Lab 3: Inheritance and STL

CSCI 104
Why Inheritance?

- Code reuse!!
- Makes code more readable and less repetitive
- Similar concept as for loop

```cpp
cout << arr[0] << endl;
cout << arr[1] << endl;
cout << arr[2] << endl;
```

```cpp
cout << i + " : " + arr[i],
```
What is Inheritance?

- Major in OOP
- Class B inherits from Class A
  - Class B = child class
  - Class A = parent/base class
  - Class B can access all the data members and functions of Class A
  - Class B can also create new data members and functions AND overwrite functions from Class A

```cpp
class B : public A
{
    // ...
}
```
Example

- Print out majors for students and department for professors
- Print out names for everyone

```cpp
class Student {
public:
    Student(std::string name, std::string major);
    std::string getName();
    std::string getMajor();
private:
    std::string mName;
    std::string mMajor;
};

class Professor {
public:
    Professor(std::string name, std::string department);
    std::string getName();
    std::string getDepartment();
private:
    std::string mName;
    std::string mDepartment;
};
```
Example but with Inheritance

- **Person**
  - name
  - age (private)
  - getName()

- **Student**
  - GPA (private)
  - major
  - getMajor()

- **Professor**
  - department
  - salary (private)
  - getDepartment()

- **USC student**
  - uscID (private)
  - uscEmail
  - getUacEmail()
class Person {
  public:
    Person(std::string name);
    std::string getName();
  private:
    std::string mName;
    int mAge;
};

class Professor : public Person {
  public:
    Professor(std::string name, std::string department);
    std::string getDepartment();
  private:
    int mSalary;
    std::string mDepartment;
};

class Student : public Person {
  public:
    Student(std::string name, std::string major);
    std::string getMajor();
  private:
    std::string mMajor;
};

class USCStudent : public Student {
  public:
    USCStudent(std::string name, std::string major);
    std::string getUscEmail();
  private:
    int mUscID;
    std::string mUscEmail;
};
Private, Protected, Public

- **public**: anyone who works with your class can call the function/use the variable
- **protected**: only derived classes can see these functions/variable
- **private**: no one outside the class can access this directly

- **Ask yourself 2 questions**:
  - What does the base class let me see?
    - (everything public and protected)
  - What do I let other classes see?
    - (choose your access accordingly)
Polymorphism

- Determining whether to use the function in child or base class

```cpp
class Person {
  public:
    printTitle(); // prints "Person"
};

class Professor {
  public:
    printTitle(); // prints "Professor"
};

class Student {
  public:
    printTitle(); // prints "Student"
};

class UscStudent {
  public:
    printTitle(); // prints "USC Student"
};
```
Static Binding

- Looks at the Type of pointer

UscStudent* u = new UscStudent();
u->printTitle(); // will print "USC Student"

What will this print out?

Person* p = new UscStudent();
p->printTitle();

```cpp
class Person {
    public:
    printTitle(); // prints "Person"
};

class Professor {
    public:
    printTitle(); // prints "Professor"
};

class Student {
    public:
    printTitle(); // prints "Student"
};

class UscStudent {
    public:
    printTitle(); // prints "USC Student"
};
```
Dynamic Binding

- Virtual keyword
- Looks at the type of object that is being pointed at
- Note: all base classes should have virtual destructor

```cpp
class Person {
    public:
        virtual void printTitle(); // prints "Person"
};

class Professor {
    public:
        void printTitle(); // prints "Professor"
};

class Student {
    public:
        virtual void printTitle(); // prints "Student"
};

class UscStudent {
    public:
        void printTitle(); // prints "USC Student"
};

Person* p = new UscStudent();
p->printTitle(); // USC Student
Abstract Classes

- Class that has at least one pure virtual function
- Virtual function
  - Member function declared in the base class
  - re-defined/overridden in base class
- Pure virtual function
  - Virtual function
  - Only declare it in the base class
  - Implement in the child classes
  - Indication by “=0”
Abstract Class Example

```cpp
class Shape {
    public:
        virtual double getArea() = 0; // = 0 indicates that this class doesn't implement this
        virtual double getPerimeter() = 0;
};
```

- Child classes could include: Circle, Rectangle, Triangle, etc
- To instantiate this class, we need to implement these functions in the children classes
Summary

- **Syntax:**
  ```cpp
  class B : public A
  {
    // ...
  }
  ``

- **Dynamic binding:** go back and check what you are @ function call
  - “virtual”

- **Static binding:** whatever you’re labelled as is what it runs

- “IS-A” relationship (B is-a A)

