Function and struct

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Contents

Function

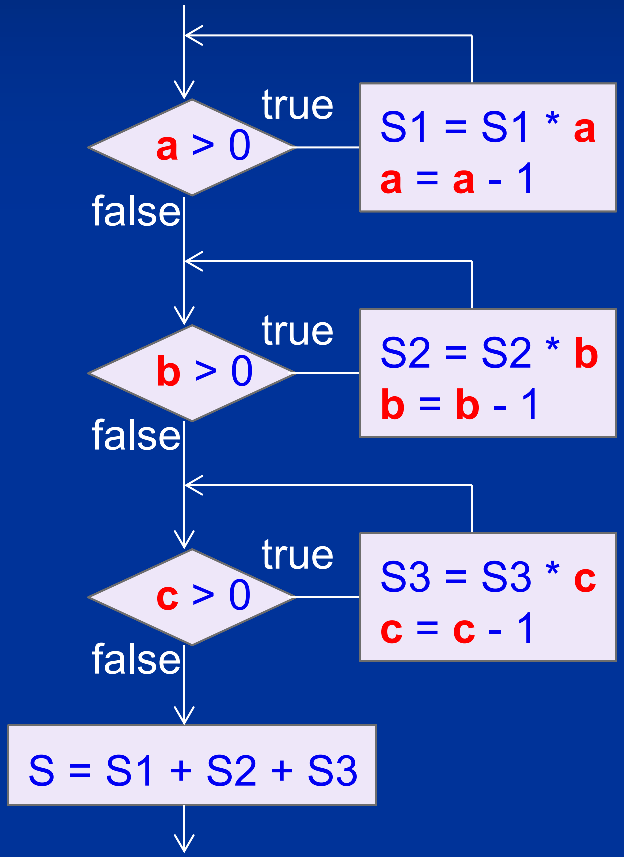
- Problem with repeated code:
  - Consider a program:
    - Enter 3 positive integers a, b, c >= 0.
    - Compute and print S = a! + b! + c!.

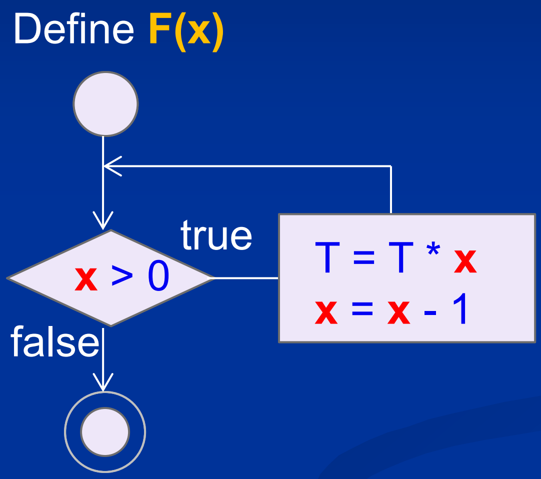
    ➔ Identify repeated code.
  - Disadvantages of repeated code:
    - Time and cost.
    - Changes → fix multiple places.

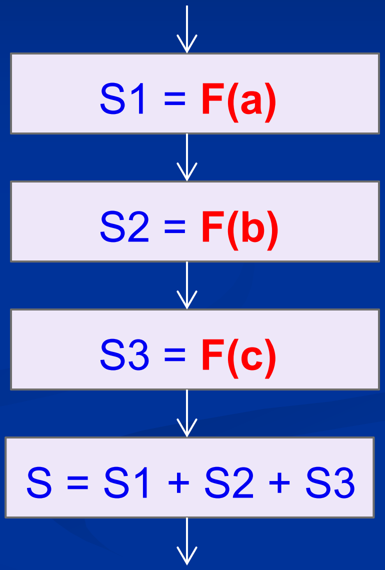
    ➔ Write once, reuse everywhere.

