespace std;
int main() {
    // Stack
    // int numbers[1000];
    int x;

    // Heap (Free Store)
    int* numbers = new int[10];
    int* number = new int;
    delete number;
    delete[] numbers;
    number = nullptr;
    numbers = nullptr;

    return 0;
}
```

Dynamic Memory Allocation

- Static variables are created in the stack memory location and deleted automatically once the function ends.
- Dynamic variables are created in the heap memory location and are not deleted automatically.
- User is responsible for the deletion of variables in the heap.
- If not properly deleted, a “memory leak” will occur and the program will crash.

Dynamically Resizing Arrays

```
using namespace std;
int main() {
    int capacity = 5;
    int* numbers = new int[capacity];
    int entries = 0;

    while (true) {
        cout << "Number: ";
        cin >> numbers[entries];
        if (cin.fail()) break;
        entries++;
        if (entries == capacity) {
            capacity *= 2;
            int* temp = new int[capacity];
            for (int i = 0; i < entries; i++)
                temp[i] = numbers[i];
            delete[] numbers;
            numbers = temp;
        }
    }
```

```
    for (int i = 0; i < entries; i++)
        cout << numbers[i] << endl;

    delete[] numbers;

    return 0;
}
```

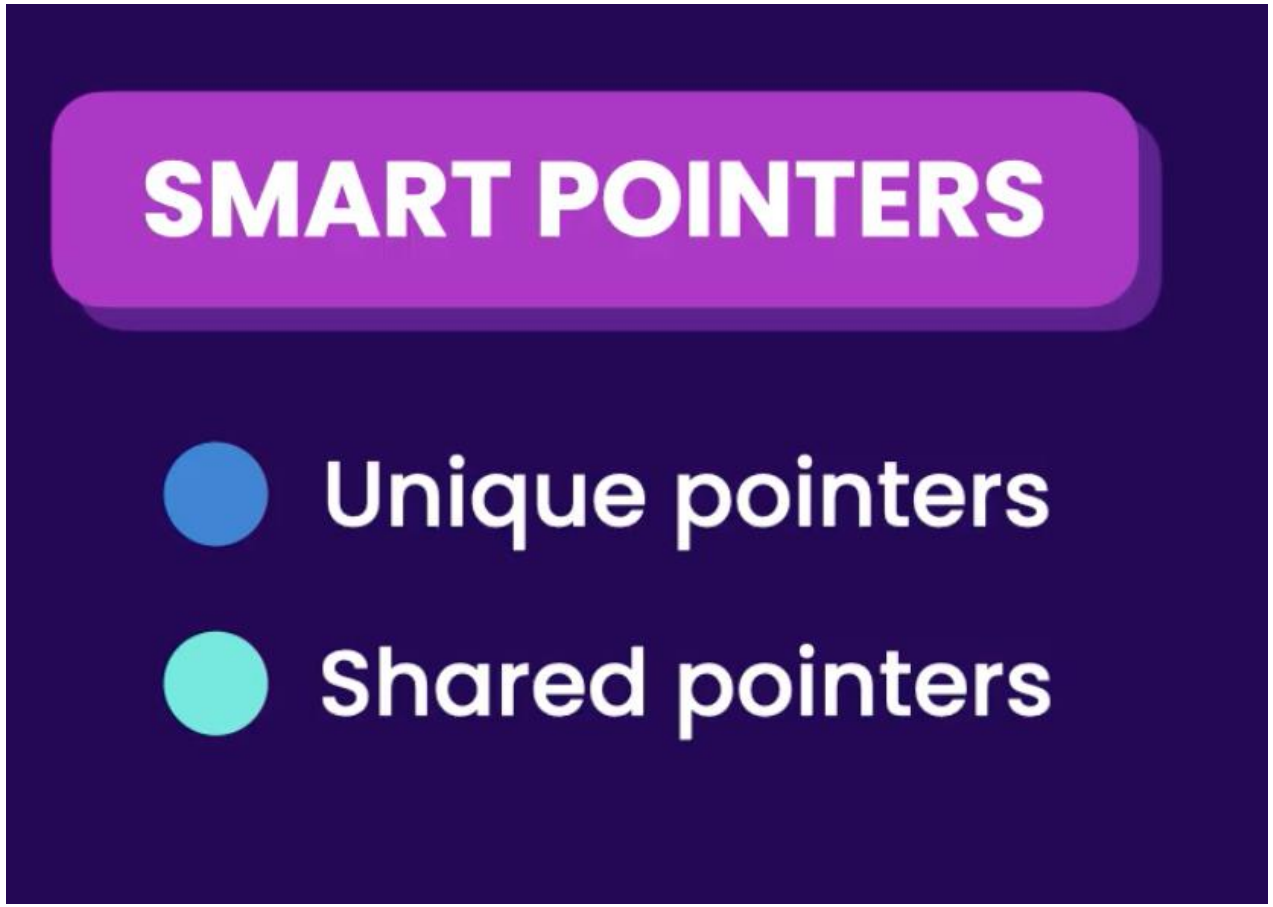
Smart Pointers

```
using namespace std;

int main() {
    int* x = new int;
    delete x;
    delete x;


    return 0;
}
```

- Deleting a pointer more than once will crash the program.
- With smart pointers, we do not need to worry about deleting them.

