Introduction to Classes

Unit 4

Chapter 13

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13.2 The Class

- A class in C++ is similar to a structure.
  - It allows you to define a new (composite) data type.
- A class contains the following:
  - variables AND
  - **functions** (these manipulate the variables)
- These are called members
- A class declaration defines the member variables and the prototypes of the member functions.

Example class declaration

```
// models a 12 hour clock

class Time         //new data type
{
  private:
    int hour;
    int minute;
    void addHour();

  public:
    void setHour(int);
    void setMinute(int);
    int getHour() const;
    int getMinute() const;

    string display() const;
    void addMinute();
};
```


Access specifiers

- Used to control access to members of the class
  - public members can be accessed by functions inside AND outside of the class
  - private members can be called or accessed only from functions inside the class (the class's member functions) Private is the default setting for class members.
- Member variables are declared private, to hide their definitions from outside the class.
- Certain functions are declared public to provide controlled access to the hidden/private data.
  - these public functions form the interface to the class

Using const with member functions

- `const` appearing after the parentheses in a member function declaration specifies that the function will **not** change any data inside the object.

```
int getHour() const;
int getMinute() const;
string display() const;
```

- **These** member functions won't change hour or minute.
- Other functions may or may not change them.
- using const here is optional.

Accessors and mutators

- Accessor functions
  - return a value from the object (without changing it)
  - can be defined using const.
  - a "getter" is a special accessor function that returns the value of **one** member variable
- Mutator functions
  - Change the value(s) of member variable(s).
  - a "setter" is a special mutator function that changes (sets) the value of **one** member variable.

Defining member functions

- Member function definitions usually occur after of the class definition.
- The name of each function is preceded by the class name and scope resolution operator (::)

```
void Time::setHour(int hr) {
   hour = hr;
}
```

hour appears to be undefined,
but it is a member variable of the Time class

Defining Member Functions

```
void Time::setHour(int hr) {
  hour = hr;            // hour is a member var
}
void Time::setMinute(int min) {
  minute = min;         // minute is a member var
}
int Time::getHour() const {
  return hour;
}
int Time::getMinute() const {
  return minute;
}

void Time::addHour() {  // a private member func
  if (hour == 12)
     hour = 1;
  else
     hour++;
}
```

Defining Member Functions

```
void Time::addMinute() {
  if (minute == 59) {
     minute = 0;
     addHour();   // call to private member func
  } else
     minute++;
}

string Time::display() const {
    // returns time in string formatted to hh:mm
    string hourString = to_string(hour);
    string minuteString = to_string(minute);
    if (minuteString.length()==1)
        minuteString = "0" + minuteString;
    return hourString + ":" + minuteString;
}
```

to_string(int): converts an int to string.
string.length(): returns number of chars in string.
str1+str2: returns a new string formed by adding chars of str1 followed by chars of str2.

13.3 Defining an instance of the class

- `ClassName variable;`

like declaring a structure variable

```
Time t1;
```

- This defines `t1` to contain an object of type Time (with hour and minute members).
- Then access public members of class with dot notation:

```
t1.setHour(3);
t1.setMinute(41);
t1.addMinute();
```

calls to member functions

Using the Time class

```
int main() {
  Time t;
  t.setHour(12);
  t.setMinute(58);
  cout << t.display() <<endl;
  t.addMinute();
  cout << t.display() << endl;
  t.addMinute();
  cout << t.display() << endl;
}
```

Output:

```
12:58
12:59
1:00
```

Note: the program includes the code from slides 3, 8, 9, and 11 (and any #includes needed). See AllTime.cpp in timedemo.zip

13.1 Procedural Programming

A style of programming in which:

- Data is stored in variables
  - Perhaps using arrays and structs.
- Program is a collection of functions that perform operations over the variables
  - Good example: PA2 Music Library program
- Variables are passed to the functions as arguments
- Focus is on organizing and implementing the **functions**.

Procedural Programming: Problem

- It is not uncommon for
  - program specifications to change
  - representations of data to be changed for internal improvements.
- As procedural programs become larger and more complex, it is difficult to make changes.
  - A change to a given variable or data structure requires changes to all of the functions operating over that variable or data structure.
- Example: use vectors or linked lists instead of arrays for the inventory

Object Oriented Programming: Solution

- An object (instance of a class) contains
  - data (like fields of a struct)
  - functions that operate over that data
- Code outside the object can access the data **only** through the object's functions.
- If the representation of the data inside the object needs to change:
  - Only the object's function definitions must be redefined to adapt to the changes.
  - The code outside the object does not need to change, it accesses the object in the same way.

