Chapter 7

INTRODUCTION TO CLASSES

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Programming Fundamentals
Chapter 7

- Classes
- Information Hiding
- Member functions
- Dynamic Memory Allocation using *new* and *delete* operators
Overview

- Object-oriented programming (OOP) *encapsulates* data (attributes) and functions (behavior) into packages called *classes*.
- The data and functions of a class are intimately tied together.
- A class is like a blueprint. Out of a blueprint, a builder can build a house. Out of a class, we can create many objects of the same class.
- Classes have the property of *information hiding*. Implementation details are hidden within the classes themselves.
In C++ programming, classes are structures that contain variables along with functions for manipulating that data.

The functions and variables defined in a class are referred to as *class members*.

Class variables are referred to as *data members*, while class functions are referred to as *member functions*.

Classes are referred to as user-defined data types because you can work with a class as a single unit, or objects, in the same way you work with variables.
Class definition

- The most important feature of C++ programming is class definition with the `class` keyword. You define classes the same way you define structures.

Example:

```cpp
class Time {
public:
    Time();
    void setTime( int, int, int );
    void printMilitary();
    void printStandard();
private:
    int hour;
    int minute;
    int second;
};
```
Instantiating an object

- Once the class has been defined, it can be used as a type in object, array and pointer definitions as follows:
  
  ```
  Time sunset,    // object of type Times
  ArOfTimes[5],   // array of Times objects
  *ptrTime;        // pointer to a Times objects
  ```

- The class name becomes a new type specifier. There may be many objects of a class, just as there may be many variables of a type such as `int`.

- The programmer can create new class types as needed.
The principle of *information hiding* states that any class members that other programmers do not need to access or know about should be hidden.

Many programmers prefer to make all of their data member “private” in order to *prevent* clients from accidentally assigning the wrong value to a variable or from viewing the internal workings of their programs.
Access Specifiers

- Access specifiers control a client’s access to data members and member functions. There are four levels of access specifiers: **public, private, protected,** and **friend.**

- The **public** access specifier allows anyone to call a class’s function member or to modify a data member.

- The **private** access specifier is one of the key elements in information hiding since it prevents clients from calling member functions or accessing data members.

**Note:** Class members of both access types are accessible from any of a class’s member functions.
Example

class Time {
public:
  Time();
  void setTime( int, int, int );
  void printMilitary();
  void printStandard();
private:
  int hour;
  int minute;
  int second;
};

A class’ private data members are normally not accessible outside the class
Interface and Implementation Files

- The separation of classes into separate *interface* and *implementation files* is a fundamental software development technique.

- The *interface* code refers to the data member and function member declarations inside a class’s braces.

- The *implementation* code refers to a class’s function definitions and any code that assigns values to a class’s data members.
Preventing Multiple Inclusion

- With large program, you need to ensure that you do not include multiple instances of the same header file.
- C++ generates an error if you attempt to compile a program that includes multiple instances of the same header file.

- To prevent this kind of error, we use the `#define` preprocessor directive with the `#if` and `#endif` directives in header files.

- The `#if` and `#endif` determine which portions of a file to compile depending on the result of a conditional expression.

- The syntax for the `#if` and `#endif` preprocessor directives:

  ```
  #if conditional expression
  statements to compile;
  #endif
  ```
Example:
#if !defined(TIME1_H)
define TIME1_H
class Time {
public:
    Time();
    void setTime( int, int, int );
    void printMilitary();
    void printStandard();
private:
    int hour;
    int minute;
    int second;
};
#endif

Note: Common practice when defining a header file’s constant is to use the header file’s name in uppercase letters appended with H.

For example, the constant for the time1.h header is usually defined as TIME1_H.
**MEMBER FUNCTIONS**

- **Inline functions**
  Although member functions are usually defined in an implementation file, they can also be defined in an interface file. Functions defined in an interface file are called *inline functions*.