```
HelloWorld(18860,0x11a910e00) malloc: *** error for object 0x
HelloWorld(18860,0x11a910e00) malloc: *** set a breakpoint in
```

Smart Pointers



- Deleting a pointer more than once will crash the program.
- With smart pointers, we do not need to worry about deleting them.

Working with Unique Pointers

```cpp
#include <iostream>
#include <memory>

using namespace std;

int main() {
    unique_ptr<int> x( p: new int);
    cout << x;

    return 0;
}
```

- A unique pointers owns the memory location it points to.
- No two unique pointers can share the same memory location.
- **Limitation:** We cannot do arithmetic operations on unique pointers.
- unique_ptr< > is a generic class. It uses raw pointers.
- x is an object and an instance of the class.
- It contains a method to delete the pointer automatically.

Working with Unique Pointers

```cpp
#include <iostream>
#include <memory>

using namespace std;

int main() {
    unique_ptr<int> x( p: new int);
    unique_ptr<int> y = make_unique<int>();
    *x = 10;
    cout << *x;

    return 0;
}
```

- A unique pointers owns the memory location it points to.
- No two unique pointers can share the same memory location.
- **Limitation:** We cannot do arithmetic operations on unique pointers.
- unique_ptr< > is a generic class. It can work with different data types.
- It contains a method to delete the pointer automatically.
- make_unique<> function creates the unique pointer (Another way).

Working with Unique Pointers

```cpp
#include <iostream>
#include <memory>

using namespace std;

int main() {
    auto x : unique_ptr<int> = make_unique<int>();
    auto y : unique_ptr<int> = make_unique<int>();
    *x = 10;
    cout << *x;

    return 0;
}
```

- A unique pointers owns the memory location it points to.
- No two unique pointers can share the same memory location.
- **Limitation:** We cannot do arithmetic operations on unique pointers.
- unique_ptr< > is a generic class. It can work with different data types.
- It contains a method to delete the pointer automatically.
- **make_unique<>** function creates the unique pointer (Another way).
- **auto** function lets the compiler infer the type returned from the make_unique function.

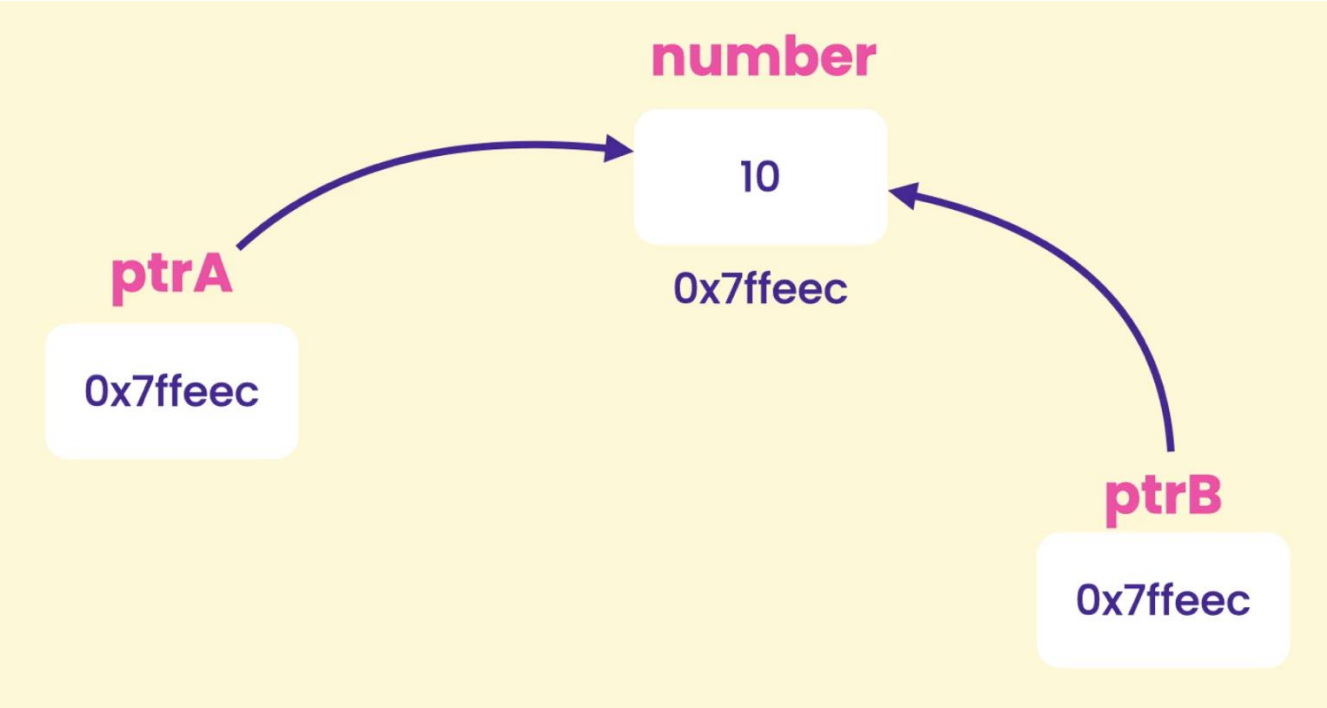
Working with Unique Pointers

