Week 4

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Outline

- Preprocessor
- Arrays
  - Basic arrays
  - Char arrays
  - String arrays
- Use arrays inside a function

Outline

- ***Preprocessor***
- Arrays
  - Basic arrays
  - Char arrays
  - String arrays
- Use arrays inside a function

Preprocessor

- Preprocessor: executed before the actual compilation of code, therefore the preprocessor digests all these directives before any code is generated by the statements
- Start with Hash sign #
- **No semicolon at the end**
- #include is also one kind of preprocessors
- Macro definition is another kind of preprocessors:
  - #define pattern target_value

```
#define PI 3.14
#define MAXSIZE 1000
```

Preprocessor

```
#include <iostream>
using namespace std;
#define PI 3.14159
#define NEWLINE '\n'

int main ()
{
        double r=5.0;
        circle = 2 * PI * r;
        cout << circle; cout << NEWLINE;
        return 0;
}
```

3.14159
It is one way to define a constant value

*http://www.cplusplus.com/doc/tutorial/constants/

Preprocessor

- You can change the value of a defined pattern by using *#undef*
- In following example, we define three arrays, a1[10], a2[100], a3[1000]

```
#define MAX 10
int a1[MAX];
#undef MAX
#define MAX 100
int a2[MAX];
#undef MAX
#define MAX 1000
int a3[MAX];
```

Preprocessor

- Conditional inclusions: allow to include or discard part of the code of a program if a certain condition is met
  - #ifdef, #ifndef, #if, #else and #elif
- #ifdef allows a section of a program to be compiled only if specific macro has been defined (no matter what value it has).
- #ifndef prevents redefinition of a macro

```
#ifndef DISPLAY
// run some code here
#endif
```

Preprocessor

```
#ifndef DISPLAY1
#define DISPLAY1 2147483647
#endif
#define DISPLAY2 -2147483648

int main()
{
	#ifdef DISPLAY1
	cout << "We defined display1!" << endl;
	#endif

	#ifdef DISPLAY2
	cout << "We defined display2!" << endl;
	#endif
}
```

We defined display1!
We defined display2!

Preprocessor

- A widely used technique to comment out long pieces of code in large projects

```
#if 0 func();
...
#endif
```

- Companies use this instead of using /* ... */

Outline

- *Preprocessor*
- ***Arrays***
  - ***Basic arrays***
  - Char arrays
  - String arrays
- Use arrays inside a function

Arrays

- A consecutive set of variables of the same type

Arrays

- Two classes of basic arrays

The ordinary ones	The only special one
int a[5]; float b[5]; double c[5]; …	char c[5]

- String arrays

Declare an array

- How to declare an array
  - Type name [# of elements];

```
int a[5];
```

- # of elements:
  - An explicit positive number: 5, 100, ...
  - A predefined integer:

```
#define MAX_LENGTH 100
int a[MAX_LENGTH]
```

  - A constant int:

```
const int num=100;
int a[num];
```

Declare an array

- int variables as # of elements

```
int length = 5;
int a[length];
```

✘

This is not allowed in many compilers.

- int a[]; ✘
- int a[0]; ✘
- int a[2.1]; ✘

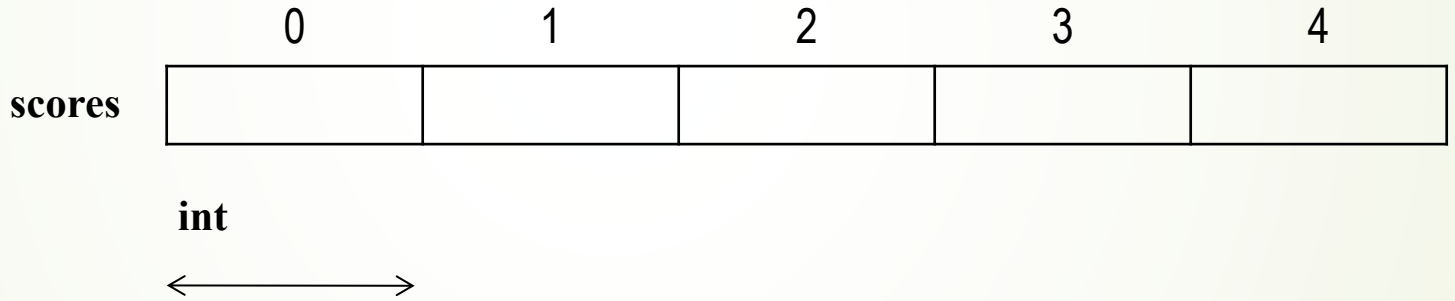
int a[] = {1, 2, 3 } is allowed

Declare an array

- Why do we need to specify a constant #elements for an array?
- Actually it's just an ill-designed feature of the C language
- Elements of an array is **consecutive** in the memory
- If the size of an array can change in C++, it may affect an memory allocation of another variable / array / object, etc...
- **(Though, it appears that some newer versions of compilers are removing this constraint.)**