Function

- Function solution:



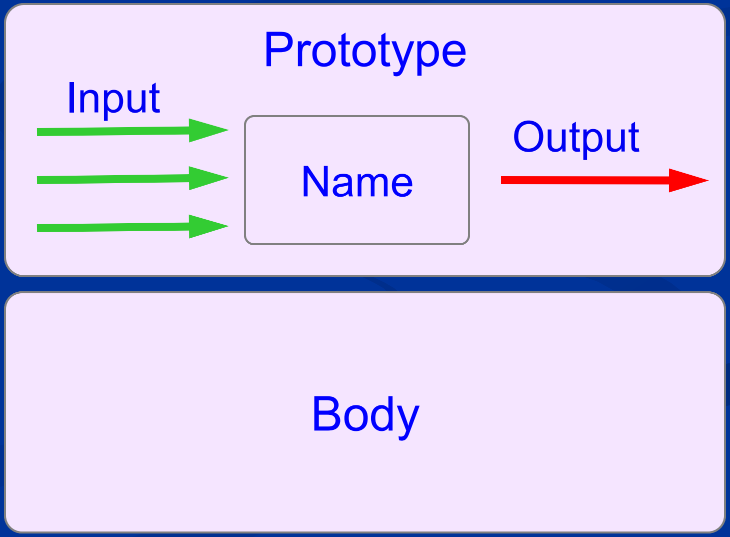




Function

- C/C++ function:
  - A named block of statements.
  - Can be called:
    - From anywhere in program.
    - With different arguments.
  - Function structure:
    - Prototype: declaration.
      - Function name.
      - Arguments.
      - Return type.

      ➔ Identification.
    - Body: implementation.



Function

- C/C++ function:
  - Declaration (prototype):

    <Return type> **<Function name>(** *<Arguments>* **)**;

    <Return type>: int, float, char, …, **void** (không trả về).

    ```
    float calcGPA( float literature, float math );
    void printResult( );
    ```
  - Implementation (body):

    ```
    <Return type> <Function name>( <Arguments> )
    {
                [Statements]
                [return <value>;]
    }
    ```
  - Calling:

    <Function name>(*<Arguments>* **)**;

    ```
    float gpa = calcGPA( 7.0, 8.5 );
    ```

Function

- C/C++ function:

```
// Function declaration.
long long factorial( int n );

int main()
{
        // Declare and input a, b, c.

        // Function calls.
        S1 = factorial( a );
        S2 = factorial( b );
        S3 = factorial( c );

        S = S1 + S2 + S3;
}
```

```
// Function implementation.
long long factorial( int n )
{
        long long s = 1;
        for ( ; n > 0; n--)
                s = s * n;
        return s;
}
```

Function

- Passing arguments:
  - Pass-by-value:
    - Argument values are passed to function.
    - Function receives only the COPY.
    - Real arguments are UNCHANGED.
    - Arguments are: variables, constant, expressions.

```
float calcGPA( float lit, float math )
{
        lit = lit * 2;
        math = math * 3;
        return (lit + math) / 5;
}
```

```
int main()
{
        float a, b, gpa;

        gpa = calcGPA( a, b );
        gpa = calcGPA( 6, 8.5 );
        gpa = calcGPA( a + 1, b );
        // a, b are UNCHANGED.
}
```

Function

- Passing arguments:
  - Pass-by-reference (C++):
    - Real arguments are passed to function.
    - Function receives the original ones.
    - Real arguments can be CHANGED.
    - Arguments are variables only.
    - Syntax: **&**<argument>.

```
float calcGPA( float &lit, float math )
{
        lit = lit * 2;
        math = math * 3;
        return (lit + math) / 5;
}
```

```
int main()
{
    float a, b, gpa;

    gpa = calcGPA( a, b);
    // a is CHANGED.
    gpa = calcGPA( 6, 8.5 );      //wrong
    gpa = calcGPA(a + 1, b);      //wrong
}
```

Function

- Passing arguments:
  - Notes:
    - Use pass-by-reference to return values.

