SWEG2102 Fall 2026

Fundamentals of Programming II

Lecture 03

Modular Programming (Part II)
Advanced Functions

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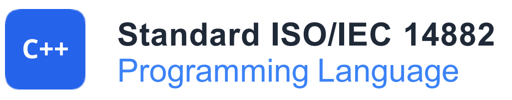
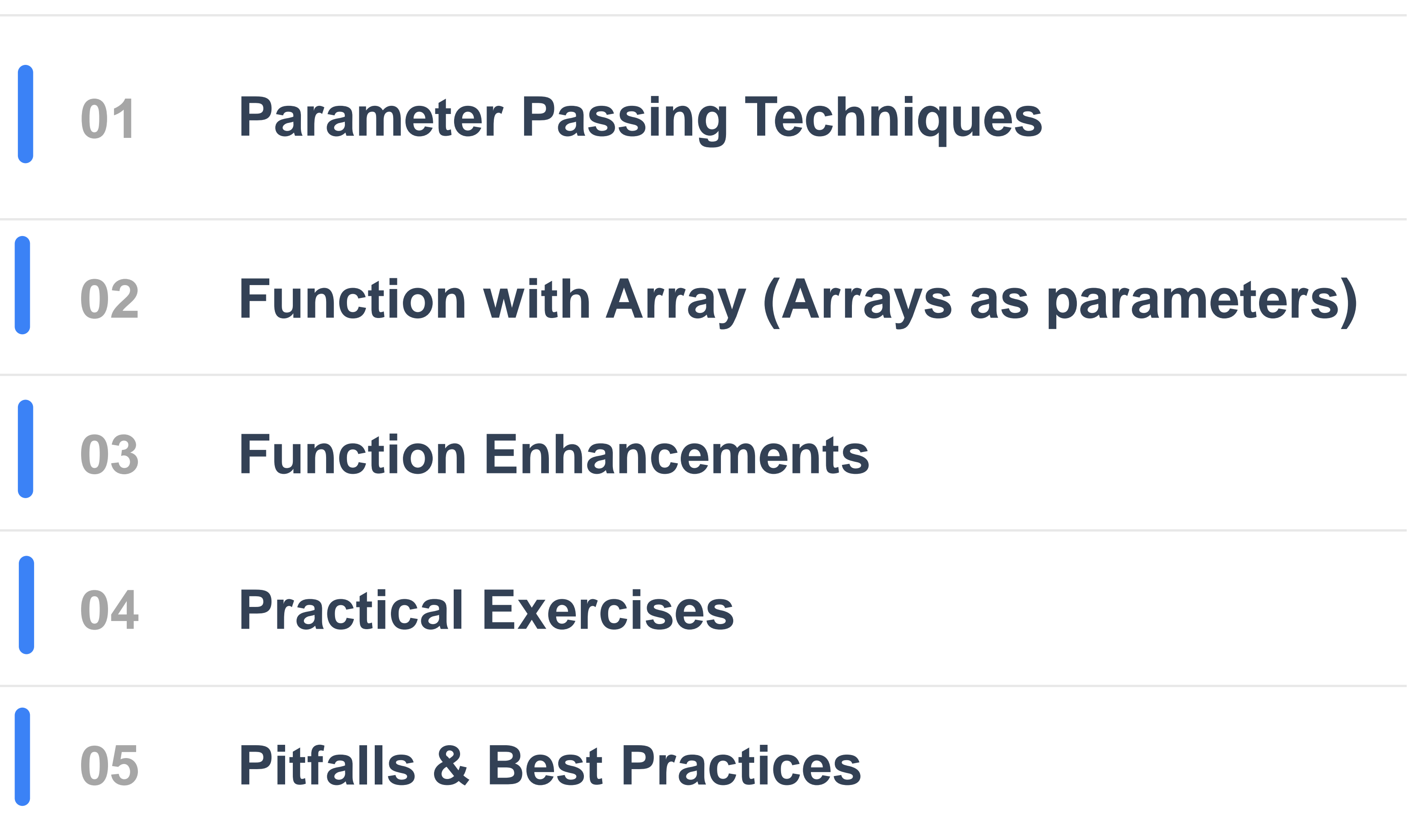


Outline

Topics Covered



Learning Objectives

By the end of this lecture, you will be able to:

- Explain and differentiate parameter passing techniques.
- Use arrays as function parameters correctly.
- Apply function enhancements for cleaner and more efficient code.
- Identify and avoid common function pitfalls following best practices.
- Build small programs using both basic and advanced function concepts.

Parameter Passing Techniques

1. Parameter Passing

Core Concept

Parameter passing is the mechanism used in programming to transfer **data (arguments)** from the calling function to the called function.