```cpp
#include <iostream>
#include <memory>

using namespace std;
```

```cpp
int main() {
    auto numbers : unique_ptr<int[]> = make_unique<int[]>( n: 10);
    auto y : unique_ptr<int> = make_unique<int>();
    numbers[0] = 10;
    cout << numbers[0];

    return 0;
}
```

- A unique pointers owns the memory location it points to.
- No two unique pointers can share the same memory location.
- **Limitation:** We cannot do arithmetic operations on unique pointers.
- unique_ptr< > is a generic class. It can work with different data types.
- It contains a method to delete the pointer automatically.
- **make_unique<>** function creates the unique pointer (Another way).
- **auto** function lets the compiler infer the type returned from the make_unique function.

Working with Shared Pointers



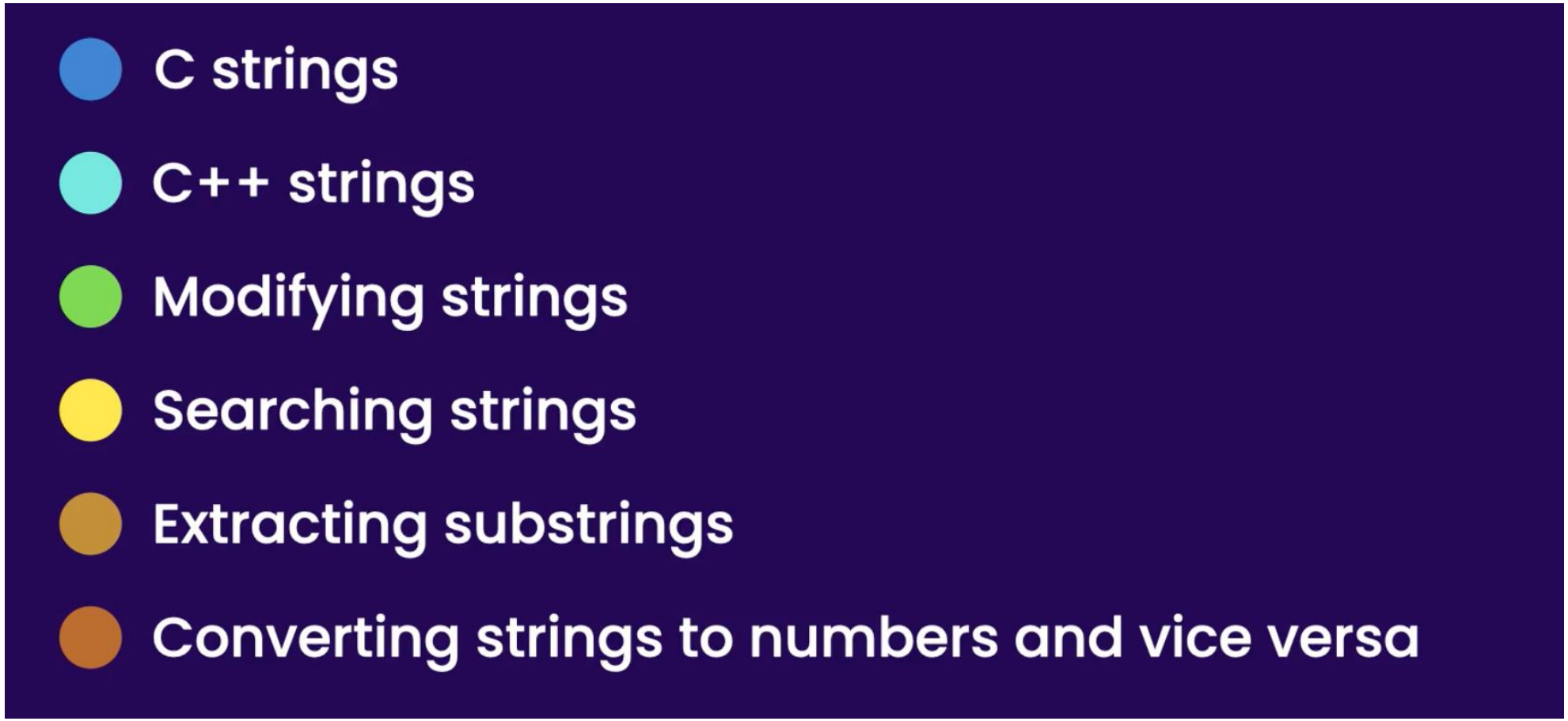
- Two pointers can share the same memory location.

Working with Shared Pointers

