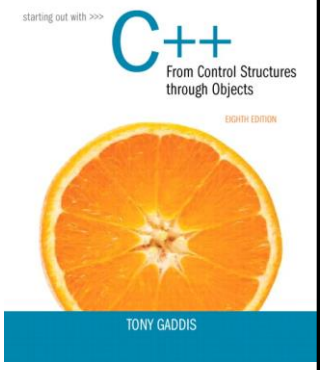
Chapter 14:

More About Classes



14.1

Instance and Static Members

Instance and Static Members

- instance variable: a member variable in a class. Each object has its own copy.
- `static` variable: one variable shared among all objects of a class
- `static` member function: can be used to access `static` member variable; can be called before any objects are defined

`static` member variable

Contents of `Tree.h`

Static member declared here.

```
// Tree class
class Tree
{
private:
   static int objectCount;    // Static member variable.
public:
   // Constructor
   Tree()
      { objectCount++; }

   // Accessor function for objectCount
   int getObjectCount() const
      { return objectCount; }
};

// Definition of the static member variable, written
// outside the class.
int Tree::objectCount = 0;
```

Static member defined here.

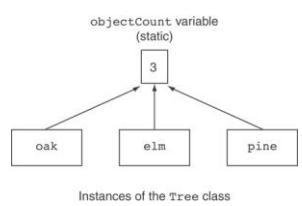
Program 14-1

```
// This program demonstrates a static member variable.
#include <iostream>
#include "Tree.h"
using namespace std;

int main()
{
   // Define three Tree objects.
   Tree oak;
   Tree elm;
   Tree pine;

   // Display the number of Tree objects we have.
   cout << "We have " << pine.getObjectCount()
        << " trees in our program!\n";
   return 0;
}
```

Program Output

```
We have 3 trees in our program!
```


Three Instances of the Tree Class, But Only One `objectCount` Variable



`static` member function

- Declared with `static` before return type:

```
static int getObjectCount() const
{ return objectCount; }
```

- Static member functions can only access static member data
- Can be called independent of objects:

```
int num = Tree::getObjectCount();
```


Modified Version of `Tree.h`

```
// Tree class
class Tree
{
private:
   static int objectCount;    // Static member variable.
public:
   // Constructor
   Tree()
      { objectCount++; }

   // Accessor function for objectCount
   static int getObjectCount() const
      { return objectCount; }
};

// Definition of the static member variable, written
// outside the class.
int Tree::objectCount = 0;
```

Now we can call the function like this:

```
cout << "There are " << Tree::getObjectCount()
     << " objects.\n";
```


14.2

Friends of Classes

Friends of Classes

- Friend: a function or class that is not a member of a class, but has access to private members of the class
- A friend function can be a stand-alone function or a member function of another class
- It is declared a friend of a class with `friend` keyword in the function prototype

`friend` Function Declarations

- Stand-alone function:

```
friend void setAVal(intVal&, int);
// declares setAVal function to be
// a friend of this class
```

- Member function of another class:

```
friend void SomeClass::setNum(int num)
// setNum function from SomeClass
// class is a friend of this class
```


`friend` Class Declarations

- Class as a friend of a class:

```
class FriendClass
{
  ...
};
class NewClass
{
  public:
    friend class FriendClass; // declares
  // entire class FriendClass as a friend
  // of this class
  ...
};
```

14.3

Memberwise Assignment

Memberwise Assignment

- Can use = to assign one object to another, or to initialize an object with an object's data
- Copies member to member. *e.g.*,

  `instance2 = instance1;` means:

  copy all member values from `instance1` and assign to the corresponding member variables of `instance2`
- Use at initialization:

  `Rectangle r2 = r1;`

Program 14-5

```
// This program demonstrates memberwise assignment.
#include <iostream>
#include "Rectangle.h"
using namespace std;

int main()
{
   // Define two Rectangle objects.
   Rectangle box1(10.0, 10.0);  // width = 10.0, length = 10.0
   Rectangle box2 (20.0, 20.0);  // width = 20.0, length = 20.0

   // Display each object's width and length.
   cout << "box1's width and length: " << box1.getWidth()
        << " " << box1.getLength() << endl;
   cout << "box2's width and length: " << box2.getWidth()
        << " " << box2.getLength() << endl << endl;

   // Assign the members of box1 to box2.
   box2 = box1;

   // Display each object's width and length again.
   cout << "box1's width and length: " << box1.getWidth()
        << " " << box1.getLength() << endl;
   cout << "box2's width and length: " << box2.getWidth()
        << " " << box2.getLength() << endl;

   return 0;
}
```


Program 14-5 *(continued)*

Program Output

```
box1's width and length: 10 10
box2's width and length: 20 20

box1's width and length: 10 10
box2's width and length: 10 10
```


14.4

Copy Constructors

Copy Constructors

- Special constructor used when a newly created object is initialized to the data of another object of same class
- Default copy constructor copies field-to-field
- Default copy constructor works fine in many cases

Copy Constructors

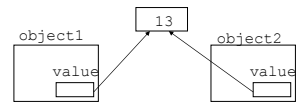
Problem: what if object contains a pointer?

```
class SomeClass
{ public:
     SomeClass(int val = 0)
        {value=new int; *value = val;}
     int getVal();
     void setVal(int);
    private:
     int *value;
}
```


Copy Constructors

What we get using memberwise copy with objects containing dynamic memory:

```
SomeClass object1(5);
SomeClass object2 = object1;
object2.setVal(13);
cout << object1.getVal(); // also 13
```



Programmer-Defined Copy Constructor

- Allows us to solve problem with objects containing pointers:

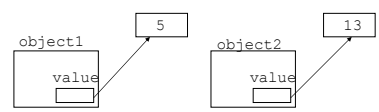
```
SomeClass::SomeClass(const SomeClass &obj)
{
   value = new int;
   *value = obj.value;
}
```

- Copy constructor takes a reference parameter to an object of the class

Programmer-Defined Copy Constructor

- Each object now points to separate dynamic memory:

```
SomeClass object1(5);
SomeClass object2 = object1;
object2.setVal(13);
cout << object1.getVal(); // still 5
```



Programmer-Defined Copy Constructor

- Since copy constructor has a reference to the object it is copying from,

```
SomeClass::SomeClass(SomeClass &obj)
```

it can modify that object.