Parameters

- Refers to the variables listed in the function definition/declaration
- They define what kind of data the function expects (placeholders).
- Also called **Formal Parameters**

Arguments

- Refers to the actual values passed to the function when it is called
- Provide actual data, not a placeholder
- Also referred as **Actual Parameters**

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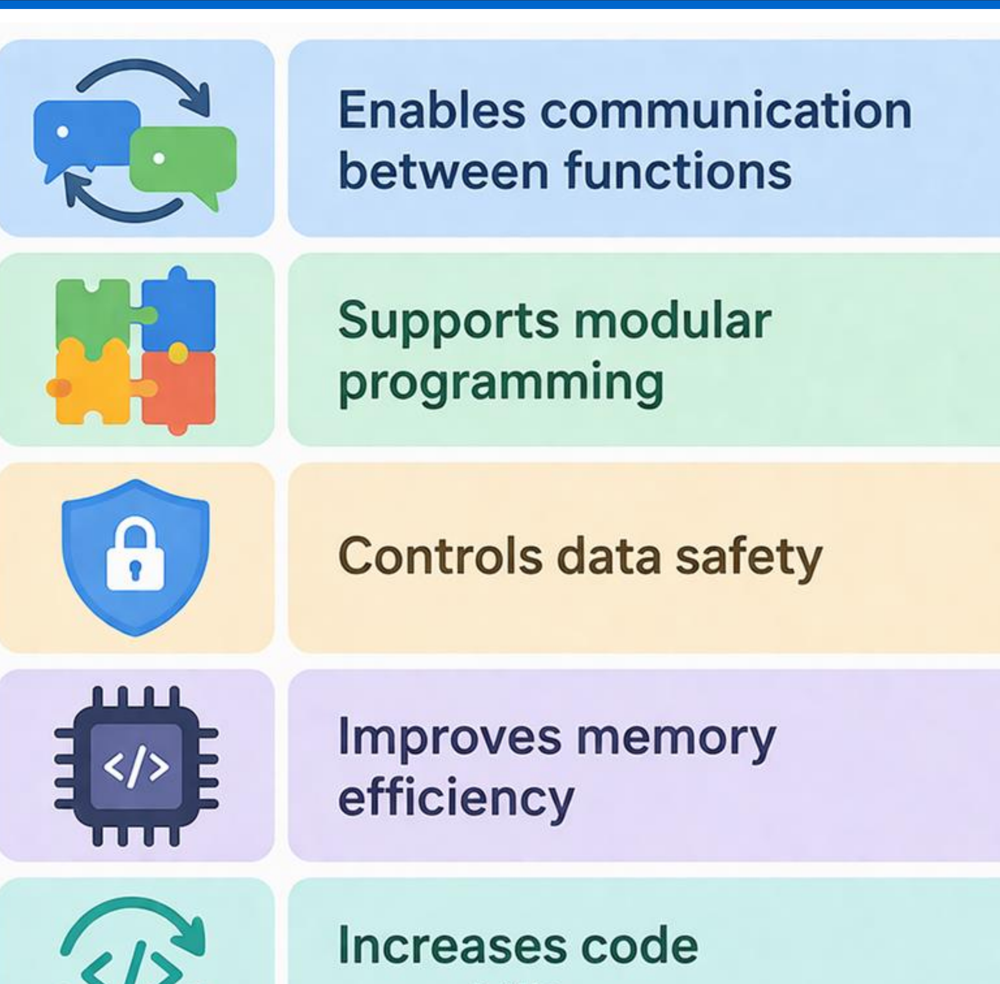
Why Parameter Passing is Important?



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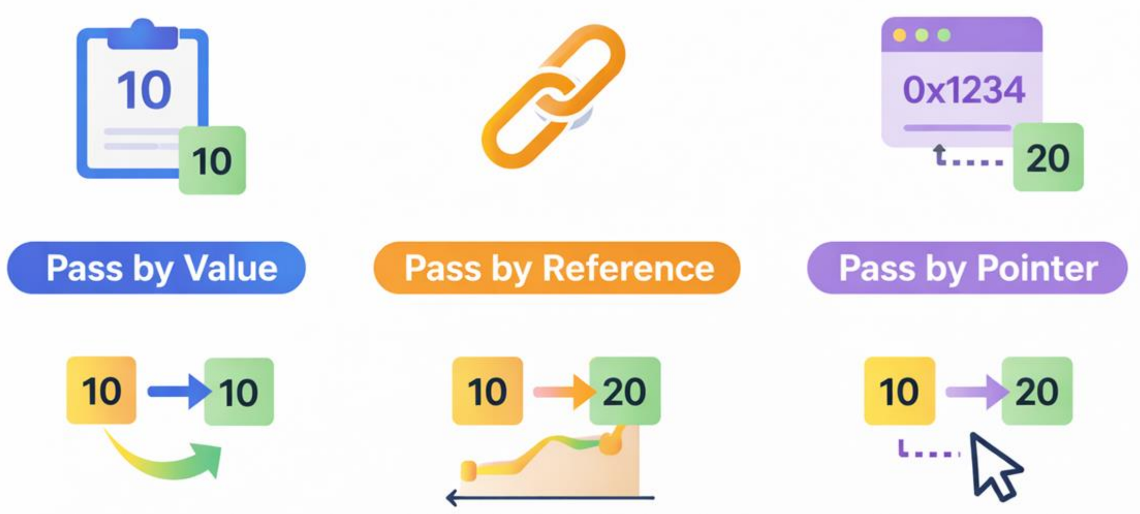
Parameter Passing Techniques

- There are **three common techniques** of parameter passing.
- The choice of parameter passing technique determines **how memory is managed** and whether the o**riginal data can be modified**.
- In other terms, it also affects **program performance and data safety**.