```cpp
#include <iostream>
#include <memory>

using namespace std;

int main() {
    auto x : shared_ptr<int> = make_shared<int>();
    *x = 10;

    shared_ptr<int> y(x);
    if (x == y)
        cout << "Equal";

    return 0;
}
```

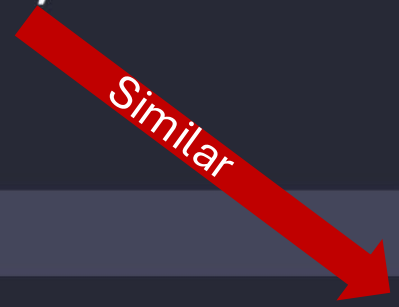
- Two pointers can share the same memory location.

Strings


C strings
C++ strings
Modifying strings
Searching strings
Extracting substrings
Converting strings to numbers and vice versa

C Strings

```cpp
#include <iostream>

using namespace std;

int main() {
    // Null terminator (\0)
    // String literal
    char name[5] = "Mosh";
    // Character literal
    name[0] = 'm';
    cout << name[0];

    return 0;
}
```




```
name[5] = {[0]: 'M', [1]: 'o', [2]: 's', [3]: 'h', [4]: '\0'}
```

- ❑ String type always adjusts its size automatically.
- ❑ Functions working on strings are in <string> but it is already included in <iostream>, so we do not need to include in the header.
- ❑ Functions working on C strings are in <cstring> file, but it is already included in <iostream>, so we do not need to include in the header.

```cpp
#include <iostream>

using namespace std;

int main() {
    // Null terminator (\0)
    // String literal
    char name[5] = "Mosh";
    // Character literal
    name[0] = 'm';
    cout << strlen( s: name);

    return 0;
}
```

C Strings

- **strlen ()** returns the length of the string.

C Strings

- **strcat ()** concatenates two strings.
- The first string should have enough space to hold the second string.

```cpp
#include <iostream>

using namespace std;

int main() {
    char name[50] = "Mosh";
    char lastName[] = "Hamedani";
    // Concatenate (combine)
    strcat( s1: name,  s2: lastName);
    cout << name;

    return 0;
}
```

```cpp
#include <iostream>

using namespace std;

int main() {
    char name[50] = "Mosh";
    char lastName[] = "Hamedani";
    strcpy( dst: name,  src: lastName);
    cout << name;

    return 0;
}
```

C Strings

- **strcopy ()** copies the second string into the first strings.
- The first string should have enough space to hold the second string.

```cpp
#include <iostream>

using namespace std;

int main() {
    char name[50] = "Mosh";
    char lastName[] = "Hamedani";
    if (strcmp(name, lastName) == 0)
        cout << "Equal";

    return 0;
}
```

C Strings

- **strcmp ()** compares two strings.
- If the value returned is zero, then the two strings are equal.
- If the first value comes before the second value alphabetically, then the function will return a negative value.
- If the first value comes after the second value alphabetically, then the function will return a positive value.

```cpp
#include <iostream>

using namespace std;
```


```cpp
#include <iostream>

using namespace std;
```


```cpp
int main() {
    string name = "Mosh";
    name[0] = 'm';
    cout << name;

    return 0;
}
```

C++ Strings

- **string class** internally uses character array and hides all the implementation complexity and details.
- Has many more functions than C strings.

```cpp
#include <iostream>

using namespace std;


int main() {
    string name = "Mosh";
    name[0] = 'm';
    cout << name.length();

    return 0;
}
```

C++ Strings

- **name** is an **object** (an **instance**) of **string class** and there are many functions that can be used.
- Functions are called with their name after a ”.” after the object name.
- The **length** function returns the size of the string.

```cpp
#include <iostream>

using namespace std;


int main() {
    string name = "Mosh";
    name[0] = 'm';
    name += " Hamedani"

    return 0;
}
```

C++ Strings

- **name** is an **object** (an **instance**) of **string class** and there are many functions that can be used.
- Functions are called with their name after a "." after the object name.
- **Example:** Appending a string to another string.
- Resizing the string array, name, is done automatically.

```cpp
#include <iostream>

using namespace std;

int main() {
    string name = "Mosh";
    string another = name;
    if (name == another)
        cout << "Same";