Declare an array

- int score[5];
  - These elements are numbered (indexed) from 0 to 4



  - The first index in an array is always 0

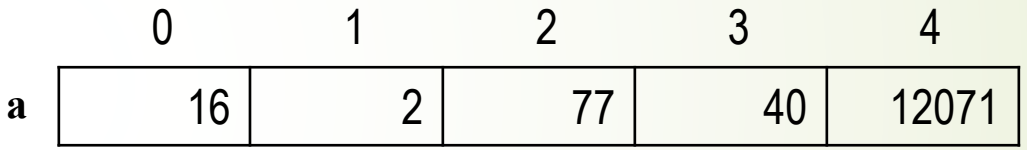
Initialize an array

- Declare an array without initializing it
  - int a[4]; // hasn't been initialized, the values are undefined

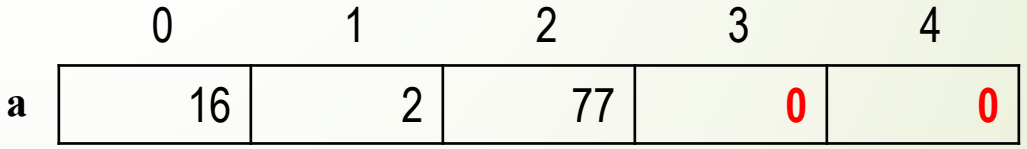
```
int a[4];
cout << a[0] << " " << a[1] << " " << a[2] << " " << a[3] << endl;
```

Acceptable initialization

- The standard way:
  - int a[5] = {16, 2, 77, 40, 12071};
  - int a[] = {16, 2, 77, 40, 12071};



- #values less than #Elements
  - int a[5] = {16, 2, 77}
  - The rest are **all 0**.



Unacceptable initialization

- Invalid #Elements:
  - #values are more than #elements

```
int score[5] = {16, 2, 77, 40, 12071, 0}
```

✘

  - Inconsistent and unconvertible types

```
int a[3] = {18, 72, “abc”}
```

✘

  - How about

```
int a[3] = {18, 72, ‘a’}
```

✔

{18, 72, 97 }

Acceptable / Unacceptable

Acceptable	Unacceptable
int a[5]; const int n=5; int a[n]; float a[] = {1.1, 2.0, 3.5, 4, 5}; int a[5] = {1, 2, 3}; int a[5] = {1, 2, 'a'};	int a[]; int n=5; int a[n]; int a[3] = {1, 2, 3, 4}; int a[3] = {1, 2, "a"};

Initialize an array

Questions:

- How to initialize int a[100] to all 0?

```
int a[100] = {0};
```

- How to initialize int a[100] to all 1?

```
for (int i = 0; i <= 99; ++i)
    a[i] = 1;
```

Access an element of an array

- Random access (or, direct access)

```
name[index];   //index must be non-negative int value
```

- Arithmetic operators can be combined with random access

```
int a[5] = {1, 2, 3, 4, 5}
```

```
a[2] = 5;
```
✔

```
++a[3];
```
✔

```
int x = 1; int b = a[x + 2];
```
✔

```
a[a[2]] = a[2] + 5;
```
✔ i.e. a[3] = 3 + 5;

```
a[5] = 5;
```
✘ out of bound

print an array

```
int a[5] = {1,2,3,4,5}
cout << a[1] << " " << a[3] << endl;
cout << a << endl;
```

output:

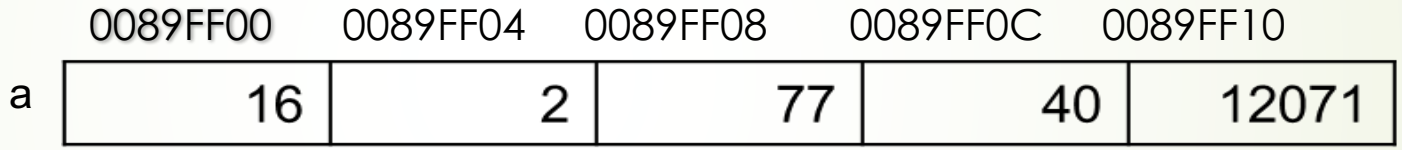
```
2 4
0089FF08
```

Start address of a[] in the memory

- To access an element, we'll get its value.
- If we just access the name of a basic array we will only see the **address** of it.
- **cout is different for char array (see following pages).**

Copy an array (Deep copy)

- The name of an array: the address of the first element in the array.



- How to copy a[] to another array b[]?