Three main techniques



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1.1. Pass by Value

Core Concept

- A copy of the actual argument is passed to the function and created in the formal parameter's memory location
  - ✓ The function works entirely on this **copy**
  - ✓ Original variable remains unchanged
- 👉 Safe but memory-consuming for large data

Syntax & Example (C++)

```
void update (int x) {
      x = x + 10;
}
int main() {
            int a = 5;
            update (a);
            cout << a;          // Output: 5
 }
```

When to Use and not

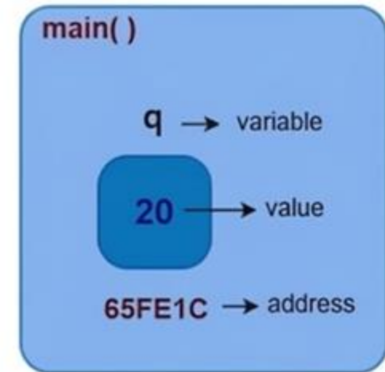
- Small Primitives data types
- Read-Only Data - When original data must be protected
- Avoid for large objects (inefficient copying)

Cont’d

Memory Visualization

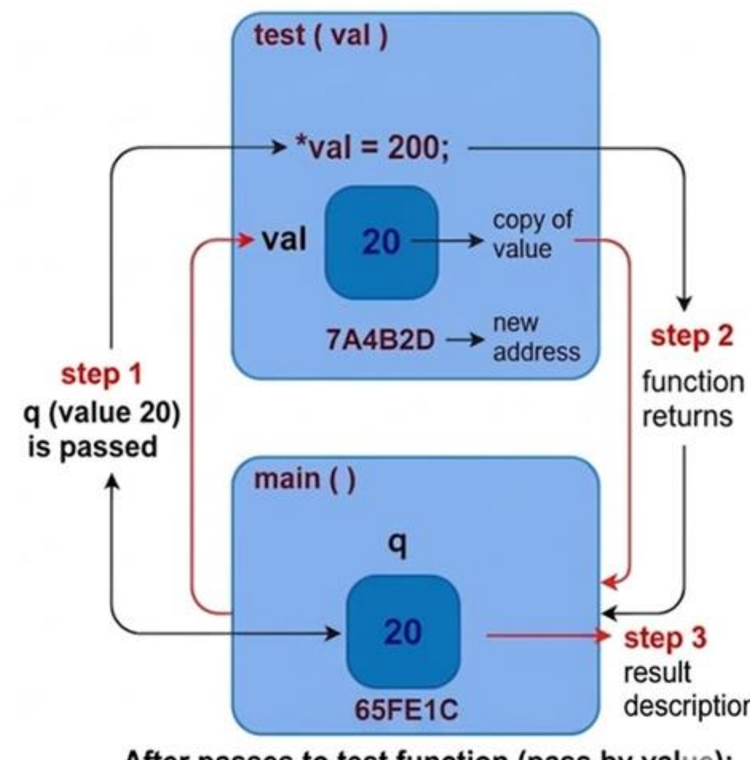
```cpp
#include <iostream>
using namespace std;

// Pass by Value function
void test(int val) {
    cout<<"Inside function: ";
    cout<< val<<endl;

    val = 200; //changes only local copy

    cout<<"After change: ";
    cout<< val<<endl;
}

int main() {
    int q = 20;

    cout<<"Before function call: ";
    cout<< q << endl;

    test(q); // original value is passed

    cout<<"After function call: ";
    cout<<q<<"(unchanged)"<< endl;

    return 0;
}
```

Before calling the function



Initial value of q = 20

After calling the function



After passes to test function (pass by value):
Inside test function: **val = 200** (modification complete)
Back in main: **q = 20** (q is unchanged)

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1.2. Pass by Reference

Core Concept

- The function receives an **alias (reference or another name)** for the original variable.
  - ✓ No copy is created
  - ✓ Both variables refer to **the same memory** location and no new memory is allocated
  - ✓ Changes **directly affect** original variable

When to Use and not

- When function must modify original variable
- To pass large objects efficiently without copying
- When returning multiple outputs indirectly

Syntax & Example (C++)

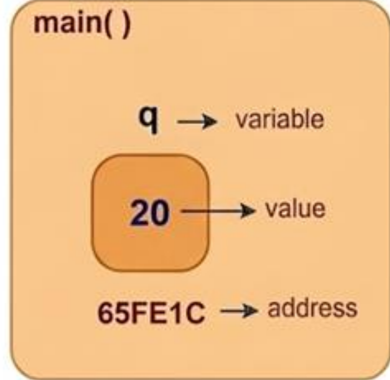
```
// '&' denotes a reference
void increment (int &n) {
      n = ++n *2;
}
int main() {
            int x = 10;
            increment (x);
            cout << x;  // x becomes 22
 }
```