    return 0;
}
```

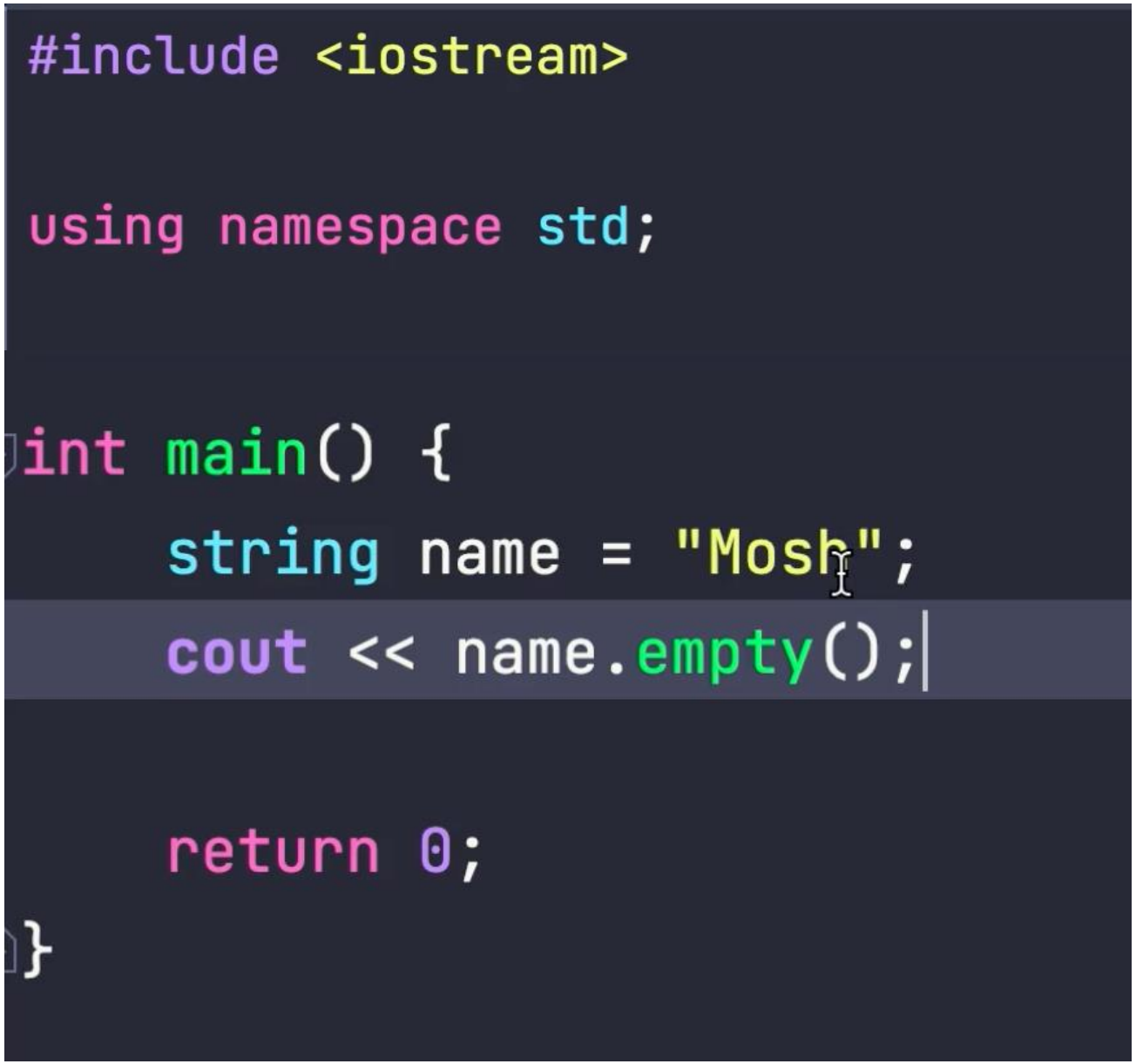
C++ Strings

- **name** is an **object** (an **instance**) of **string class** and there are many functions that can be used.
- Functions are called with their name after a ”.” after the object name.
- **Example:** Copying and comparing strings.

C++ Strings

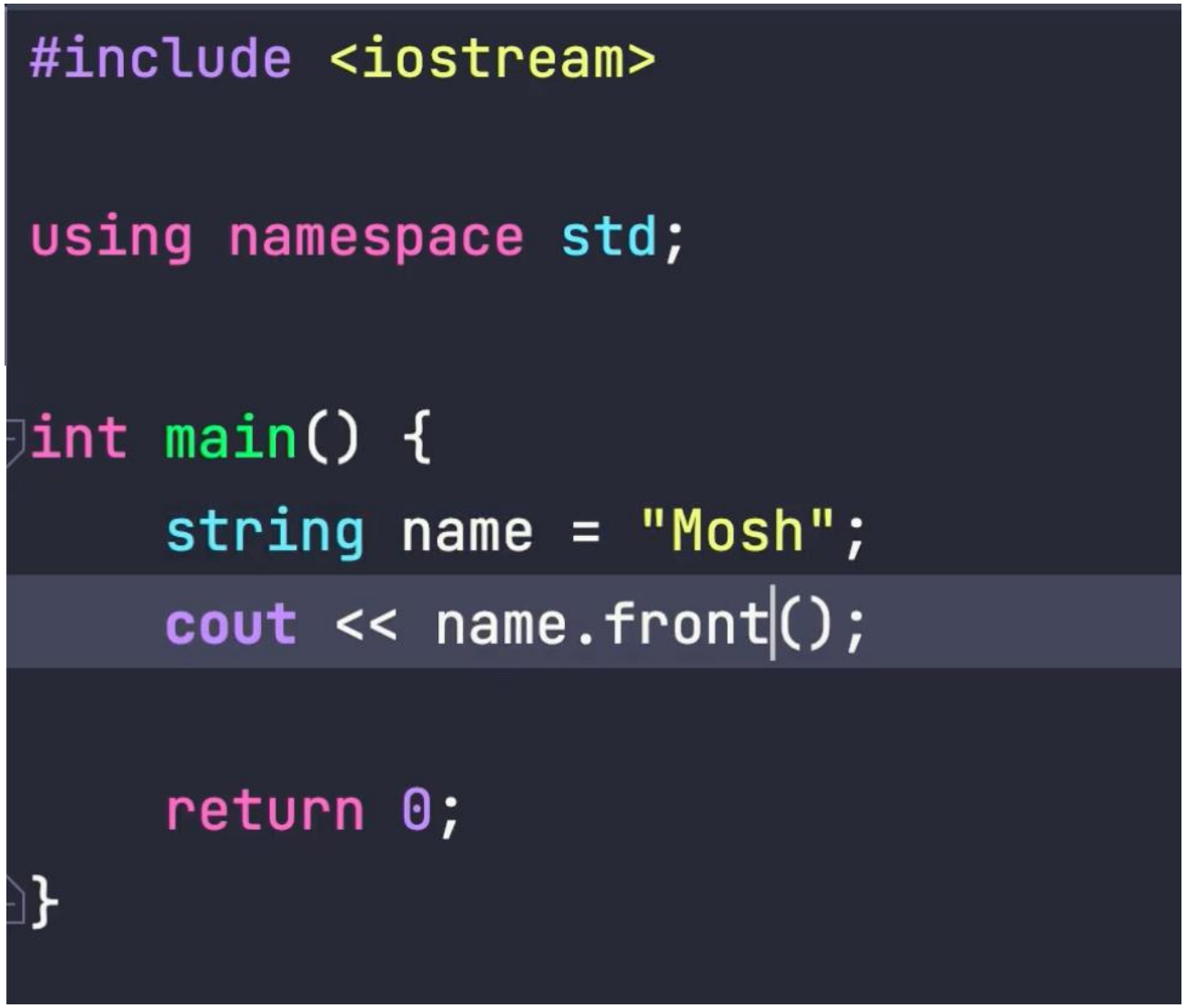
- **name** is an **object** (an **instance**) of **string class** and there are many functions that can be used.
- Functions are called with their name after a ”.” after the object name.

C++ Strings



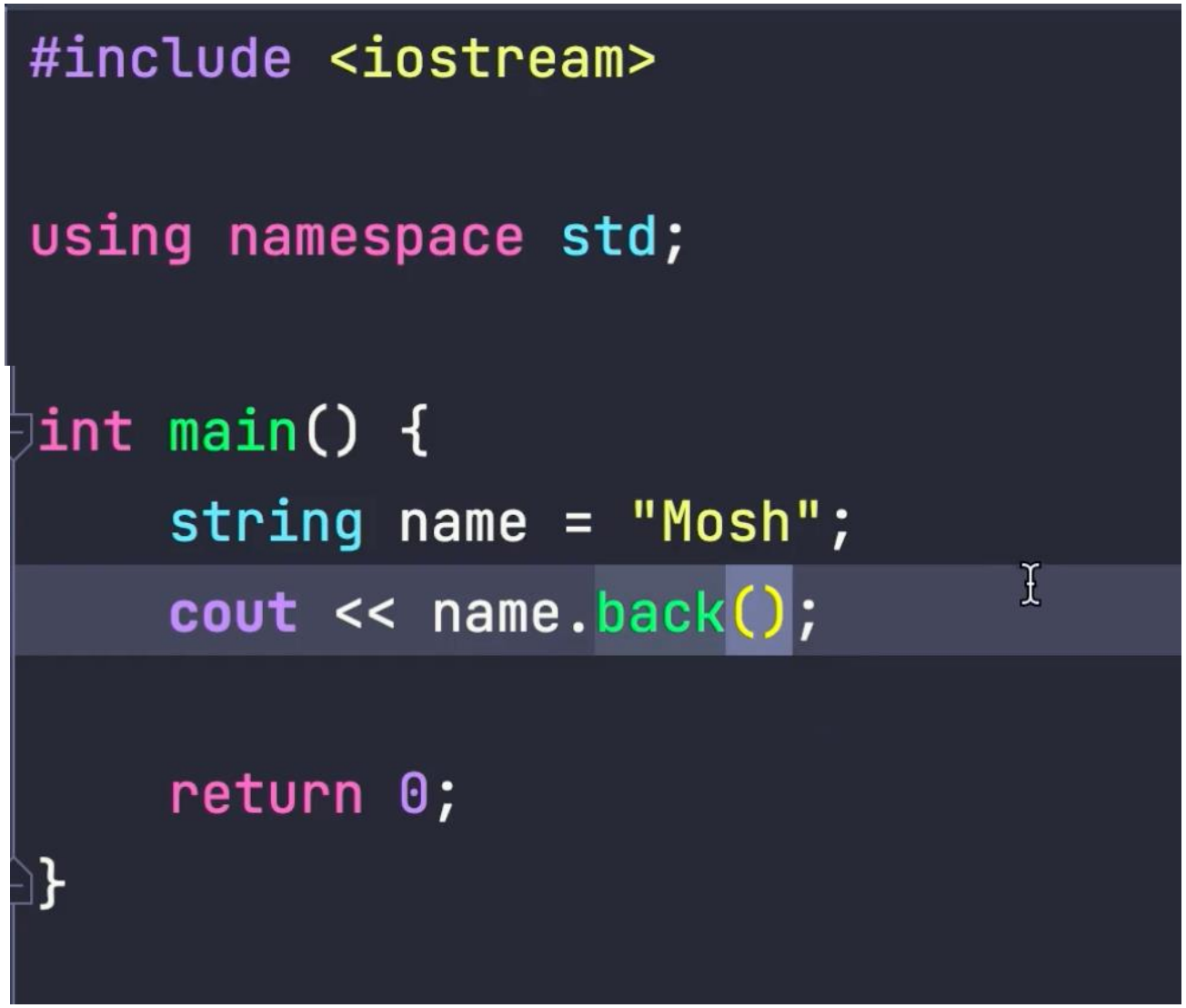
- **name** is an **object** (an **instance**) of **string class** and there are many functions that can be used.
- Functions are called with their name after a "." after the object name.
- Function **empty** returns **true (1)** if the string is empty, otherwise, returns false (0).

C++ Strings



- **name** is an **object** (an **instance**) of **string class** and there are many functions that can be used.
- Functions are called with their name after a ”.” after the object name.
- Function **front** returns the **first** character of the string.

C++ Strings



- **name** is an **object** (an **instance**) of **string class** and there are many functions that can be used.
- Functions are called with their name after a ”.” after the object name.
- Function **back** returns the **last** character of the string.

Modifying Strings

- **append** function attaches the argument string to the object string that makes the call.

Modifying Strings