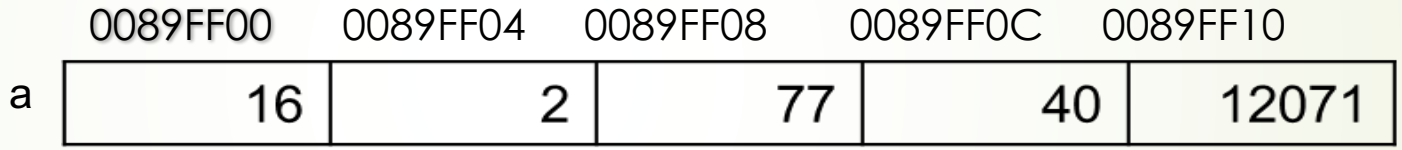
  → Copy it element by element! (**Deep Copy**)

```
int a[] = {16, 2, 77, 40, 12071};
int b[5];
for (int i=0; i<5; ++i) b[i] = a[i];
```

Copy an array

- What if we do b = a?

Not allowed in some compilers.



- This just make *b* and *a* one and the same. *b* is not a hard copy of *a*. *b* is not a hard copy of *a*.

  → (It is **Shallow Copy**; i.e. b = 0x0089FF00)

Deep copy vs. Shallow copy

shallow copy

```
int a[] = {16, 2, 77, 40, 12071};
int b[5];
b = a;
a[0] = 1;
cout << b[0]
```

b and a point to the same address in memory, with the same value

Output: 1

a is {1, 2, 77, 40, 12071}
b is {1, 2, 77, 40, 12071}
// b is exactly the same as a

deep copy

```
int a[] = {16, 2, 77, 40, 12
int b[5];
for (int i=0; i<5; ++i) b[i] = a[i];
a[0] = 1;
cout << b[0] << endl;
```

b and a point to different addresses in memory, but each element in b and a is the same

Output: 16

a is {1, 2, 77, 40, 12071}
b is {16, 2, 77, 40, 12071}

Outline

- *Preprocessor*
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  - ***Char arrays (C-String)***
  - String arrays
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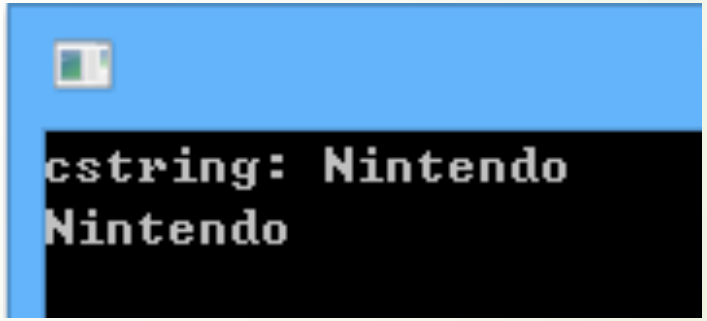
Character array (char c[])

- string in C language (when C++ has not been invented, we call it C-string)
- The special type of array. E.g.:
  - we can initialize it with a string value ("...").
  - we can cin/cout the entire char[] by its name.
  - **It uses a '\0' (0) to denote its end**
- C++ String class is a class extended from char[]

Initialize a char c[]

- initialize a char c[]
  - char c[10] = {‘a’, ‘b’, ‘c’}
  - char c[10] = “abc”
  - cin >> c (not supported for other types of arrays)
- cout << c;

```
char c[100];
cout << "cstring: ";
cin >> c;
cout << c << endl;
cout << endl;
```



Initialize a char c[]

- Question: {‘a’, ‘b’, ‘c’} == “abc” ? NO! (false?)
  - “abc” is actually {‘a’, ‘b’, ‘c’, ‘\0’}, where ‘\0’ (or 0, or NULL) is the end of a string
  - (sizeof(“abc”)/sizeof(char)) is **4** (not 3)
- Question: char c[3];
  - char c[3] = {‘a,’, ‘b’, ‘c’}; ✔
  - char c[3] = “abc”; ✘
- With a c-tring c[**100**], we can initialize it with a string whose length is **99**.