      ➔ Function with multiple return values.

```
void input( float &lit, float &math )
{
        printf("Enter literature = ");
        scanf("%f", &lit);
        printf("Enter math = ");
        scanf("%f", &math);
}
void calcGPA( float lit, float math, float &gpa )
{
        lit = lit * 2;
        math = math * 3;
        gpa = (lit + math) / 5;
}
```

```
int main()
{
        float  a, b;
        float  gpa;

        // a, b are UPDATED.
        input(a, b);

        // gpa are UPDATED.
        calcGPA(a, b, gpa);
}
```

Function

- Scope:
  - Existing area of variables and functions.
    - Global scope: across program.
    - Local scope: only in declaration block.
  - Function has global scope.
  - Variable:
    - Global variable: declared outside functions (includes main()).

      ➔ Can be used across program.
    - Local variable: declared inside a block.

      ➔ Can be used only in the block.

Function

- Scope:

```
float  S;                                        // Global declarations.
int compute();

int main()
{
      int  a = S + compute();           // Local variable in main.
      while (a > 0)
      {
            int  b = S + compute();   // Local variable in loop.
      }
}

int compute()
{
      int  y = S * 2;                          // Local variable in function.
}
```

Contents

- Function.
- **Multiple-file project.**
- struct.

Multiple-file project

- How do we organize a book?
  - Cannot write in one paper!!

    → Split into chapters.

    → Summary at first.

    → Chapter contents follow.

Multiple-file project

- Organize C/C++ project:
  - Like a book:
    - Chapters ~ source code files.
    - Summary ~ main() function.

  ➔ How to connect multiple source code files?

```
// File main.cpp
int main()
{
        input();
        compute1();
        compute2();
        output();
}
```

```
// File io.cpp
void input()
{
}

void output()
{
}
```

```
// File compute.cpp
int compute1()
{
}

int compute2()
{
}
```