```cpp
#include <iostream>

using namespace std;

int main() {
    string name = "Mosh";
    name.insert( pos: 0,  s: "I am ");
    cout << name;

    return 0;
}
```

- **insert** function inserts the argument string to the object string that makes the call starting from the specified position.

Modifying Strings

```cpp
#include <iostream>

using namespace std;

int main() {
    string name = "Mosh";
    name.erase( pos: 0,  n: 2);
    cout << name;

    return 0;
}
```

- **erase** function deletes a number of characters starting from the specified position.

```cpp
#include <iostream>

using namespace std;

int main() {
    string name = "Mosh";
    name.clear();
    name = "";
    cout << name;

    return 0;
}
```

Modifying Strings

- **clear** function empties the string.
- It is same as name = “”.

Modifying Strings

```cpp
#include <iostream>

using namespace std;

int main() {
    string name = "Mosh";
    name.replace( pos: 0,  n1: 2,  s: "MO");
    cout << name;

    return 0;
}
```

- **replace** function replaces a number of characters with specified characters, starting from the specified position.

Searching Strings

```cpp
#include <iostream>

using namespace std;

int main() {
    string name = "Mosh Hamedani";
    cout << name.find( c: 'a');

    return 0;
}
```

- The function **find** searches the content in the string starting from the specified position.
- If no position is specified to start, then it starts from the beginning.

```
6
Process finished with exit code 0
```

- Output of the cout statement.

Searching Strings

```cpp
#include <iostream>

using namespace std;

int main() {
    string name = "Mosh Hamedani";
    cout << name.find( c: 'a', pos: 7);

    return 0;
}
```

- The function **find** searches the content in the string starting from the specified position.
- If no position is specified to start, then it starts from the beginning.

```
10
Process finished with exit code 0
```

- Output of the cout statement.

Searching Strings

```cpp
#include <iostream>

using namespace std;

int main() {
    string name = "Mosh Hamedani";
    if (name.find( c: 'A') == -1)
        cout << "Doesn't Exist!";

    return 0;
}
```

- The function **find** searches the content in the string starting from the specified position.
- If no position is specified to start, then it starts from the beginning.

Searching Strings

```cpp
#include <iostream>

using namespace std;

int main() {
    string name = "Mosh Hamedani";
    cout << name.rfind( c: 'a');

    return 0;
}
```

- The function **rfind** searches the content in the string starting from the last position.

```
10
Process finished with exit code 0
```

- Output of the cout statement.

Searching Strings

```cpp
#include <iostream>

using namespace std;

int main() {
    string name = "Mosh; Hamedani";
    cout << name.find_first_of( s: ",.;");

    return 0;
}
```

```
4
Process finished with exit code 0
```

- The function **find_first_of** returns the first position of any occurrence of the characters in the argument string.
- The function **find_last_of** returns the last position of any occurrence of the characters in the argument string.
- Output of the cout statement.

```cpp
#include <iostream>

using namespace std;

int main() {
    string name = "Mosh Hamedani";
    string copy = name.substr();
    name = "";
    cout << copy;

    return 0;
}
```

Extracting Substrings

- The function **substr** without any parameter returns the whole string.

Extracting Substrings

```cpp
#include <iostream>

using namespace std;

int main() {
    string name = "Mosh Hamedani";
    string copy = name.substr( pos: 5,  n: 3);
    cout << copy;

    return 0;
}
```

- The function **substr** returns the substring from the starting position specified in the first argument and the length specified in the second argument.

```
Ham
Process finished with exit code 0
```

- Output of the cout statement.

Extracting Substrings

- **Example:** Extracting first and last name.