- **Scope of inheritance**
  - public - everything stays the same
  - protected - all public elements become protected
  - private - everything is private

- **abstract** (virtual function = 0)
  - you can’t instantiate it!
Part 1: Constructors

- Run make in part1 of the folder
- ERROR: “no matching function for call to ‘Person::Person()’ ”
- Compiler confused
  - Inheriting from Person class, need to call constructor
  - Since we didn’t call constructor, default constructor implicitly called
  - But there’s no default constructor for Person
  - Need to explicitly call Person constructor

```cpp
Student::Student(std::string name, std::string major) : Person(name) {
    // rest of student constructor
}
```

Make these changes (to Student, Professor, and UscStudent), and now your code should compile.
Inheritance Visibility

- Write public function printTranscript() in UscStudent class which prints out name of school, student’s name, GPA, and their major
- PROBLEMS when compiling!
Inheritance Visibility

- Need to change access level of GPA data member
- Would compile if we made it public but we don’t want it to be public because then even third parties can access
- Still want to access it from UscStudent Class
- What should we do???
Choosing an Access Modifier

- UscStudent is type of student: needs same data members as Student
- But we don’t want outsiders to have access to setGPA() function
- What inheritance should we use???

```cpp
class UscStudent : protected Student {
```
Part 2: STL (standard template library)
Maps

- Key-value pairs of items
- Operations: search, remove, insert
  - More specifics on these operations in the Bytes page lab writeup
- All $O(\log(n))$

Iterators

- If we want to loop through all elements
- This for loop will take $O(n)$
- Very similar to normal for loops
- Use .begin() and .end()

```cpp
std::map<std::string, std::string>::iterator it;
for (it = myMap.begin(); it != myMap.end(); ++it) {
    std::cout << it->first << std::endl;
    std::cout << it->second << std::endl;
}
```
Iterator notes:

for an array:

```cpp
for(int i = 0; i < n; ++i)
    std::cout << arr[n] << std::endl;
```

for a map

```cpp
std::map<std::string, std::string>::iterator it;
for(it = myMap.begin(); it != myMap.end(); ++it)
{
    std::cout << it->first << std::endl;
    std::cout << it->second << std::endl;
}
```

- same thing: initialization; termination condition; increment
- make sure your iterators are from the **same** map:

```cpp
std::map<std::string, std::string>::iterator it;
for(it = example.getMap().begin(); it != example.getMap().end(); ++it)
{
    //more code here
}
```

**do NOT!! do this! won’t compare correctly! 2 calls to getMap() = 2 instances**

STL

Sets

- Similar to maps
- Only have keys (no values)
- Keys are unique
- Use iterator to walk through all elements

```cpp
// insert into the set
set<string> radioStations;
radioStations.insert("KCRW");
radioStations.insert("KXSC");
string stationName = "KPWR";
radioStations.insert(stationName);

// iterating through the set
for(set<string>::iterator it=radioStations.begin(); it != radioStations.end(); ++it)
{
    // note that we don't have the concept of it->first or it->second, because there are no values, only
    cout << "Station: " << *it << endl;
}

stationName = "KPWR";

// find an element
if(radioStations.find(stationName) != radioStations.end()) {
    cout << stationName + " is a radio station!" << endl;
}
else {
    cout << "Couldn't find this station!" << endl;
}

radioStations.erase("KCRW"); // remove KCRW from the set of names
// if we try to find "KCRW" now, find() will return radioStations.end()
```
<table>
<thead>
<tr>
<th>Action</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insert</td>
<td><code>.insert()</code>&lt;br&gt;<code>map[&quot;key&quot;] = ___</code></td>
</tr>
<tr>
<td>Find</td>
<td><code>.find()</code>&lt;br&gt;<code>map[&quot;key&quot;]</code></td>
</tr>
<tr>
<td>Remove</td>
<td><code>.erase()</code></td>
</tr>
<tr>
<td>Iterate</td>
<td><code>.begin()</code> to <code>.end()</code></td>
</tr>
</tbody>
</table>

- to see what functions are available to you, google it!
- “c++ stl map” or “c++ stl set”
- [https://www.cplusplus.com/reference/map/map/](https://www.cplusplus.com/reference/map/map/)
The Lab

● Follow the bytes page on the lab
● Part1 helps conceptually and the lab page walks you through everything
● Then look at part 2 files
  ○ Three major classes: Schedule, Assignment, Course
  ○ Functions in Assignment and Course are complete, but you need to make small change to Assignment to pass all tests
  ○ Need to implement functions in Schedule
● “Make” will run tests for you
● Need to pass all tests to get checked off OR be working throughout the whole lab section