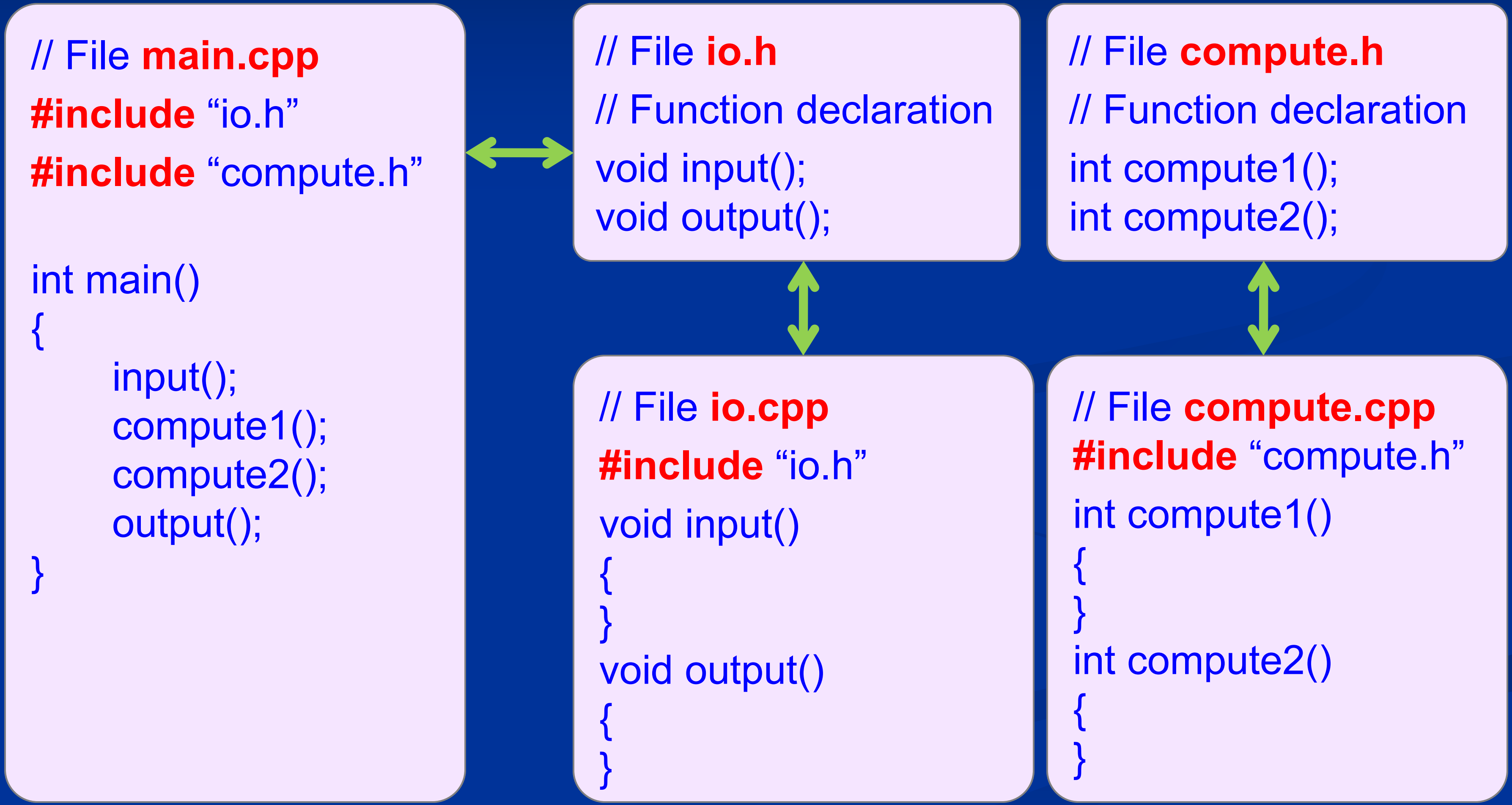
Multiple-file project

- Header file:
  - Connect source files across project.
  - Make code on a file “see” code on another file.
  - File extension **.h**.
  - Usage:
    - Create header file **.h** for source file **.cpp**.
    - File **.h** contains only **declaration** (global variables/functions).
    - File **.cpp** contains **implementation** of functions.
    - To let A.cpp “see” code in B.cpp

      ➔ A.cpp **#include** “B.h”

Multiple-file project

- Header file:



```
// File main.cpp
#include "io.h"
#include "compute.h"

int main()
{
        input();
        compute1();
        compute2();
        output();
}
```

```
// File io.h
// Function declaration
void input();
void output();
```

```
// File compute.h
// Function declaration
int compute1();
int compute2();
```

```
// File io.cpp
#include "io.h"
void input()
{
}
void output()
{
}
```

```
// File compute.cpp
#include "compute.h"
int compute1()
{
}
int compute2()
{
}
```

Multiple-file project

- Divide-conquer a project:
  - How to eat a cow?

