

ECE2800J

Programming and Elementary Data Structures

Review of C++ Basics

Learning Objectives:

Freshen your memory of C++ basics (lvalue/rvalue, function declaration vs definition, function call mechanism, array, pointer vs reference, struct...)

Very Basic Concepts

- Variables
- Built-in data types, e.g., `int`, `double`, etc.
- Input and output, e.g., `cin`, `cout`.
- Operators
 - Arithmetic: `+`, `-`, `*`, etc.
 - Comparison: `<`, `>`, `==`, etc.
 - `x++` versus `++x`
- Flow of controls
 - Branch: `if/else`, `switch/case`
 - Loop: `while`, `for`, etc.

An Example

```
#include <iostream>
using namespace std;
int main() {
    // Calculating the area of a square
    int length, area;
    cin >> length;
    if(length > 0) {
        area = length * length;
        cout << "area is " << area << endl;
    }
    else
        cout << "negative length!" << endl;
    return 0;
}
```

lvalue and rvalue

- Two kinds of expressions in C++
 - **lvalue**: An expression which may appear as either the left-hand or right-hand side of an assignment
 - **rvalue**: An expression which may appear on the right- but not left-hand side of an assignment
- E.g., any non-constant variable is an lvalue.
- Any constant is an rvalue.



Which statements are correct?

Select all the correct answers. Variables `a` and `b` are of type `int` and `c` is an array.

- **A.** `10` is an lvalue.
- **B.** `a+b` is an lvalue.
- **C.** `c[2*3]` is an rvalue.
- **D.** None of the above.



Function Declarations vs. Definitions

- Function **declaration** (or **function prototype**)

- Shows how the function is called.
- Must appear in the code before the function can be called.
- Syntax:

```
Return_Type Function_Name(Parameter_List);  
//Comment describing what function does  
int add(int a, int b); //Comment
```

- Function **definition**

- Describes how the function does its task.
- Can appear before or after the function is called.
- Syntax:

```
Return_Type Function_Name(Parameter_List)  
{  
    //function code  
}  
int add(int a, int b) {  
    return (a + b);  
}
```

Function Declaration

- Tells:

- return type
- how many arguments are needed
- types of the arguments
- name of the function
- **formal parameter** names

Type Signature

Formal Parameter Names

- Example:

```
double total_cost(int number, double price);  
// Compute total cost including 5% sales tax on  
// number items at cost of price each
```

Function Definition

- Provides the same information as the declaration
- Describes how the function does its task

- Example:

function header

```
double total_cost(int number, double price)
```

```
{  
    double TAX_RATE = 0.05; // 5% tax  
    double subtotal;  
    subtotal = price * number;  
    return (subtotal + subtotal * TAX_RATE);  
}
```

function body

Function Call Mechanisms

- Two mechanisms:
 - Pass-by-Value
 - Pass-by-Reference

```
void f(int x)
{
    x *= 2;
}
```

```
void f(int& x)
{
    x *= 2;
}
```



```
int main()
{
    ...
    int a=4;
    f(a);
    ...
}
```

What will a be?

Array

- An array is a fixed-sized, indexed data type that stores a collection of items, all of the same type.
- Declaration: `int b[4];`
- Accessing array elements using index: `b[i]`
- C++ arrays can be passed as arguments to a function.

```
int sum(int a[], unsigned int size);  
    // Returns the sum of the first  
    // size elements of array a[]
```

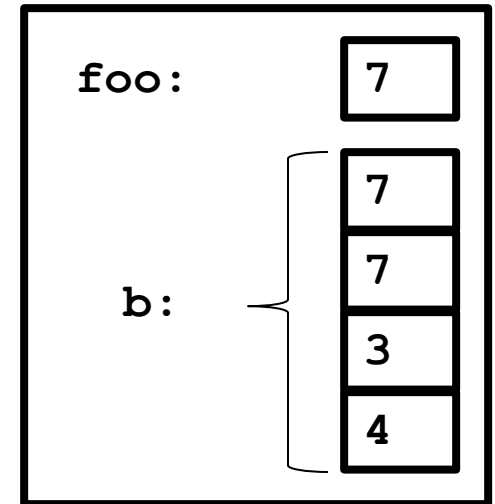
Array is passed by **reference**.



Array as Function Argument

Using the values below, what would the contents of `b` be after calling `add_one(b, 4)`?

```
void add_one(int a[], unsigned int size) {  
    unsigned int i;  
    for (i=0; i<size; i++) {  
        a[i]++;  
    }  
}
```



- **A.** 8, 8, 4, 4 **B.** 7, 7, 3, 4
- **C.** 8, 8, 4, 5 **D.** None of the above.