Object Oriented Programming: Concepts

- **Encapsulation**: combining data and code into a single object.
- **Data hiding** (or **Information hiding**) is the ability to hide the details of data representation from the code outside of the object.
- **Interface**: the mechanism that code outside the object uses to interact with the object.
  - The object's (public) functions
  - Specifically, outside code needs to "know" only the function prototypes (not the function bodies).

Object Oriented Programming: Real World Example

- In order to drive a car, you need to understand only its interface:
  - ignition switch
  - gas pedal, brake pedal
  - steering wheel
  - gear shifter
- You don't need to understand how the steering works internally.
- You can operate any car with the same interface.

Classes and Objects

- A class is like a blueprint for an object.
  - a detailed description of an object.
  - used to make many objects.
  - these objects are called **instances** of the class.
- For example, the string class in C++.
  - Make an instance (or two):

```
string cityName1="Austin", cityName2="Dallas";
```

  - use the object's functions to work with the objects:

```
int size = cityName1.length();
cityName2.append(" Cowboys");
```


13.5 Separating Specs from Implementation

- Class declarations are usually stored in their own "header files" (Time.h)
  - called the specification file
- Member function definitions are stored in a separate file (Time.cpp)
  - called the class implementation file
- Main function and standalone functions go in a third file (Driver.cpp)

See the Multi-file Development Lecture and timedemo.zip

13.6 Inline member functions

- Member functions can be defined
  - after the class declaration (normally) OR
  - inline: in class declaration
- Inline is appropriate for short function bodies:

```
class Time {
  private:
    int hour;
    int minute;
    void addHour();  // not inlined
  public:
    int getHour() const   {  return hour; }
    int getMinute() const {  return minute; }
    void setHour(int h)   {  hour = h; }
    void setMinute(int m) {  minute = m; }
    string display() const;  //not inlined
    void addMinute();        //not inlined
};
```


13.7 Constructors

- A constructor is a member function with the same name as the class.
- It is called automatically when an object is created
- It performs initialization of the new object
- It has no return type

```
class Time
{
    private:
      int hour;
      int minute;
      void addHour();
    public:
      Time();      // Constructor prototype
...
```

Constructor Definition

- Note no return type, prefixed with Class::

```
// file Time.cpp
#include <sstream>
#include <iomanip>
using namespace std;

#include "Time.h"

Time::Time() {   // initializes hour and minute
   hour = 12;
   minute = 0;
}
void Time::setHour(int hr) {
  hour = hr;
}
void Time::setMinute(int min) {
  minute = min;
}
```


Constructor "call"

- From main:

```
//using Time class (Driver.cpp)
#include<iostream>
#include "time.h"
using namespace std;

int main() {
  Time t;          //Constructor called implicitly here

  cout << t.display() <<endl;
  t.addMinute();
  cout << t.display() << endl;
}
```

Output:

```
12:00
12:01
```


13.8 Passing Arguments to Constructors

- To create a constructor that takes arguments:
  - Indicate the parameters in the prototype:

```
class Time
{
   public:
      Time(int,int);      // Constructor prototype
...
```

  - Use the parameters in the definition:

```
Time::Time(int hr, int min) {
   hour = hr;
   minute = min;
}
```


Passing Arguments to Constructors

- Pass arguments to the constructor when you create an object (in the declaration):

```
int main() {
  Time t (12, 59);
  cout << t.display() <<endl;
}
```

Output:

```
12:59
```

Default Constructors

- A default constructor is a constructor that takes no arguments (like Time()).
- If you write a class with NO constructors, the compiler will include a default constructor for you, one that does (almost) nothing.
- The original version of the Time class did not define a constructor, so the compiler provided a constructor for it.

Classes with no Default Constructor

- When all of a class's constructors require arguments, then the class has NO default constructor.
  - C++ will NOT automatically generate a constructor with no arguments unless your class has NO constructors at all.
- When there are constructors, but no default constructor, you **must** pass the required arguments to the constructor when creating an object.