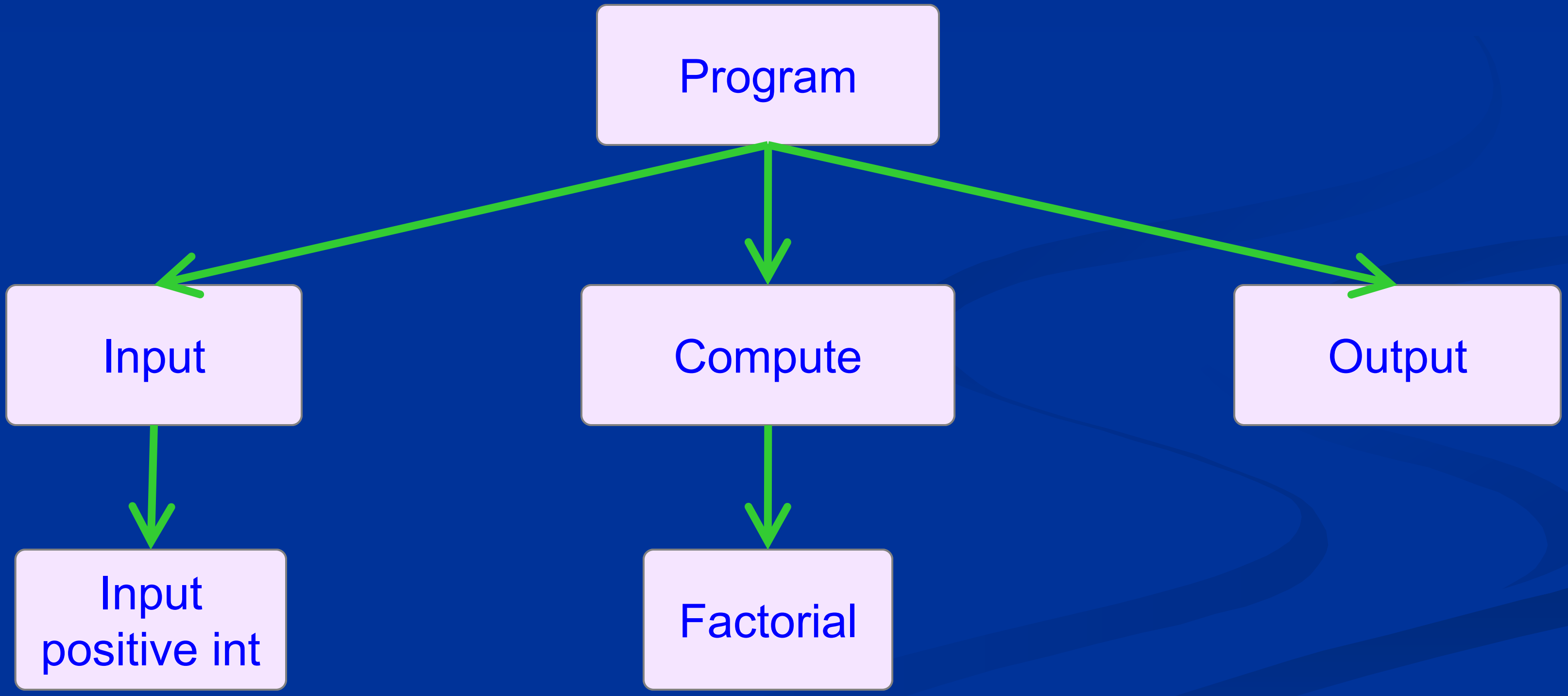
    ➔ Split into small parts.

    ➔ Eat each parts.
  - How small is small?

    ➔ Can be chewed.
  - Organize a project:
    - Split into functions and files.
    - Implement each function.
    - Should be < 30 statements.

Multiple-file project

- Program breakdown tree:
  - Enter 3 positive integers a, b, c >= 0.
  - Compute and print S = a! + (b + 1)! + (c + 2)!.



Multiple-file project

```
// File process1.h
void input(int &a, int &b,int &c);
long compute(int a, int b, int c);
void output(long result);
```

```
// File process2.h
void input_num(int x);
long factorial(int n);
```

```
// File main.cpp
#include “process1.h”

int main()
{
	int	a, b, c;
	long S;

	input(a, b, c);
	S = compute(a, b, c);
	output(S);
}
```

```
// File process1.cpp
#include “process1.h”
#include “process2.h”
void input(int &a, int &b,int &c)
{
	input_num(a);
	input_num(b);
	input_num(c);
}
long compute(int a, int b, int c)
{
	return factorial(a) +
factorial(b+1) + factorial(c+ 2);
}
void output(long result)
{
	printf(“S = %ld”, result);
}
```

```
// File process2.cpp
#include “process2.h”
#include <stdio.h>
void input_num(int &x)
{
    do {
        printf(“Positive integer = “);
        scanf(“%d”, &x);
    } while (x < 0);
}

long factorial(int n)
{
	long S = 1;
	for ( ; n > 0; n--)
		S = S * n;
	return S;
}
```

Contents

- Function.
- Multiple-file project.
- **struct.**

struct

- Organize program data:
  - Student information:
    - Student id.
    - Student name.
    - Literature, math.
  - Write program:
    - Enter information of a student.
    - Print student information with computed gpa.