- **Example:**
  
  ![Diagram of Stocks class with iNumShares, dPurchasePricePerShare, dCurrentPricePerShare, and getTotalValue()]

  ```
  Stocks
  
iNumShares
  dPurchasePricePerShare
  dCurrentPricePerShare
  
  getTotalValue()
  ```
class Stocks {
public:
    double getTotalValue(int iShares, double dCurPrice) {
        double dCurrentValue;
        iNumShares = iShares;
        dCurrentPricePerShare = dCurPrice;
        dCurrentValue = iNumShares * dCurrentPricePerShare;
        return dCurrentValue;
    }
private:
    int iNumShares;
    double dPurchasePricePerShare;
    double dCurrentPricePerShare;
};
Member functions in Implementation File

Example 7.3.1

//stocks.h
#if !defined(STOCKS_H)
define STOCKS_H
class Stocks{
public:
    double getTotalValue(int iShares, double dCurPrice);
private:
    int iNumShares;
    double dPurchasePricePerShare;
    double dCurrentPricePerShare;
};
#endif
// stocks.cpp
#include "stocks.h"
#include<iostream.h>

double Stocks::getTotalValue(int iShares, double dCurPrice){
    double dCurrentValue;
    iNumShares = iShares;
    dCurrentPricePerShare = dCurPrice;
    dCurrentValue = iNumShares* dCurrentPricePerShare;
    return dCurrentValue;
}

void main(){
    Stocks stockPick;
    cout << stockPick.getTotalValue(200, 64.25) << endl;
}

Output of the above program:
12850
The format of member functions included in the implementation section is as follows:

```
return-type Class-name::functionName(parameter-list) {
    function body
}
```

In order for your class to identify which functions in an implementation section belong to it, you precede the function name in the function header with the class name and the scope resolution operator (::).
Access Functions

- Access to a class’ private data should be controlled by the use of member functions, called *access functions*.

- For example, to allow clients to read the value of private data, the class can provide a *get* function.

- To enable clients to modify private data, the class can provide a *set* function. A *set* member function can provide data validation capabilities to ensure that the value is set properly.

- A *set* function can also translate between the form of data used in the interface and the form used in the implementation.

- A *get* function need not expose the data in “raw” format; rather, it can edit data and limit the view of the data the client will see.
An example of *set* and *get* functions

```
// time1.h
#if !defined(TIME1_H)
#define TIME1_H

class Time {
public:
    Time();                        // constructor
    void setTime( int, int, int ); // set hour, minute, second
    void printMilitary();          // print military time format
    void printStandard();          // print standard time format
private:
    int hour;
    int minute;
    int second;
};
```
// time1.cpp
#include "time1.h"
#include <iostream.h>

......

void Time::setTime( int h, int m, int s ){
    hour = ( h >= 0 && h < 24 ) ? h : 0;
    minute = ( m >= 0 && m < 60 ) ? m : 0;
    second = ( s >= 0 && s < 60 ) ? s : 0;
}

void Time::printMilitary(){
    cout << ( hour < 10 ? "0" : "" ) << hour << ":
    << ( minute < 10 ? "0" : "" ) << minute;
}

void Time::printStandard(){
    cout << ( ( hour == 0 || hour == 12 ) ? 12 : hour % 12 )
    << ":" << ( minute < 10 ? "0" : "" ) << minute
    << ":" << ( second < 10 ? "0" : "" ) << second
    << ( hour < 12 ? " AM" : " PM" );
}

......
Constructor Functions

- A constructor function is a special function with the same name as its class. This function is called automatically when an object from a class is instantiated.
- You define and declare constructor functions the same way you define other functions.

Example:
```cpp
class Payroll{
public:
    Payroll() { // constructor function
        dFedTax = 0.28;
        dStateTax = 0.05;
    }
private:
    double dFedTax;
    double dStateTax;
};
```
You also include just a *function prototype* in the interface file for the constructor function and then create the *function definition* in the implementation file.

```cpp
Payroll::Payroll( ) {    // constructor function
dFedTax = 0.28;
dStateTax = 0.05;
};
```

**Constructor functions do not return values.**
Example 7.3.3

```cpp
#include <iostream.h>
#include <iomanip.h>
// class declaration section
class Date {
    private:
        int month;
        int day;
        int year;
    public:
        Date(int = 7, int = 4, int = 2001); // constructor
};
```

```cpp
// implementation section
Date::Date(int mm, int dd, int yyyy) //constructor
{
    month = mm;
    day = dd;
    year = yyyy;
    cout << "Created a new data object
with data values "
    << month << ", " << day << ", "
    << year << endl;
}
```
int main()
{
    Date a;       // declare an object without parameters
    Date b;       // declare an object without parameters
    Date c(4,1,2002); // declare an object with parameters
    return 0;
}

The output of the above program:

Created a new data object with data values 7, 4, 2001
Created a new data object with data values 7, 4, 2001
Created a new data object with data values 4,1, 2001

- **Default constructor** refers to any constructor that does not require any parameters when it is called.
DYNAMIC MEMORY ALLOCATION WITH OPERATORS new AND delete

- The `new` and `delete` operators provide a nice means of performing dynamic memory allocation (for any built-in or user-defined type).

```
TypeName *typeNamePtr;
typeNamePtr = new TypeName;
```

- The `new` operator automatically creates an object of the proper size, calls the constructor for the object and returns a pointer of the correct type.

