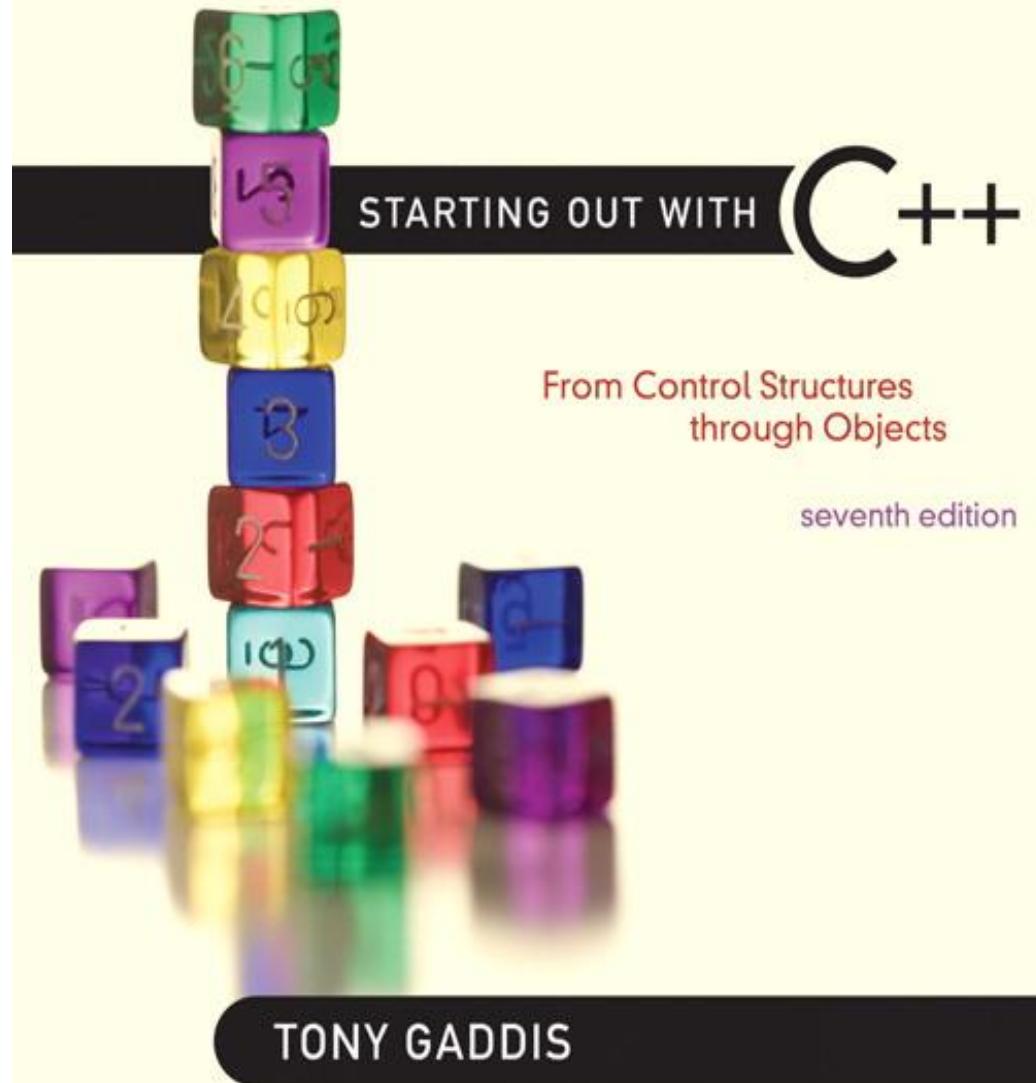


Chapter 14:

More About Classes

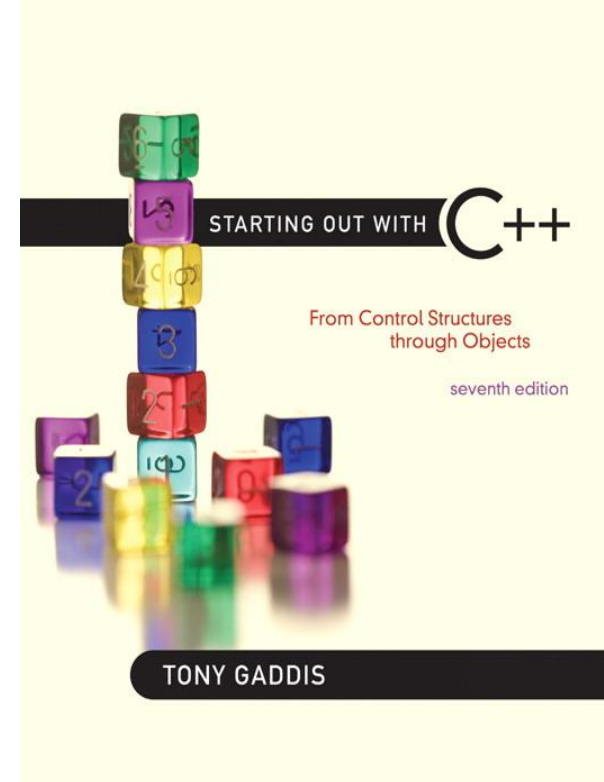


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14.1



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

```
1 // Tree class
2 class Tree
3 {
4 private:
5     static int objectCount;    // Static member variable.
6 public:
7     // Constructor
8     Tree()
9         { objectCount++; }
10
11     // Accessor function for objectCount
12     int getObjectCount() const
13         { return objectCount; }
14 };
15
16 // Definition of the static member variable, written
17 // outside the class.
18 int Tree::objectCount = 0;
```

Static member declared here.