Cont'd

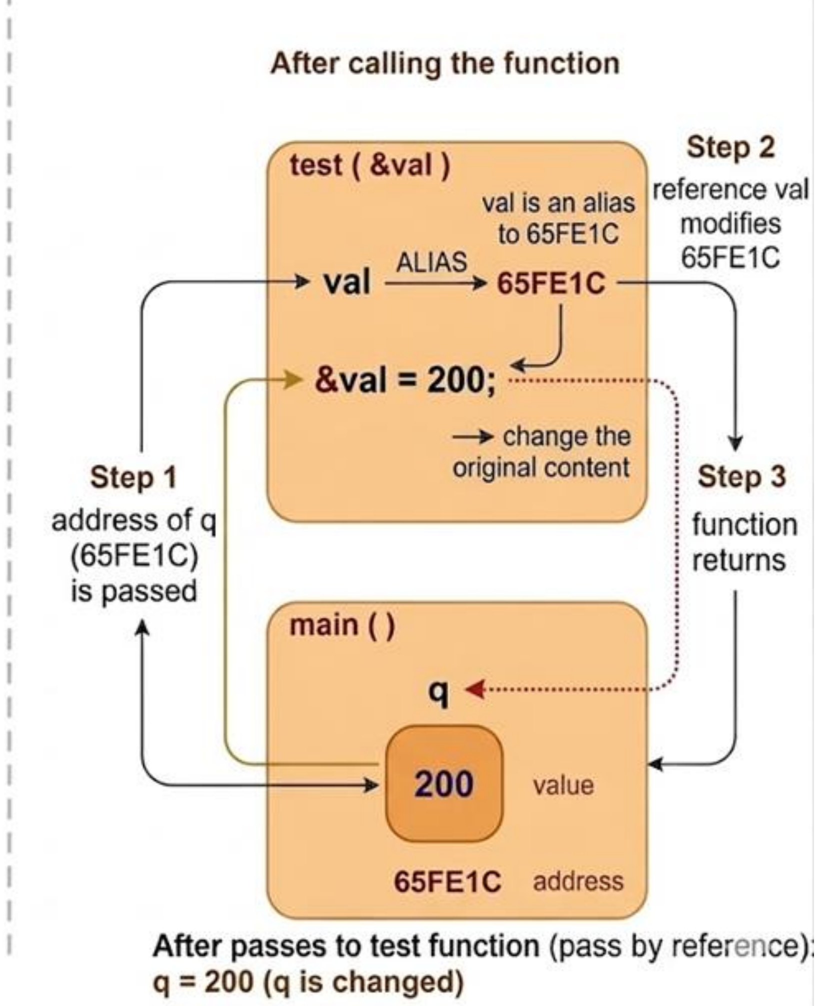
Memory Visualization

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

// Pass by Reference function
void test(int &val) {
    cout << "Inside function: "<< val << endl;

    //Directly modifies the original variable
    val = 200;

    cout<<"After change: "<< val << endl;
}

int main() {
    int q = 20;

    cout<<"Before function call: ";
    cout<< q << endl;

    test(q); // The address of q is passed

    cout<<"After function call: "<< q;
    cout<< " (changed)" << endl;

    return 0;
}
```

Before calling the function



Initial value of q = 20



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1.3. Pass by Pointer

Core Concept

- The **memory address** of the variable is passed to the function.
  - ✓ The function **uses a pointer** to "point" to the original variable's location and access it.
  - ✓ Like **pass by reference**, it allows the function to modify the original data,
  - ✓ It requires **explicit dereferencing**.

When to Use and not

- When working with dynamic memory (new, delete)
- When dealing with arrays and buffers
- Low-level memory manipulation

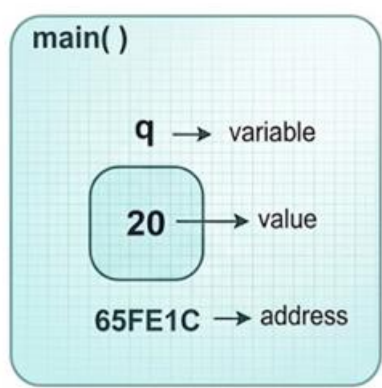
Syntax & Example (C++)

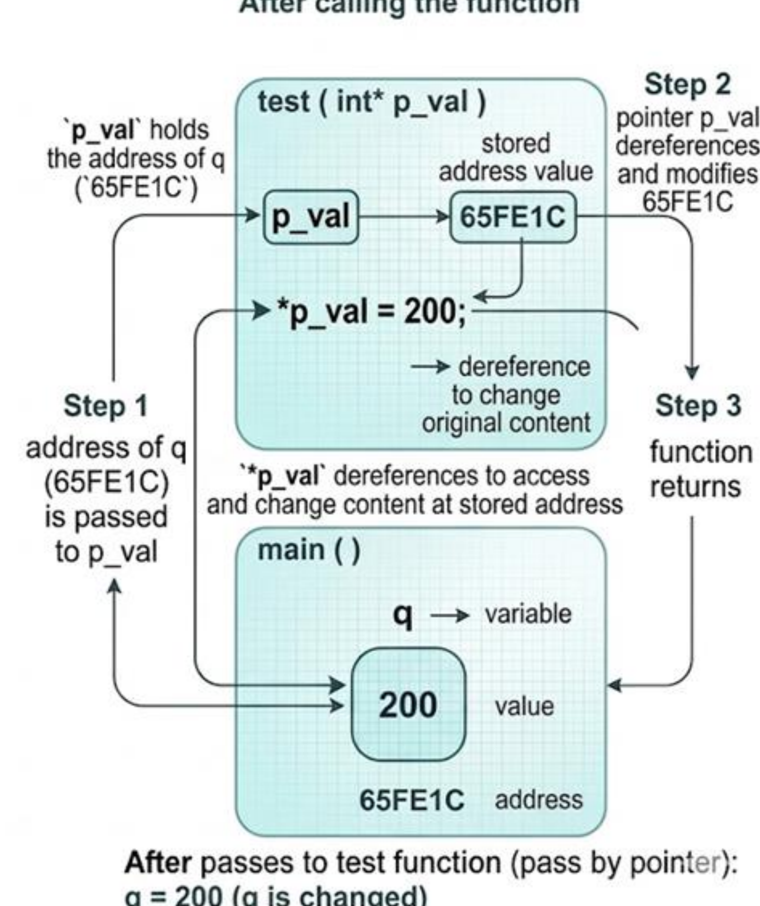
```cpp
// '&' denotes a reference and
// '*' refers to pointer / dereferencing
void update (int *x) {
    *x = *x + 10;
}
int main() {
        int a = 5;
        update (&a);
        cout << a;  // output: 15
}
```

Cont'd

Memory Visualization

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

// Pass by pointer function
void test(int *val) {
    cout<<"Inside function: "<< *val<< endl;

    //Directly modifies the original variable
    *val = 200;

    cout<<"After change: "<< *val << endl;
}

int main() {
    int q = 20;

    cout<<"Before function call: ";
    cout<< q << endl;

    test(&q); // The address of q is passed

    cout<<"After function call: ";
    cout<< q <<" (changed)" << endl;

    return 0;
}
```