```cpp
#include <iostream>

using namespace std;

int main() {
    string name = "Mosh Smith Hamedani";
    auto index = name.rfind( c: ' ');
    string firstName = name.substr( pos: 0, n: index);
    string lastName = name.substr( pos: index + 1);
    cout << "(" << firstName << ")";
    cout << "(" << lastName << ")";

    return 0;
}
```

Working with Characters

```cpp
#include <iostream>

using namespace std;

int main() {
    string name = "Mosh Hamedani";
    islower( c: name[0])

    return 0;
}
```

- **islower:** Checks if the character is lower case.

Working with Characters

```cpp
#include <iostream>

using namespace std;

int main() {
    string name = "Mosh Hamedani";
    cout << isupper( c: name[0]);

    return 0;
}
```

- **isupper:** Checks if the character is upper case.

```cpp
#include <iostream>

using namespace std;

int main() {
    string name = "Mosh Hamedani";
    cout << isalpha( c: name[0]);

    return 0;
}
```

Working with Characters

- **isalpha:** Return true (1) if character is alphabetic.

Working with Characters

```cpp
#include <iostream>

using namespace std;

int main() {
    string name = "1Mosh Hamedani";
    cout << isdigit( c: name[0]);

    return 0;
}
```

- **isdigit:** Return true (1) if character is a digit.

Working with Characters

```cpp
#include <iostream>

using namespace std;

int main() {
    string name = " Mosh Hamedani";
    cout << isspace( c: name[0]);

    return 0;
}
```

- **isspace:** Return true (1) if character is a space.

Working with Characters

- **toupper:** Converts character to upper case.
- If the character is a non-alphabetic character, then the character is returned.

Working with Characters

```cpp
#include <iostream>

using namespace std;

int main() {
    string name = " Mosh Hamedani";
    cout << (char) tolower( c: 'A');

    return 0;
}
```

- **tolower:** Converts character to lower case.

String-Numeric Conversion Functions

```cpp
#include <iostream>

using namespace std;

int main() {
    double price = stod( str: "19.99");
    cout << price;

    return 0;
}
```

```
19.99
Process finished with exit code 0
```

- **stod:** Converts a nuber in a string to a double number.

- Output of the cout statement.

String-Numeric Conversion Functions

```cpp
#include <iostream>

using namespace std;

int main() {
    double price = stod( str: "19.x99");
    cout << price;

    return 0;
}
```

```
19
Process finished with exit code 0
```

- **stod:** Converts a number in a string to a double number.

- Output of the cout statement.

String-Numeric Conversion Functions

```cpp
#include <iostream>

using namespace std;

int main() {
    double price = stod( str: "x19.99");
    cout << price;

    return 0;
}
```

- **stod:** Converts a number in a string to a double number.
- If the string starts with a non-digit, then the program will crash with an exception.
  - Output of the cout statement.

```
libc++abi: terminating with uncaught exception of type std::i
```

String-Numeric Conversion Functions

```cpp
#include <iostream>

using namespace std;

int main() {
    string str = to_string( val: 19);
    cout << str;

    return 0;
}
```

- **to_string:** Converts a number into a string.

```
19
Process finished with exit code 0
```

- Output of the cout statement.

Escape Sequences

```cpp
#include <iostream>

using namespace std;

int main() {
    string str = "c:\\my folder";
    cout << str;

    return 0;
}
```

```
c:\my folder
Process finished with exit code 0
```

- \ character is used to include \ (or “) in a string.

- Output of the cout statement.

Escape Sequences

```cpp
#include <iostream>

using namespace std;

int main() {
    string str = "\"Hello World\"";
    cout << str;

    return 0;
}
```

- \ character is used to include \ (or “) in a string.

```
"Hello World"
Process finished with exit code 0
```

- Output of the cout statement.

Escape Sequences

```cpp
#include <iostream>

using namespace std;

int main() {
    char ch = '\'';
    string str = "'Hello World'";
    cout << ch;

    return 0;
}
```

```
'

Process finished with exit code 0
```

- \ character is used to include \ (or “) in a string.
- \ is not needed for ‘ character in a string.
- \ is needed for ‘ character in a **char array**.

- Output of the cout statement.

Escape Sequences

```cpp
#include <iostream>

using namespace std;

int main() {
    string str = "Hello\nWorld";
    cout << str;

    return 0;
}
```

- **\n** puts a new line character into the string.

```
Hello
World
Process finished with exit code 0
```

- Output of the cout statement.

Escape Sequences

```cpp
#include <iostream>

using namespace std;

int main() {
    string str = "Hello\tWorld";
    cout << str;

    return 0;
}
```

- **\t** puts a tab into the string.

```
Hello	World
Process finished with exit code 0
```

- Output of the cout statement.

Raw Strings

```cpp
#include <iostream>

using namespace std;

int main() {
    string str = "\"c:\\folderA\\folderB\\file.txt\"";
    cout << str;

    return 0;
}
```

Using raw string

```cpp
int main() {
    string str = R"("c:\folderA\folderB\file.txt")";
    cout << str;

    return 0;
}
```

- We do not need to use escape sequences for special characters if we use raw strings.