Pointers: Working with Addresses

```
int foo = 1;  
int *bar;    // Define a pointer  
bar = &foo;  // addressing operation  
*bar = 2;    // dereference operation
```

0x804240c0 **foo:**

A rectangular box representing the memory location for the variable 'foo'. It is empty, indicating its current value.

0x804240e4 **bar:**

A rectangular box representing the memory location for the variable 'bar'. It is empty, indicating its current value.

References

- **Reference** is an **alternative** name for an object.

```
int iVal = 1024;  
int &refVal = iVal;
```

- refVal is a reference to iVal. We can change iVal through refVal.

- Reference **must be initialized** using an **lvalue** of the same type.

```
int &refVal2; // Error: not initialized  
int &refVal3 = 10; // Error: 10 is not  
                  // an lvalue
```

References

- There is **no way to rebind** a reference to a different object after initialization.

```
int iVal = 1024;  
int &refVal = iVal;  
int iVal2 = 10;  
refVal = iVal2;
```

- refVal still binds to iVal, not iVal2.

Pointers Versus References

- Both pointers and references allow you to pass objects by reference.
- Any differences between pointers and references?
 - Pointers require some extra syntax at calling time (&), in the argument list (*), and with each use (*); references only require extra syntax in the argument list (&).
 - You can change the object to which a pointer points, but you cannot change the object to which a reference refers.
 - In this sense, pointer is **more flexible**



What are the final values?

Select all the correct answers. A and C correspond to the left example, while B and D to the right one.

```
int x = 0;  
int &r = x;  
int y = 1;  
r = y;  
r = 2;
```

```
int x = 0;  
int *p = &x;  
int y = 1;  
p = &y;  
*p = 2;
```

- **A.** $x = 2, y = 1, r = 2$ **B.** $x = 0, y = 1, *p = 2$
- **C.** $x = 0, y = 1, r = 2$ **D.** $x = 2, y = 2, *p = 2$



Pointers

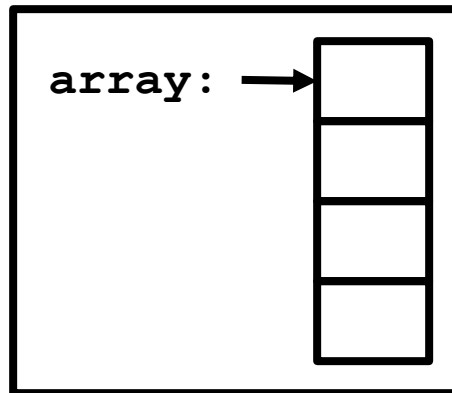
Why use them?

- You might wonder why you'd ever want to use pointers, since they require extra typing, and is error-prone.
- There are (at least) two reasons to use pointers:
 1. They provide a convenient mechanism to work with arrays.
 2. They allow us to create structures (unlike arrays) whose size is not known in advance.

Pointers and Arrays

- If you look at the **value** of the variable `array` (not `array[0]`) you would find that it would be exactly the same as the **address** of `array[0]`.
- In other words,

```
array == &array[0]
```



Structs

- Declare a `struct` type that holds grades.
- Why struct? To create a **compound type**

```
struct Grades {  
    char name[9];  
    int  midterm;  
    int  final;  
};
```

name:

--	--	--	--	--	--	--	--	--

midterm:

--

final:

--

- This statement declares the **type** “struct Grades”, but does not declare any **objects** of that type.
- We can define a single object of this type as follows:

```
Grades  alice;
```

Structs

```
struct Grades {  
    char name[9];  
    int  midterm;  
    int  final;  
};
```

name:

A	l	i	c	e	\0			
---	---	---	---	---	----	--	--	--

midterm:

60

final:

85

- We can initialize them in the following way:
`Grades alice= {"Alice", 60, 85};`

Structs

```
struct Grades {  
    char name[9];  
    int  midterm;  
    int  final;  
};
```

name:

A	l	i	c	e	\0			
---	---	---	---	---	----	--	--	--

midterm:

65

final:

85

- Once we have a struct, we can access its individual components using the “dot” operator:
`alice.midterm = 65;`
 - This changes the `midterm` element of `alice` to 65
- If you have a pointer to struct, visit component using “->”
`Grades *gPtr = &alice;`
`gPtr->final = 90;`

Reference

- **Pointers**
 - Problem Solving with C++, 8th Edition, Chapter 9.1
- **References**
 - C++ Primer, 4th Edition, Chapter 2.9