CMSC 240 Lecture 4

CMSC 240 Software Systems Development

Fall 2023

Today

- Collections
- Arrays
- Vectors
- File Input/Output
- In-class coding exercise

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Collections
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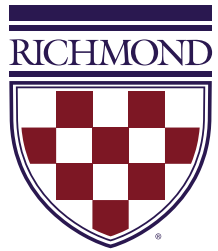
Collections

- Almost all interesting programs process **data**
- Data comes from many sources

- **Collections** are objects that store data, a.k.a. data structures
  - The stored data objects are called **elements**
  - Some collections maintain ordering of elements
  - Some allow for duplicate elements
  - Typical operations: `add`, `remove`, `clear`, `find`, `size`



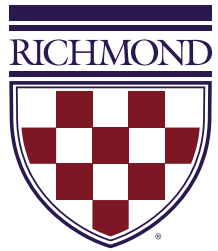
Standard Template Library (STL)

- The C++ Standard Template Library (STL) contains a powerful library of collections for you to use in your programs

- We will learn about collections from the STL library

Containers library

array (C++11)
vector – deque
list – forward_list (C++11)
set – multiset
map – multimap
unordered_map (C++11)
unordered_multimap (C++11)
unordered_set (C++11)
unordered_multiset (C++11)
stack – queue – priority_queue




Arrays
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C-Style Arrays

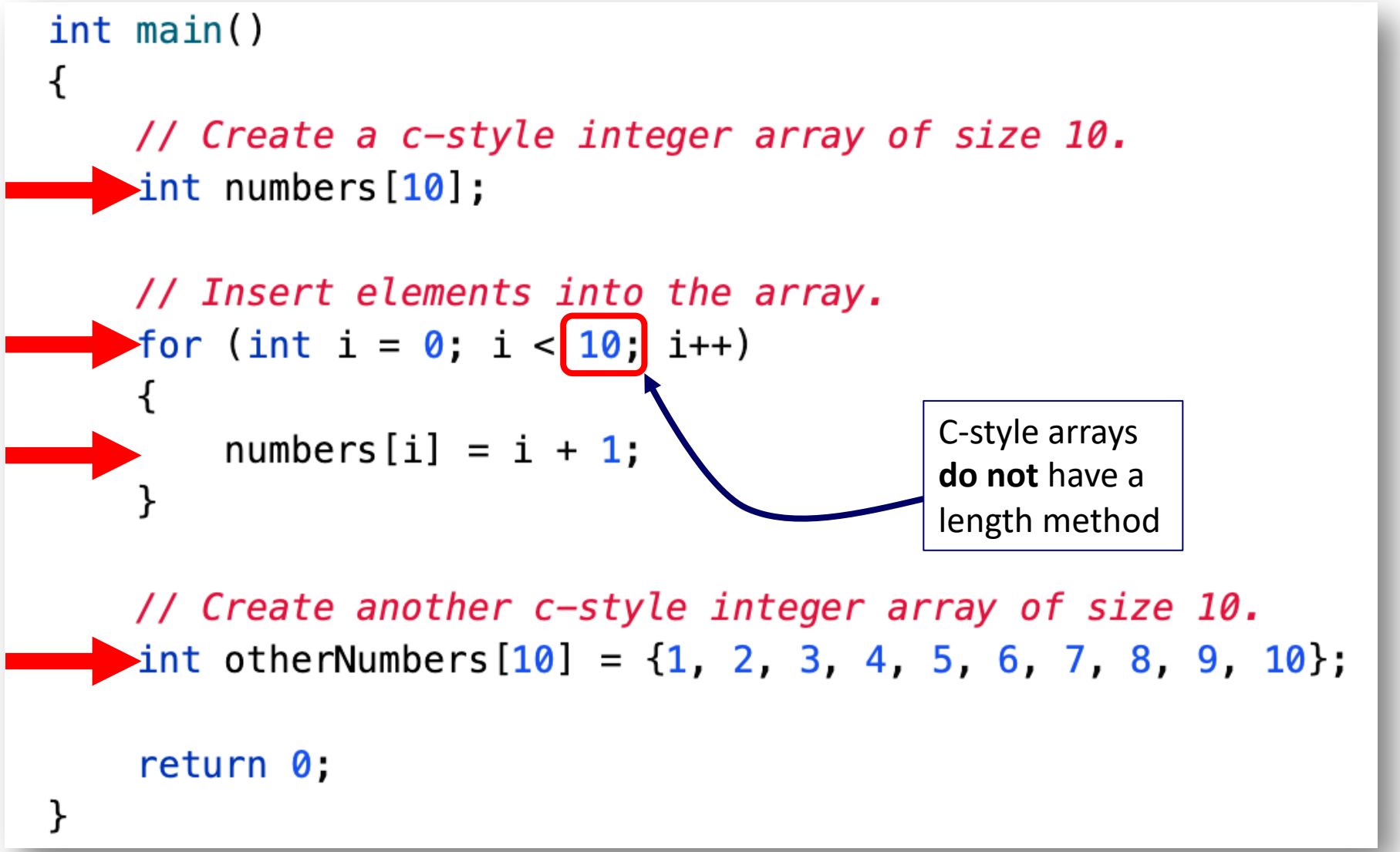
```
int main()
{
    // Create a c-style integer array of size 10.
    int numbers[10];

    // Insert elements into the array.
    for (int i = 0; i < 10; i++)
    {
        numbers[i] = i + 1;
    }

    // Create another c-style integer array of size 10.
    int otherNumbers[10] = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10};

    return 0;
}
```