- To destroy the object and free the space for this object you must use the `delete` operator:

```
delete typeNamePtr;
```
For built-in data types, we also can use the `new` and `delete` operators.

Example 1:

```cpp
int *pPointer;
pPointer = new int;
```

Example 2:

```cpp
delete pPointer;
```

Example 3: A 10-element integer array can be created and assigned to `arrayPtr` as follows:

```cpp
int *arrayPtr = new int[10];
This array is deleted with the statement
```
Stack versus heap

- A *stack* is a region of memory where applications can store data such as local variables, function calls, and parameters.

- The programmers have no control over the stack. C++ automatically handles placing and removing data to and from stack.

- The *heap* or free store, is an area of memory that is available to application for storing data whose existence and size are not known until run-time.

- **Note:** When we use *new* operator, we can allocate a piece of memory on the heap and when we use *delete* operator, we can deallocate (free) a piece of memory on the heap.
Example 7.4.1
#include<iostream.h>
void main( )
{
    double* pPrimeInterest = new double;
    *pPrimeInterest = 0.065;
    cout << "The value of pPrimeInterest is: "
        << *pPrimeInterest << endl;
    cout << "The memory address of pPrimeInterest is:"
        << &pPrimeInterest << endl;
    delete pPrimeInterest;
    *pPrimeInterest = 0.070;
    cout << "The value of pPrimeInterest is: "
        << *pPrimeInterest << endl;
    cout << "The memory address of pPrimeInterest is:"
        << &pPrimeInterest << endl;
}
The output of the above program:

The value of pPrimeInterest is: 0.065
The memory address of pPrimeInterest is: 0x0066FD74
The value of pPrimeInterest is: 0.070
The memory address of pPrimeInterest is: 0x0066FD74.

Note: You can see that after the delete statement executes, the pPrimeInterest pointer still point to the same memory address!!!
Example 7.4.2

In the following program, we can create some objects of the class \textit{Stocks} on the stack or on the heap and then manipulate them.

```cpp
#include<iostream.h>

class Stocks{
    public:
        int iNumShares;
        double dPurchasePricePerShare;
        double dCurrentPricePerShare;
    }

double totalValue(Stocks* pCurStock){
    double dTotalValue;
    dTotalValue = pCurStock->dCurrentPricePerShare*
                  pCurStock->iNumShares;
    return dTotalValue;
}
```
void main( ){
    //allocated on the stack with a pointer to the stack object
    Stocks stockPick;
    Stocks* pStackStock = &stockPick;
    pStackStock->iNumShares = 500;
    pStackStock->dPurchasePricePerShare = 10.785;
    pStackStock->dCurrentPricePerShare = 6.5;
    cout << totalValue(pStackStock) << endl;
    //allocated on the heap
    Stocks* pHeapStock = new Stocks;
    pHeapStock->iNumShares = 200;
    pHeapStock->dPurchasePricePerShare = 32.5;
    pHeapStock->dCurrentPricePerShare = 48.25;
    cout << totalValue(pHeapStock) << endl;
}

The output of the above program:

3250
9650
Note

- When declaring and using pointers and references to class objects, follow the same rules as you would when declaring and using pointers and references to structures.

- You can use the *indirect member selection operator* (->) to access class members through a pointer to an object either on stack or on the heap.

- As we will see, using *new* and *delete* offers other benefits as well. In particular, *new* invokes the constructor and *delete* invokes the class’ destructor.
A class can contain any C++ data type. Thus, the inclusion of a pointer variable in a class should not seem surprising.

Example 7.5.1
#include <iostream.h>
#include <string.h>
// class declaration
class Book
{
private:
    char *title;  // a pointer to a book title
public:
    Book(char * = NULL);  // constructor with a default value
    void showtitle();    // display the title
};
// class implementation
Book::Book(char *strng)
{
    title = new char[strlen(strng)+1];  // allocate memory
    strcpy(title,strng);                // store the string
}
void Book::showtitle()
{
    cout << title << endl; return;
}
int main()
{
    Book  book1("DOS Primer");   // create 1st title
    Book  book2("A Brief History of Western Civilization");
    book1.showtitle();   // display book1's title
    book2.showtitle();   // display book2's title
    return 0;
}