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Parameter Passing Comparison

Pass by Value

10 → Function (param) → 10

Original — Copy

A **copy** of the actual value is passed to the function.

- Changes inside function do not affect original
- Safer (data is protected)
- Uses more memory (for the copy)

Syntax: `void f(int x);`

Pass by Reference

10 → Function (param) → 20

Original — Modified

A **reference** (alias) of the original variable is passed.

- Changes inside function affect the original
- Efficient (no copying of data)
- Direct access to actual variable

Syntax: `void f(int &x);`

Pass by Pointer

10 → Function (*ptr) → 20

Original — Modified

A memory address (**pointer**) of the variable is passed.

- Passes the address of the variable
- Function can modify original data using *ptr
- Used in low-level & system programming

Syntax: `void f(int *x);`

Source: *AI-generated image (Gemini 3)*

Quick Check: Pause & Predict

1. Given **void change(int &x) { x = 50},** What will be the value of **y** after function call **change(y),** where initially **y =13?**

***Answer: 50** (Since x is a reference parameter, it directly modifies the original variable y)*

2. Given **void change(int *a) { *a = + 2 },** What will be printed with function call **change(a),** where **a =3?**

***Answer: compiler error** (The function expects a pointer (int*), but an integer value (int) is passed)*

3. Given the below code segment, What will be the value of **a & b** with function call **swap(a, b),** where **a = 3, b = 5?**

```
void swap (int &x, int y) {
    int temp = *x;
    *x = y;
    y = temp
}
```

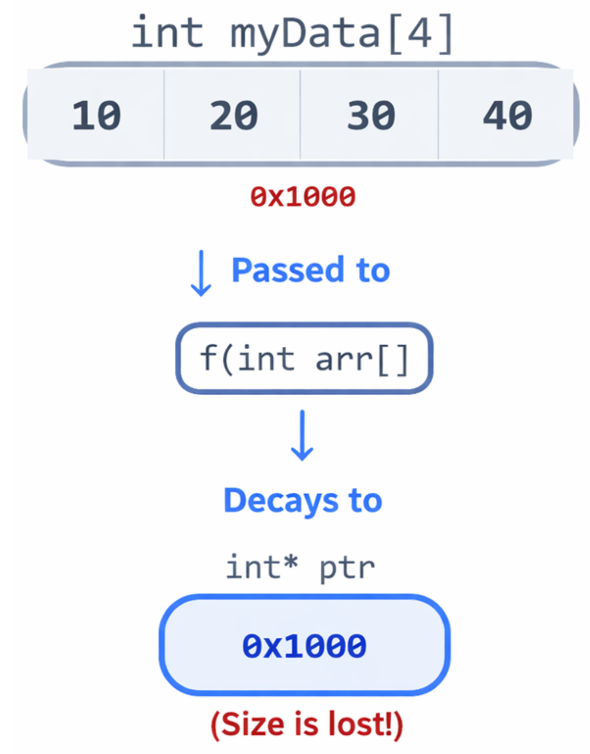
Answer: a = 5, b = 3
(Because both parameters are passed by reference)

2. Arrays as a Parameter

What does it mean?

- **Passing an array** to a function means sending the array's data so the function can process multiple values.
  - 👉 Instead of **passing one value**, we pass a collection of values.
- When **array** passed to a function, an **array T arr[N]** implicitly decays into a **pointer T*** to its first element.
- The **size information** is completely lost in the parameter and the **function** only knows where the **array starts**, **not where it ends**.