C-style arrays **do not** have a length method



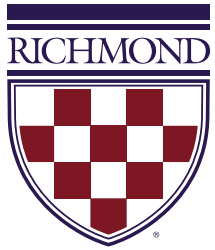
C-Style Arrays

- A C-style array is
  - fixed-sized collection
  - data elements of the same type
  - stored in contiguous memory locations

```
double numbers[4] = {3.1, 2.7, 4.2, 9.9};
```

Index	0	1	2	3
Element	3.1	2.7	4.2	9.9

- Problems with C-style arrays
  - Doesn’t know its own size
  - No methods available
  - Converts to a pointer to its first element



C++ Arrays

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

int main()
{
    // A new integer array object called numbers of size 10.
    array<int, 10> numbers;

    for (int i = 0; i < numbers.size(); i++)
    {
        numbers[i] = i + 1;
    }

    array<int, 10> moreNumbers = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10};

    return 0;
}
```





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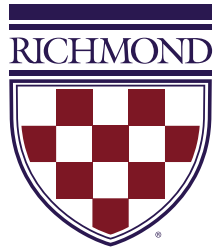
C++ Arrays

Array Member Functions	Description
`a.at(`**`index`**`)`	Return the element at the given **index**
`a.front()`	Return the first element
`a.back()`	Return the last element
`a.empty()`	Checks whether the array is empty
`a.size()`	Returns the number of elements
`a.fill(`**`value`**`)`	Fill the array with specified **value**
`a.swap(`**`array`**`)`	Exchanges the contents of the array with those of the given **array**



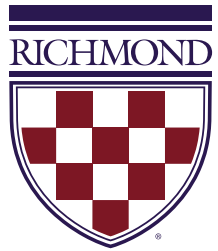
C++ Array Limitations

- They have a **fixed size** and cannot be easily resized after creation
- If you index **out of bounds** of the array, it lets you do it, and you access random garbage memory (yuck!)

```
array<int, 10> numbers;
cout << numbers[323] << endl;  // Clearly out of array bounds!!
```

```
795897921
```

- An array **does not support** many operations that you may want
  - Inserting/deleting elements into the front/middle/back
  - Reversing the order, or sorting the elements
  - Searching the array for a given element



Ask me questions


Vectors
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Vectors

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

int main()
{
    // Create a new vector of integers.
    vector<int> numbers;

    cout << "Enter an integer, or Ctrl-D to quit: ";
    int num;
    while (cin >> num)
    {
        numbers.push_back(num);
        cout << "Enter an integer, or Ctrl-D to quit: ";
    }

    return 0;
}
```




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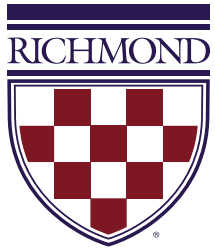
Vector Type Parameters

```
vector<type> name;
```

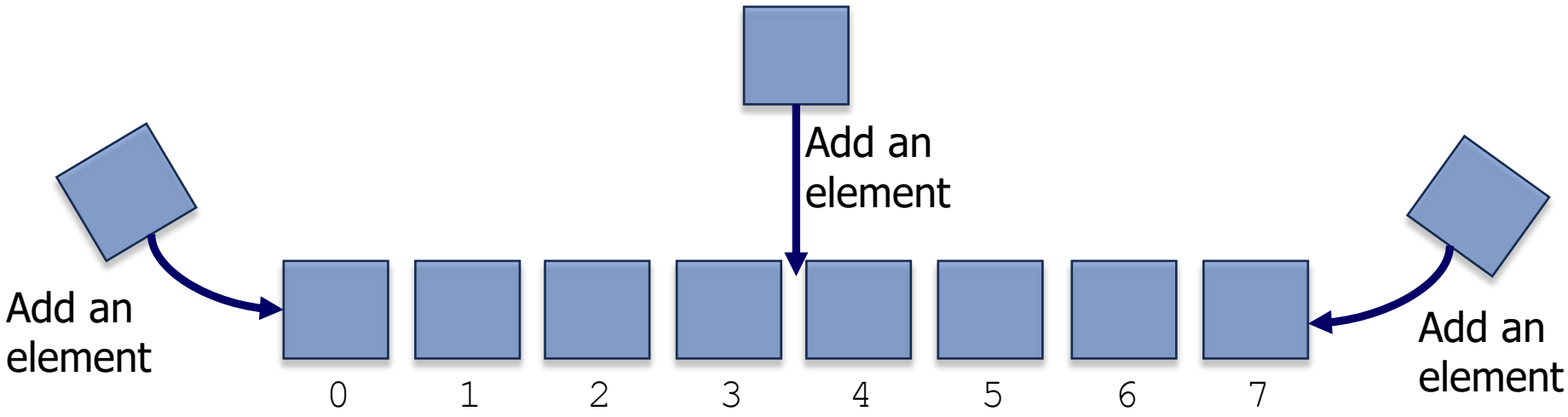
- When constructing a vector, you must specify the **type** of its elements in < >
  - This is called a **type parameter**
  - A vector is a **parameterized class**, aka. **template** classes
- The above constructs a vector object
  - You can use any type of elements, even primitive types like `int`

```
vector<string> mascots;
mascots.push_back("WebstUR");
mascots.push_back("Ram");
mascots.push_back("Turtle");
```