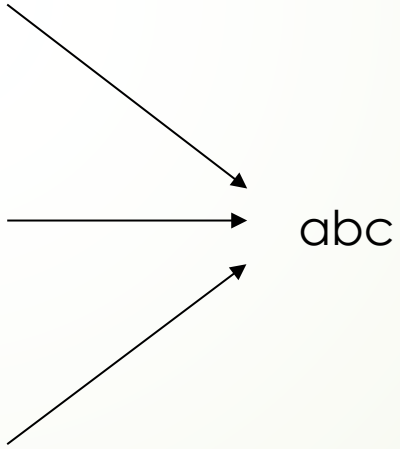
cout a char c[]

- Output characters until reaching a '\0'

```
char c[100] = "abc";
cout << c;
```

```
char c[100] = {'a', 'b', 'c', 0};
cout << c;
```

```
char c[100] = {'a', 'b', 'c'};
cout << c;
```



cout a char c[]

- Question:

```
char c[3] = {‘a’, ‘b‘, ‘c’};
cout << c << endl;
```

Undefined behavior

- What will we get now?

```
char c[3] = {'a', 'b', 'c'};
*(c + 3) = '1'; //ignore this for now
cout << c << endl;
```

A Glance at Two Dimensional Arrays

- int xy[3][4] = {{1,2,3,4}, {5,6,7,8}, {4,3,2,1}};

1	**2**	**3**	**4**
5	6	7	8
4	3	2	1

- xy[1]

5	**6**	**7**	**8**

- xy[1][3] = 8
- xy[2][2] = 2

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String array

- Array of strings.

```
string fruits[4] = "lemon", "coconut", "apple", "orange"};
```

- Each element is a string

```
cout << fruit[1] << endl;
```

output: coconut

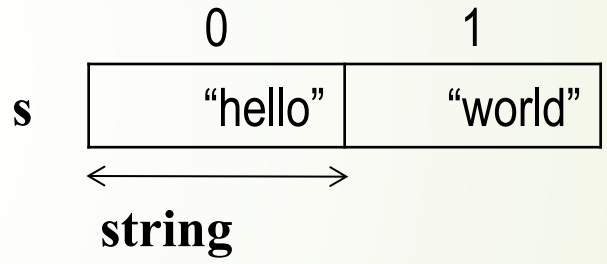
- similar to a two dimensional character array.

```
cout << fruit[1][0] << endl;
```

output: c

String Arrays

```
string s[2];
string hello = “hello”;
s[0] = hello;
s[1] = “world”;
cout << hello[1];
cout << s[0][1];
```




```
output:
ee
```

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Use Arrays Inside a Function

Cannot add #elements to an array parameter

A function will not know the length of a basic array unless you provide it.

```
void print_array(int a[], int len)
{
	for (int i=0;i<len;i++)
		cout << "[" << i << "] = " << a[i] << endl;
}
int main()
{
	int a[7] = [2, 0, 1, 2, 2, 2, 7];
	print_array(a, 7);
}
```

To pass an array to a function, just pass the name of the array.

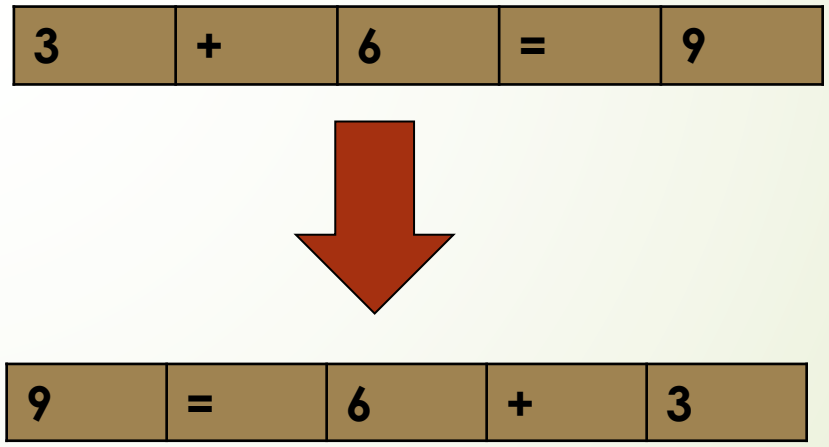
Array As a Parameter

- An array as a parameter is always an **actual (or reference) parameter**. (mutable)

```
void invert_array (char a[], int len) {
      for (int i=0; i < len / 2; ++i) {
            char tmp = a[i];
            a[i] = a[len – 1 – i];
            a[len – 1 – i] = tmp;
      }
}

int main(){
      char a[5] = {‘3’, ‘+’, ‘6’, ‘=‘, ‘9’};
      invert_array(a, 5);
      cout << a;
}
```

9=6+3



One (might be) useful function for project 3

- string substr(unsigned int pos, unsigned int len);
  - str.substr(pos, len): return the substring starting at pos with a length of len
  - string str = “D3/F#3/A3/D4//D3F#3A3D4/”;
  - string chord = str.substr(3, 4); //will get “F#3/”

Thank you!

Preprocessor

- Is macro definition the same as a constant variable?

```
#include <iostream>
using namespace std;
#define MAX(a,b) ((a)>(b)?(a):(b))

#define DISPLAY2 -2147483648

int main()
{
	cout << MAX(2147483648, INT_MAX) << endl;
	return 0;
}
```

That is the MAX macro in the C standard library.