Decay Visualization



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Syntax and Example

- void function_name (type arrayName[], int arraySize);

Or

- void function_name (type* arrayName, int arraySize);

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

void printArray(int arr[], int size) {
    for(int i = 0; i < size; i++) {
        cout << arr[i] << " ";
    }
}

int main() {
    int numbers[] = {1, 2, 3, 4, 5};

    printArray(numbers, 5);

    return 0;
}
```

Cont'd

Passing Array by Reference

When an array is **passed by reference**, the function receives the **entire array** as it is, instead of a pointer to its first element.

- ✅ This **prevents array decay** (i.e., it does NOT turn into a pointer)
- ✅ The **size of the array is preserved**
- ✅ The compiler knows the array size at **compile time**

Syntax:

```
void funcName (type (&array)[size]);
```

Example:

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

void print(int (&arr)[5]) {
    for(int i = 0; i < 5; i++) {
        cout << arr[i] << " ";
    }
}

int main() {
    int data[5] = {1, 2, 3, 4, 5};

    print(data); // size is known (5)
}
```

Function Enhancements

3.1. Default Arguments

Concept

Allows functions to use **default values** if arguments are omitted by the caller.

👉 *It makes functions more flexible and reduces the need for multiple versions.*

Syntax

👉 return_type function_name (type param = default_value);

Rules

- Defaults **must be the trailing** (rightmost) parameters in the function signature
- Specify the default value only once, usually within the **function declaration/prototype**
- Values are resolved statically at **compile time**

Cont'd

Example: Default Argument Scenarios

Case 1: No Argument is Passed

```
void temp(int = 10, float = 8.8);

int main() {
  temp();
}

void temp(int i, float f) {
  cout << i << "," << f << ";" << endl;
}
```

DEFAULT (10)
DEFAULT (8.8)
RESULT: 10, 8.8;

Case 2: First Argument is Passed

```
void temp(int = 10, float = 8.8);

int main() {
  temp(6);
}

void temp(int i, float f) {
  cout << i << "," << f << ";" << endl;
}
```

PASSED (6)
DEFAULT (8.8)
RESULT: 6, 8.8;

Case 3: All Arguments are Passed

```
void temp(int = 10, float = 8.8);

int main() {
  ...
  temp(6, -2.3);
  ...
}

void temp(int i, float f) {
  cout << i << "," << f << ";" << endl;
}
```

PASSED (6)
PASSED (-2.3)
RESULT: 6, -2.3;

Case 4: Second Argument is Passed (Attempt)

```
void temp(int = 10, float = 8.8);

int main() {
  ...
  temp(3.4);
  ...
}

void temp(int i, float f) {
  cout << i << "," << f << ";" << endl;
}
```

Warning: Argument coerced from float to int
COERCED (3.4 → 3)
Error
COMPILER ERROR: Argument mismatch

Source:
https://www.programiz.com/cpp-programming/default-argument

Recreate with AI (Gemini 3)

3.2. Function Overloading

Concept

- Refers to functions with the **same name** but **different parameter lists** (signatures).
  - 👉 Compiler decides which function to call based on **Number and Type** of parameters
- Improves expressiveness—use one meaningful name for similar conceptual actions.

Syntax

- 👉 return_type function_name (type1);
- 👉 return_type function_name (type1, type2);

Overloading Rules

- Functions must differ in **Number** OR type of parameters
- ❌ Cannot overload only by return type

Cont'd

Code Examples

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

// function with 2 parameters
void display(int var1, double var2) {
    cout << "Integer number: " << var1;
    cout << " and double number: " << var2 << endl;
}

// function with double type, single parameter
void display(double var) {
    cout << "Double number: " << var << endl;
}

// function with int type, single parameter
void display(int var) {
    cout << "Integer number: " << var << endl;
}
```

```cpp
int main() {

    int a = 5;
    double b = 5.5;

    // call function with int type parameter
    display(a);

    // call function with double type parameter
    display(b);

    // call function with 2 parameters
    display(a, b);