Vectors Are Dynamic

- A **vector** is a dynamic collection of elements with 0-based indexes
  - Elements can be added to the front, back, or elsewhere
  - A vector has a **size** (number of elements that have been added)



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Vectors

- A vector is like an array that **resizes** to fit its contents
  - Similar to an `ArrayList` in Java

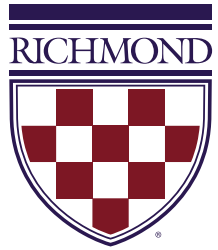
- When a vector is created, it is **initially empty**

```
{ }
```

- You can add items to the vector, by default it adds at the end

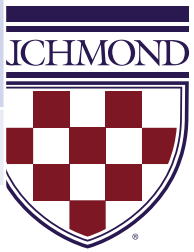
```
{ 3.5, 6.8, 4.2, 0.9 }
```

- Vector objects keep track of the element values that have been added to it, their order, indexes, and its total size
- You can **add**, **remove**, **get**, and **set** any index at any time



Vector Functionality

Vector Member Functions	Description
`v.at(`**`index`**`)`	Return the element at the given **index**
`v.front()`	Return the first element
`v.back()`	Return the last element
`v.empty()`	Checks whether the vector is empty
`v.size()`	Returns the number of elements
`v.clear()`	Clears the contents of the vector
`v.insert(`**`position, value`**`)`	Inserts **value** before **position** in this vector
`v.erase(`**`position`**`)`	Removes the element at **position**
`v.push_back(`**`value`**`)`	Appends the given element **value** to the end
`v.pop_back()`	Removes the last element
`v.swap(`**`vector`**`)`	Exchanges the contents of the vector with those of the given **vector**
`v.emplace(`**`position`**`)`	Inserts a new element directly before **position**



Ask me questions


File Input/Output
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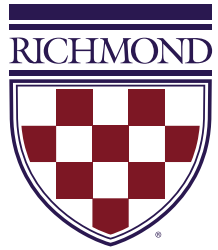
Reading From Files

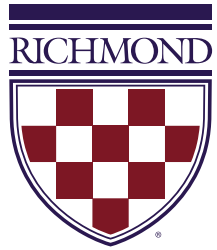
- `#include <fstream>`
  - Imports `ifstream`, `ofstream` classes for input/output files
  - Common pattern: open a file; read each line from it; close it

```
// Read and print every line of a file.
ifstream inputFileStream;
inputFileStream.open("filename.txt");
string line;
while(getline(inputFileStream, line))
{
    cout << line << endl;
}
inputFileStream.close();  // Close stream when done.
```



ifstream Member Functions

ifstream Member Functions	Description
`f.fail()`	Returns true if the last read call failed (e.g. EOF)
`f.open(`**`filename`**`)`	Opens the file represented by given string
`f.close()`	Stops reading the file
`f.get()`	Reads and returns 1 character
`getline(`**`file, line`**`)`	Reads line of input into a string; returns a true/false indicator of success
`f >>` **`var`**	Reads data from input file into variable (like cin)



Reading From Files

```
#include <iostream>
#include <fstream>
#include <string>
using namespace std;

int main()
{
    ifstream inputFile;
    inputFile.open("numbers.txt"); // open the file
    int number;
    string numberText;
    for (int i = 1; i < 8; i++)
    {
        inputFile >> number >> numberText;  // use file stream like cin

        cout << "number = " << number << " " << numberText << endl;
    }
    inputFile.close();  // Close the file.
    return 0;
}
```

```
1 one
2 two
3 three
4 four
5 five
6 six
7 seven
```

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Writing to Files

```
#include <fstream>
using namespace std;

int main()
{
    ofstream outputFile;
    outputFile.open("countdown.txt");  // Open the file for writing.

    for (int i = 10; i > 0; i--)
    {
        outputFile << i << endl;   // Write to the file like cout.
    }

    outputFile.close();  // Close the file.

    return 0;
}
```





In-Class Coding Exercise
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