  ➔ What is the inconvenience?

struct

- C/C++ struct:
  - Combine data into one place.
  - Compound data-type.
  - Declaration:

```
// Syntax 1:
struct <struct name>
{
        <struct member 1>;
        <struct member 2>;
        …
};
```

```
// Syntax 2:
typedef struct
{
        <struct member 1>;
        <struct member 2>;
        …
} <struct name>;
```

struct

- C/C++ struct:
  - struct variable:

```
struct <struct name>  <variable>;

// With typedef struct or C++
<struct name>  <variable>;
```

```
struct Student
{
    char  id[9];
    char  name[50];
    float  literature;
    float  math;
};

int main()
{
    struct Student  s1;
    Student  s2;  // C++
}
```

struct

- C/C++ struct:
  - Initialization:

```
struct <struct name> <variable> =
{    // In declaration order.
    <member 1 value>,
    <member 2 value>,
              …
};
struct <struct name> <variable> =
{    // C99 standard.
    .<member name> = <value>,
    …
};
```

  - Access struct member:

```
<variable> . <member name>.
```

```
int main()
{
    struct Student s =
    {
         "24127001",
         "Nguyen Van A",
         7.5,
         8.0
    };

    s.literature = 5.5;
}
```

struct

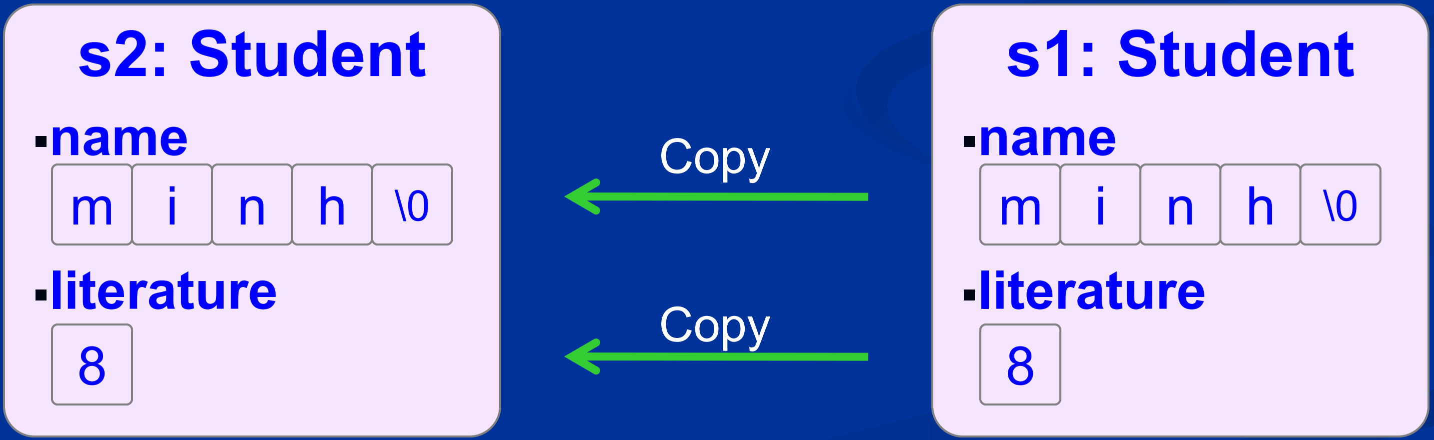
- C/C++ struct:
  - Passing arguments:
    - Pass-by-value:
      - ➔ Pass a copy.
      - ➔ Unchanged.
    - Pass-by-reference (C++).
      - ➔ Pass the real one.
      - ➔ Can be changed.

```
void  add1( struct Student s )
{
        s.literature++;
        s.math++;
}
void  add2( Student &s )
{
        s.literature++;
        s.math++;
}
int main()
{
        struct Student  s1, s2;
        add1( s1 );
        add2( s2 );
        // s1 unchanged.
        // s2 changed.
}
```

struct

- C/C++ struct:
  - struct assignment:
    - All struct members are copied.
    - Array members are copied too!

```
struct Student  s1 = { .name = “minh”, .literature = 8.0 };
struct Student  s2 = s1;
```



Summary

- Function:
  - A named block of statement can be called anywhere.
  - Function structure:
    - Prototype: name, arguments, return type.
    - Body: implementation.
  - Passing arguments:
    - pass-by-value.
    - pass-by-reference (C++).
- Multiple-file project:
  - Program ~ book:
    - main() ~ summary.
    - source files ~ chapters.