    return 0;
}
```

Source: *https://www.programiz.com/cpp-programming/function-overloading*

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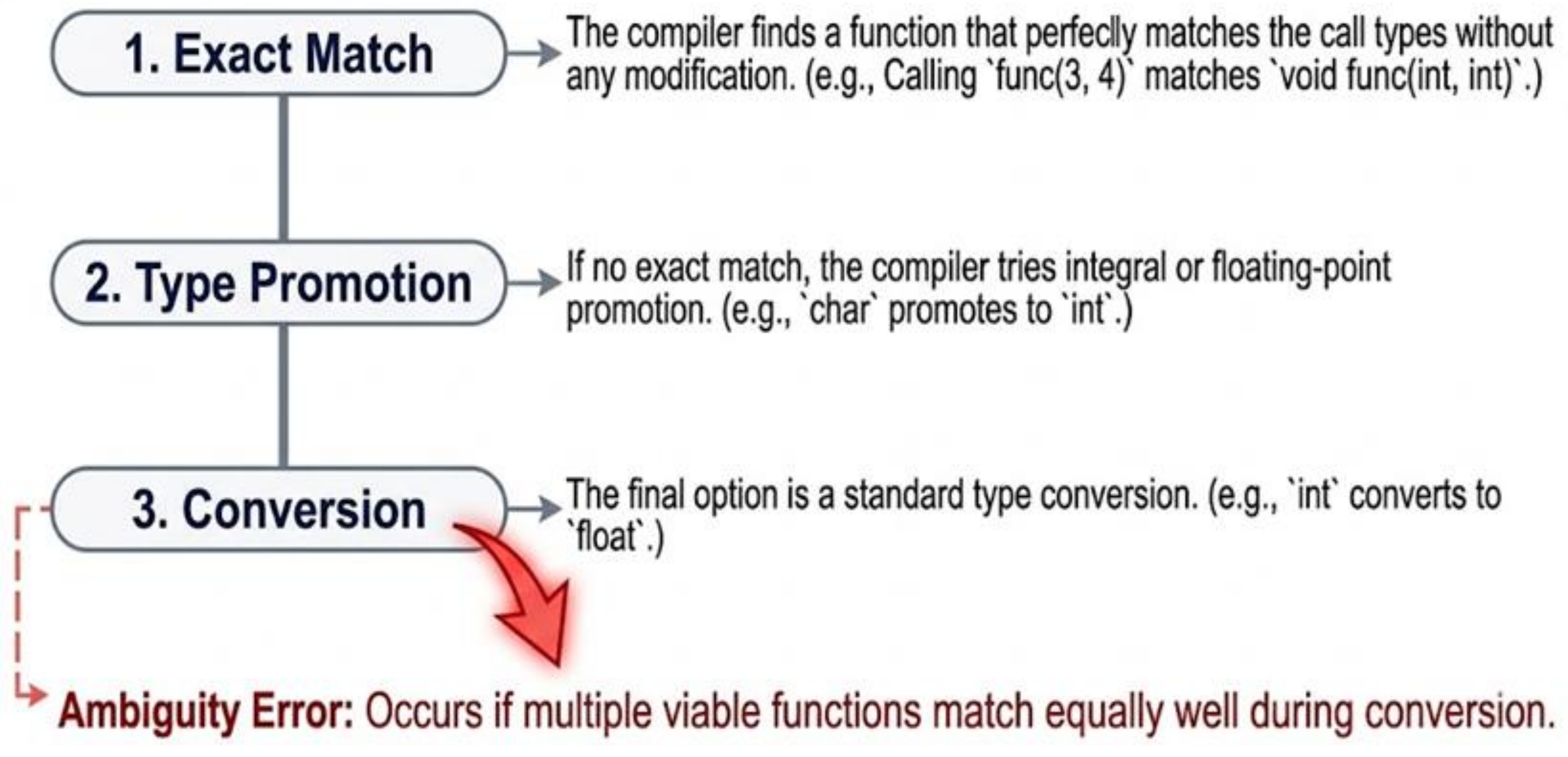
Compiler Resolution Flow



3.3. Inline Functions

Concept

- An **inline function** tells the compiler to **replace the function call** with the actual function code.

👉 Eliminates function call overhead → faster execution.

When to Use & Caveats

- Ideal for very small (tiny), frequently executed functions to avoid call overhead
  - ✓ e.g., getters, math operations.
- Performance-critical code
  - ✓ Inlining large functions copies code everywhere, increasing executable size.

❌ Avoid using with:

- *Large functions*
- *Recursive functions*
- *Functions with loops/complex logic*

Cont'd

Code Examples

```
inline void displayNum(int num) {
  cout << num << endl;
}

int main() {

  displayNum(5);

  displayNum(8);

  displayNum(666);
}
```

Compilation

```
inline void displayNum(int num) {
  cout << num << endl;
}

int main() {

  cout << 5 << endl;

  cout << 8 << endl;

  cout << 666 << endl;
}
```

Source: *https://www.programiz.com/cpp-programming/inline-function*

Summary of Function Enhancement

DEFAULT ARGUMENTS

SYNTAX:

```
void f(int x = 0);
```

BEHAVIOR:

- ✓ Supplies missing args
- ✓ Trailing params only
- ✓ Resolved at compile time

USE WHEN:

- ➢ Adding optional config
- ➢ When parameters are optional
- ➢ To reduce multiple similar functions
- ➢ For cleaner and shorter function calls

FUNCTION OVERLOADING

SYNTAX:

```
void f(int);
void f(double);
```

BEHAVIOR:

- ✓ Different signatures
- ✓ Same function name
- ✓ Resolved by param match

USE WHEN:

- ➢ Same conceptual action/operation, but different data types/arity
- ➢ Improves readability and reuse
- ➢ Reduces need for different function names

INLINE FUNCTIONS

SYNTAX:

```
inline int getX();
```

BEHAVIOR:

- ✓ Substitutes call with body
- ✓ Reduces call overhead
- ✓ Compiler optimization hint

USE WHEN:

- ➢ Very small / hot functions (e.g., math operations)
- ➢ Frequently called functions
- ➢ Performance-critical code

Source: *AI-generated image (Gemini 3)*

Quick Check: Pause & Predict

1. **What's wrong here?**