13.9 Destructors

- Member function that is automatically called when an object is destroyed.
- Destructor name is ~classname, e.g., `~Time`
- Has no return type; takes no arguments.
- Only one destructor per class
  (it cannot be overloaded, cannot take arguments).
- If the class dynamically allocates memory, the destructor should release (delete) it

Destructors

- Example: Inventory class, with a dynamically allocated array of part numbers:

Inventory.h

```
class Inventory {
   private:
      String *parts;  //dynamically allocated array
      int count;
   public:
      Inventory (int);
      ~Inventory();       //destructor
      bool addPart(string);
      int removePart(string);
      void showInventory();
};
```

Destructors

- Example: member function definitions for constructor and destructor:

Inventory.cpp

```
#include "Inventory.h"

Inventory::Inventory(int size){
   parts = new String[size]; //dynamic allocation
   count = 0;
}

Inventory::~Inventory() {
   delete [] parts;
}
```


Destructors

- Example: driver creates and destroys an Inventory

```
int main() {

  Inventory inv(100);  //calls constructor, allocates array

  //do stuff with inv here

}  //end of main, inv object destroyed here,
   // calls its destructor (which deletes parts array)
```

- When is an object destroyed?
  - at the end of its scope (regular variables) OR
  - when it is deleted (if it's dynamically allocated)

13.10 Overloaded Constructors

- Recall: when 2 or more functions have the same name they are *overloaded*.
- A class can have more than one constructor function
  - They have the same name, so they are overloaded
- Overloaded functions must have different parameter lists:

```
class Time
{
    private:
      int hour;
      int minute;
    public:
      Time();
      Time(int);
      Time(int,int);
...
```


Overloaded Constructors

- definitions:

```
#include "Time.h"

Time::Time() {
   hour = 12;
   minute = 0;
}
Time::Time(int hr) {
   hour = hr;
   minute = 0;
}
Time::Time(int hr, int min) {
   hour = hr;
   minute = min;
}
```

Overloaded Constructor "call"

- From main:

```
int main() {
  Time t1;
  Time t2(2);
  Time t3(4,50);

  cout << t1.display() <<endl;
  cout << t2.display() <<endl;
  cout << t3.display() << endl;
}
```

Output:

```
12:00
2:00
4:50
```


13.12 Arrays of Objects

- An array can contain objects (the element type can be a Class):

```
int main() {

  Time recentCalls[10];  //times of last 10 phone calls

}
```

- The default constructor (Time()) is used to initialize each element of the array when it is created.
- This array is initialized to 10 Time objects, each set to 12:00.
- To invoke a constructor that takes arguments, you must use an initializer list . . .

Arrays of Objects
initializer lists

- Each initializer takes the form of a function call:

```
int main() {
  Time  recentCalls[7] = {Time(1),
                          Time(2,13),
                          Time(3,24),
                          Time(4),
                          Time(4,50)};
}
```

- If there are fewer initializers in the list than elements in the array, the default constructor will be called for all the remaining elements.
- This array is initialized to 7 Time objects, set to 1:00, 2:13, 3:24, 4:00, 4:50, 12:00 and 12:00.

Accessing Objects in an Array

- Objects in an array are referenced using subscripts
- Member functions are referenced using dot notation
- Must access the specific object in the array BEFORE calling the member function:

```
recentCalls[2].setMinute(30);
cout << recentCalls[4].display() << endl;
```

- Processing array elements in a loop:

```
for (int i=0; i<7; i++)
   cout << recentCalls[i].display() << " ";
cout << endl;
```

Composition

- When one class contains another as a member:

Calls.h

```
#include "Time.h"
class Calls
{
  private:
    Time calls[10];  // times of 10 phone calls
    // this array is initialized using default constructor
  public:
    void set(int,Time);
    void displayAll();
}
```

Calls.cpp

```
#include <iostream>
using namespace std;
#include "Calls.h"

void Calls::set(int i, Time t) {
   calls[i] = t;
}
void Calls::displayAll () {
   for (int i=0; i<10; i++) {
      cout << calls[i].display();     //calls member function
      cout << "  ";
   }
}
```


Composition

- Driver for Calls

```
//Example using Calls and Time classes
#include<iostream>
using namespace std;
#include "Calls.h"     //this includes "Time.h"

int main() {
    Calls callTimes;
    Time t1(4,30);
    callTimes.set(0,t1);
    Time t2(11,42);
    callTimes.set(1,t2);

    callTimes.displayAll();
    cout  << endl;
}
```

Output:

```
4:30 11:42 12:00 12:00 12:00 12:00 12:00 12:00 12:00 12:00
```