Summary

- Multiple-file project:
  - Header file .h: connect code across source files.
  - Program breakdown tree:
    - Split program into files and functions.
    - Based on levels of abstraction and reusability.
- struct:
  - Compound data-type.
  - Combine data into one place.
  - Assignment: all members are copied.

Practice

- Practice 4.1:

  Write C/C++ program to find prime numbers:

  (organize in functions and multiple-file project)

  - Enter a positive integer N (re-enter if invalid).

  - Print all prime numbers <= N.

  Input format:

  Enter a positive integer = 11

  Output format:

  #1 = 2

  #2 = 3

  #3 = 5

  #4 = 7

  #5 = 11

  There are 5 prime numbers.

Practice

- Practice 4.2:

  Write C/C++ program to simulate a calculator as follow:

  - Enter two integers.
  - Enter an operator (+, -, *, /, %).
  - Perform the operator on two integers and print result.

  Notes: flush the standard input stream after each input.

  - C: fgets, or while getchar, C++: cin.getline, or cin.ignore.

  Input format:

  Enter two integers = 7 5

  *Enter an opertor (+, -, *, /, %) = +*

  Output format (no error):

  Result = 12

  Output format (divided-by-zero error):

  Error: divided by zero.

Practice

- Practice 4.3:

  Write C/C++ program to classify a triangle:

  (organize in functions and multiple-file project)

  - Enter 3 positive real numbers a, b, c (re-enter if invalid).

  - Check if a, b, c can forms a triangle.

  - If yes, print the triangle type.
  (normal, right, isosceles, right-isosceles, equilateral).

  Input format:

  Enter 3 positive real numbers = 3 4 5

  Output format (can form a triangle):

  Can form a triangle.

  Right triangle.

  Output format (cannot form a triangle):

  Cannot form a triangle!

Practice

- **Practice 4.4:**

  Write C/C++ program to simulate a menu as follow:
  (organize in functions and multiple-file project):

  - Print the menu:

```
1. Practice 4.1.
2. Practice 4.2.
3. Practice 4.3.
4. Exit.
-----------------
Selection (1-4):
```

  - Enter an integer for your selection.
  - Selection 1-3:
    + Execute the selected practice.
    + Go back to menu.
  - Selection 4: exit program.

Practice

- Practice 4.5:

  Write C/C++ program to operate on fractions:

  (organize in functions and multiple-file project):

  - Declare struct to represent a fraction.
  - Enter 2 fractions.
  - Perform the following operations on 2 fractions and print result: add, multiply, inverse, reduce.

Practice

- Practice 4.6:

  Write C/C++ program to operate on students:

  (organize in functions and multiple-file project):

  - Declare struct to represent a student (stated in the lesson).

  - Enter a students.

  - Print GPA and their rank:

    + Excellent: GPA >= 8.5.

    + Good: GPA >= 7.0.

    + Fair: GPA >= 5.0.

    + Failed: GPA < 5.0.

Practice

- Practice 4.7:

  Write C/C++ program to operate on triangle:

  (organize in functions and multiple-file project):

  - Declare structs to represent point (x, y) and triangle (3 points).
  - Enter information of a triangle.
  - Compute and print triangle perimeter.
  - Find and print triangle centroid.

Practice

- Practice 4.8:

  Write C/C++ program to operate on date:

  (organize in functions and multiple-file project):

  - Declare struct to represent date (day, month, year).
  - Enter two date d1 and d2.
  - Check if d1 is latest than d2 and print result.
  - Print tomorrow date of d1.
  - Print yesterday date of d2.

Practice

- Practice 4.9 (*):

  Write compile command for the following projects:

Simple project with multiple folders	Simple project with external libraries	Complex project project 1 uses project 2

project/
    bin/
    src/
        subfolder/
	project/
	    bin/
	    lib/
	        libA/
	        libB/
	    src/
	        subfolder/
		project/
		    lib/
		        libA/
		        libB/
		    subproject1/
		        bin/
		        src/
		            subfolder1/
		    subproject2/
		        bin/
		        src/
		            subfolder2/