```
void g(int a=1, int b);
```

Answer: Defaults must be trailing.

- *Parameter **b** lacks a default value after the defaulted parameter **a**.*

2. **Are these valid overloads?**

```
int height(int);
double height(double = 3.14);
```

Answer: Yes, they have different signatures

- *However, passing types requiring conversions (like long) can cause ambiguity at the call site*

3. **Which function uses pass by reference?**

A. `void func (int x);`

B. `void func (int *x);`

C. `void func (int &x);`

D. `void func (const int x);`

Answer: C

- ***&** indicates reference parameter*

Practical Exercises

4. Practice Exercise

Exercise #1 — Student Score Analyzer

Objective

Build a modular student sc**ore analyzer system** that demonstrates:

- Different **parameter passing techniques**
- Use of **default arguments**
- Implementation of **function overloading**

Requirements

1. Create overload function named **calcAvergae ()**
   - *Return type: double*
   - *Parameters: int type*
   - *Overloading**:** number of **parameter** (2, 3, 4)*
2. Create function with default arguments
   - *void displayResult(double avg, char grade = “F");*
3. Create functions that compute bonus:
   - *Pass by value: void addBonus (int score);*
   - *Pass by value: void addBonusRef (int score);*

Cont’d

Solution : Student Score Analyzer

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

// ====== Function Overloading ===========
double calculateAverage(int a, int b) {
    return (a + b) / 2.0;
}

double calculateAverage(int a, int b, int c) {
    return (a + b + c) / 3.0;
}

double calculateAverage(int a, int b, int c, int d) {
    return (a + b + c + d) / 4.0;
}

// ================ Default Argument =================
void displayResult(double avg, char grade = "F") {
    cout << "Average Score: " << avg << endl;
    cout << "Grade: " << grade << endl;
}
```

```cpp
// ============== Parameter Passing ==============
// Pass by Value
void addBonus(int score) {
    score += 5;
    cout<<"[Pass by Value] Score inside function: "
    cout<< score << endl;
}

// Pass by Reference
void addBonusRef(int &score) {
    score += 5;
    cout<<"[Pass by Reference] Score inside function:
    cout<< score << endl;
}

// Pass by Pointer
void addBonusPtr(int *score) {
    *score += 5;
    cout<<"[Pass by Pointer] Score inside function: "
    cout<< *score << endl;
}
```

Cont'd

Solution : Student Score Analyzer

```cpp
int main() {
    int a, b, c, d;
    int choice;
    cout << "Enter number of scores (2-4): ";
    cin >> choice;
    double avg;

    if (choice == 2) {
        cout << "Enter 2 scores: ";
        cin >> a >> b;
        avg = calculateAverage(a, b);
    } else if (choice == 3) {
        cout << "Enter 3 scores: ";
        cin >> a >> b >> c;
        avg = calculateAverage(a, b, c);
    } else if (choice == 4) {
        cout << "Enter 4 scores: ";
        cin >> a >> b >> c >> d;
        avg = calculateAverage(a, b, c, d);
    }
    else {
        cout << "Invalid choice!" << endl;
        return 0;
    }
```

```cpp
    // Display with default argument
    displayResult(avg);

    // ======== Demonstrate Parameter Passing ============
    int score = 50;
    cout << "\nOriginal Score: " << score << endl;

    addBonus(score);
    cout << "After Pass by Value: " << score << endl;

    addBonusRef(score);
    cout << "After Pass by Reference: " << score << endl;

    addBonusPtr(&score);
    cout << "After Pass by Pointer: " << score << endl;

    return 0;
}
```

5. Common Pitfalls and Best Practices

Common Pitfalls

- ✕ Passing wrong argument type
- ✕ Mixing default arguments with function overloading
- ✕ Wrong order in default argument definition
- ✕ Overloading function only by return type
- ✕ Redefining default values in multiple places
- ✕ Using **inline** for large functions and with recursion or complex logic
- ✕ Forgetting **array size** while using array as argument in function

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Best Practices

- ✓ Use pass **by value** for small data and safety
- ✓ Use pass **by reference** for large data or modification required
- ✓ Always validate pointers before dereferencing
- ✓ Define defaults arguments from **right to left**
- ✓ Declare **default values** in function prototype
- ✓ Avoid using inline with recursion function, and function that has large logic
- ✓ Avoid excessive overloading

References

Textbooks

- **C++ How to Program** [10th edition], Deitel, P. & Deitel, H., Global Edition, Global Edition (2017).
- **Problem Solving With C++** [10th edition], Walter Savitch, University of California, San Diego, 2018.

Reference Books

- **Programming: Principles and Practice Using C++** by Bjarne Stroustrup, Addison-Wesley, 2014.
- **An Introduction to Programming with C++** (8th Edition), Diane Zak, Cengage Learning, 2016

Online Resources

- https://www.geeksforgeeks.org/cpp/c-plus-plus/
- https://www.w3schools.com/cpp/default.asp
- https://programiz.pro/resources/cpp
- https://www.hackerrank.com/domains/cpp
- https://cplusplus.com/doc/tutorial/

Study Tip: *Don't just read the code! Retype the examples from these slides and resources into your IDE, compile them, and modify them to see what happens.*

Thank You!

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