

Admin

- ◆ Sections start this week
 - Section assignments e-mailed, revisit signup page to switch
- ◆ Compiler installation fun
 - Any news will post to announcements on class web site
- ◆ Today's topics
 - C++ stream classes
 - CS106 class library: Scanner, Vector
- ◆ Reading
 - Reader Ch. 3, Handout I4 (today & next)

Lecture #4

C++ console I/O

- ◆ Stream objects cout/cin
 - cout is the console output stream, cin for console input
 - << is stream insertion, >> is stream extraction
- ◆ Safer, easier read from console using our simpio.h

```
#include <iostream>

int main()
{
    int x,y;
    cout << "Enter two numbers: ";
    cin >> x >> y;
    cout << "You said: " << x << " and " << y << endl;
```

```
#include "simpio.h"

int main()
{
    int x = GetInteger();
    string answer = GetLine();
```

C++ file I/O

- ◆ File streams declared in <fstream>
 - streams are objects, dot notation used
 - ifstream for reading, ofstream for writing
- ◆ Use open to attach stream to file on disk
- ◆ Check status with fail, clear to reset after error

```
#include <fstream>
```

```
ifstream in;
ofstream out;
```

```
in.open("names.txt");
out.open(filename.c_str()); // requires C-string!
```

```
if (in.fail())
    in.clear();
```

Stream operations

- ◆ Read/write single characters
- ◆ Read/write entire lines
- ◆ Formatted read/write
- ◆ Use fail to check for error

```
ch = in.get();
out.put(ch);
```

```
getline(in, line);
out << line << endl;
```

```
in >> num >> str;
out << num << str;
```

```
if (in.fail()) ...
```

Class libraries

- ◆ Some libraries provide free functions
 - `RandomInteger`, `getline`, `sqrt` etc
- ◆ Other libraries provide classes
 - `string`, `stream`
- ◆ Class = data + operations
 - Tight coupling between value and operations that manipulate it
 - Class interface describes *abstraction*
 - Models `string/time/ballot/database/etc` with appropriate features
- ◆ Client use of object
 - Learn the abstraction, use public interface
 - Unconcerned with implementation details

Why is OO so successful?

- ◆ Tames complexity
 - Large programs become interacting objects
 - Each class developed/tested independently
 - Clean separation between client & implementer
- ◆ Objects can model real-world
 - Time, Ballot, ClassList, etc
 - Build on existing understanding of concepts
- ◆ Facilitates re-use
 - Also easily change/extend class in future

CS106 class library

- ◆ Provide common functionality, highly leveraged
 - ◆ Scanner
 - ◆ Vector, Grid, Stack, Queue, Map, Set
- ◆ Why?
 - ◆ Living "higher on the food chain"
 - ◆ Efficient, debugged
 - ◆ Clean abstraction
- ◆ We study as client and later as implementer
 - ◆ Why client-first?

CS106 Scanner

- ◆ Scanner's job: break apart input string into tokens
 - ◆ Mostly divide on white-space
 - ◆ Some logic for recognizing numbers, punctuation, etc.
- ◆ Operations
 - ◆ `setInput`
 - ◆ `nextToken/hasMoreTokens`
 - ◆ Fancy options available with `set/get`
- ◆ Used for?
 - ◆ Handling user input, reading text files, parsing expressions, processing commands, etc.

`This` `line` `contains` `10` `tokens` `.`

Scanner interface

```
class Scanner {
public:
    Scanner();           // constructor (invoked when allocated)
    ~Scanner();         // destructor (invoked when deallocated)

    void setInput(string str); // set string to be scanned

    string nextToken();
    bool hasMoreTokens();

    enum spaceOptionT { PreserveSpaces, IgnoreSpaces };

    void setSpaceOption(spaceOptionT option);
    spaceOptionT getSpaceOption();

    // other advanced options excerpted for clarity
};
```

Client use of Scanner

```
void CountTokens()
{
    Scanner scanner;

    cout << "Please enter a sentence: ";
    scanner.setInput(GetLine());
    int count = 0;
    while (scanner.hasMoreTokens()) {
        scanner.nextToken();
        count++;
    }
    cout << "You entered " << count << " tokens." << endl;
}
```

Containers

- ◆ Most classes in our library are container classes
 - ◆ Store data, provide convenient and efficient access
 - ◆ High utility for all types of programs
- ◆ C++ has a built-in "raw array"
 - ◆ Functional, but serious weaknesses (sizing, safety)
- ◆ CS106B Vector class as a "better" array
 - ◆ Bounds-checking
 - ◆ Add, insert, remove
 - ◆ Memory management, knows its size

Template containers

- ◆ C++ templates perfect for container classes
 - ◆ Template is pattern with one or more placeholders
 - ◆ Client using template fills in placeholder to indicate specific version
- ◆ Vector class as template
 - ◆ Template class has placeholder for type of element being stored
 - ◆ Interface/implementation written using placeholder
 - ◆ Client instantiates specific vectors (vector of chars, vector of doubles) as needed

Vector interface

```
template <typename ElemType>
class Vector {

public:
    Vector();
    ~Vector();

    int size();
    bool isEmpty();

    ElemType getAt(int index);
    void setAt(int index, ElemType value);

    void add(ElemType value);
    void insertAt(int pos, ElemType value);
    void removeAt(int pos);
};
```

Templates are type-safe!

```
#include "vector.h"

void TestVector()
{
    Vector<int> nums;
    nums.add(7);

    Vector<string> words;
    words.add("apple");

    nums.add("banana"); // COMPILE ERROR!
    char c = words.getAt(0); // COMPILE ERROR!
    Vector<double> s = nums; // COMPILE ERROR!
}
```

Rules for template clients

- ◆ Client includes interface file as usual
 - ◆ #include "vector.h"
- ◆ Client must specialize to fill in the placeholder
 - ◆ Cannot use Vector without qualification, must be Vector<char>, Vector<locationT>, ...
 - ◆ Applies to declarations (variables, parameters, return types) and calling constructor
- ◆ Vector is specialized for its element type
 - ◆ Attempt to add locationT into Vector<char> will not compile!

Client use of Vector

```
#include "vector.h"

Vector<int> MakeRandomVector(int sz)
{
    Vector<int> numbers;
    for (int i = 0; i < sz; i++)
        numbers.add(RandomInteger(1, 100));
    return numbers;
}

void PrintVector(Vector<int> &v)
{
    for (int i = 0; i < v.size(); i++)
        cout << v[i] << " ";
}

int main()
{
    Vector<int> nums = MakeRandomVector(10);
    PrintVector(nums);
    ...
}
```