- To prevent this from happening, make the object parameter `const`:

```
SomeClass::SomeClass
                (const SomeClass &obj)
```


Contents of `StudentTestScores.h` (Version 2)

```
#ifndef STUDENTTESTSCORES_H
#define STUDENTTESTSCORES_H
#include <string>
using namespace std;

const double DEFAULT_SCORE = 0.0;

class StudentTestScores
{
private:
   string studentName;  // The student's name
   double *testScores;  // Points to array of test scores
   int numTestScores;   // Number of test scores

    // Private member function to create an
    // array of test scores.
   void createTestScoresArray(int size)
   { numTestScores = size;
     testScores = new double[size];
     for (int i = 0; i < size; i++)
        testScores[i] = DEFAULT_SCORE; }

public:
    // Constructor
   StudentTestScores(string name, int numScores)
   { studentName = name;
```

```
    createTestScoresArray(numScores); }

   // Copy constructor
   StudentTestScores(const StudentTestScores &obj)
   { studentName = obj.studentName;
     numTestScores = obj.numTestScores;
     testScores = new double[numTestScores];
     for (int i = 0; i < numTestScores; i++)
        testScores[i] = obj.testScores[i]; }

    // Destructor
   ~StudentTestScores()
   { delete [] testScores; }

    // The setTestScore function sets a specific
    // test score's value.
   void setTestScore(double score, int index)
   { testScores[index] = score; }

    // Set the student's name.
   void setStudentName(string name)
   { studentName = name; }

    // Get the student's name.
   string getStudentName() const
   { return studentName; }
```



```

   // Get the number of test scores.
   int getNumTestScores() const
   { return numTestScores; }

    // Get a specific test score.
   double getTestScore(int index) const
   { return testScores[index]; }
};
#endif
```


14.5

Operator Overloading

Operator Overloading

- Operators such as =, +, and others can be redefined when used with objects of a class
- The name of the function for the overloaded operator is `operator` followed by the operator symbol, *e.g.*,
  - `operator+` to overload the + operator, and
  - `operator=` to overload the = operator
- Prototype for the overloaded operator goes in the declaration of the class that is overloading it
- Overloaded operator function definition goes with other member functions

Operator Overloading

- Prototype:

```
void operator=(const SomeClass &rval)
```

return type — function name — parameter for object on right side of operator

- Operator is called via object on left side

Invoking an Overloaded Operator

- Operator can be invoked as a member function:

```
object1.operator=(object2);
```

- It can also be used in more conventional manner:

```
object1 = object2;
```

Returning a Value

- Overloaded operator can return a value

```
class Point2d
{
  public:
    double operator-(const point2d &right)
    { return sqrt(pow((x-right.x),2)
                + pow((y-right.y),2)); }
...
  private:
    int x, y;
};
Point2d point1(2,2), point2(4,4);
// Compute and display distance between 2 points.
cout << point2 – point1 << endl; // displays 2.82843
```


Returning a Value

- Return type the same as the left operand supports notation like:

```
object1 = object2 = object3;
```

- Function declared as follows:

```
const SomeClass operator=(const someClass &rval)
```

- In function, include as last statement:

```
return *this;
```


The `this` Pointer

- `this`: predefined pointer available to a class's member functions
- Always points to the instance (object) of the class whose function is being called
- Is passed as a hidden argument to all non-static member functions
- Can be used to access members that may be hidden by parameters with same name

`this` Pointer Example

```
class SomeClass
{
   private:
        int num;
   public:
        void setNum(int num)
        { this->num = num; }
        ...
};
```


Notes on Overloaded Operators

- Can change meaning of an operator
- Cannot change the number of operands of the operator
- Only certain operators can be overloaded. Cannot overload the following operators:

```
?:   .   .*   :: sizeof
```


Overloading Types of Operators

- `++`, `--` operators overloaded differently for prefix vs. postfix notation
- Overloaded relational operators should return a `bool` value
- Overloaded stream operators >>, << must return reference to `istream`, `ostream` objects and take `istream`, `ostream` objects as parameters

Overloaded [ ] Operator

- Can create classes that behave like arrays, provide bounds-checking on subscripts
- Must consider constructor, destructor
- Overloaded [ ] returns a reference to object, not an object itself

14.6

Object Conversion

Object Conversion

- Type of an object can be converted to another type
- Automatically done for built-in data types
- Must write an operator function to perform conversion
- To convert an `FeetInches` object to an `int`:

```
FeetInches::operator int()
{return feet;}
```

- Assuming distance is a `FeetInches` object, allows statements like:

```
int d = distance;
```


14.7

Aggregation

Aggregation

- Aggregation: a class is a member of a class
- Supports the modeling of 'has a' relationship between classes – enclosing class 'has a' enclosed class
- Same notation as for structures within structures

Aggregation

```
class StudentInfo
{
   private:
         string firstName, LastName;
         string address, city, state, zip;
  ...
};
class Student
{
   private:
         StudentInfo personalData;
  ...
```

See the `Instructor`, `TextBook`, and `Course` classes in Chapter 14.