Static member defined here.

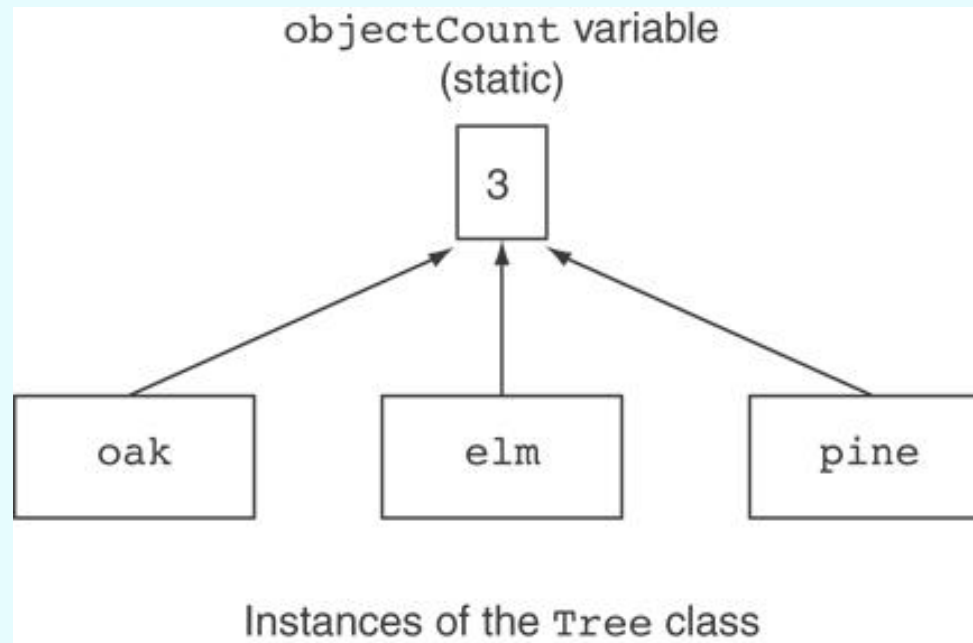
Program 14-1

```
1 // This program demonstrates a static member variable.
2 #include <iostream>
3 #include "Tree.h"
4 using namespace std;
5
6 int main()
7 {
8     // Define three Tree objects.
9     Tree oak;
10    Tree elm;
11    Tree pine;
12
13    // Display the number of Tree objects we have.
14    cout << "We have " << pine.getObjectCount()
15         << " trees in our program!\n";
16    return 0;
17 }
```

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

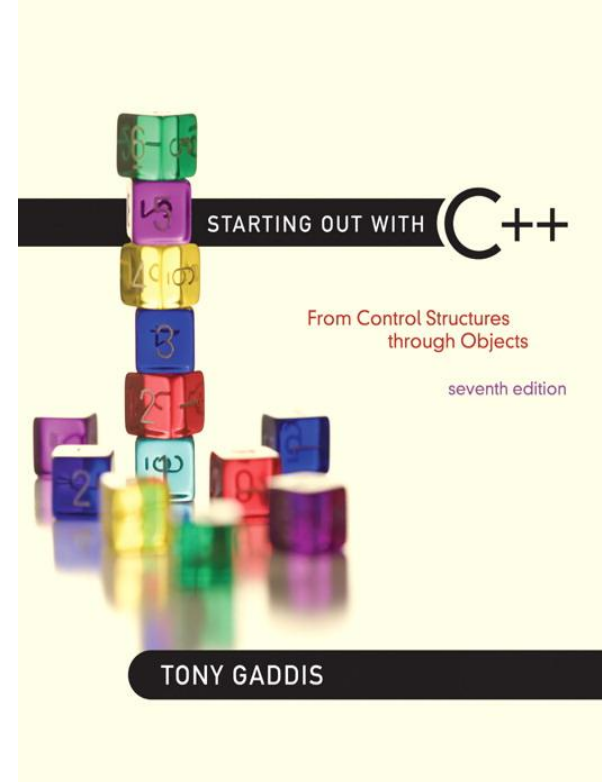
```
1 // Tree class
2 class Tree
3 {
4 private:
5     static int objectCount;    // Static member variable.
6 public:
7     // Constructor
8     Tree()
9         { objectCount++; }
10
11     // Accessor function for objectCount
12     static int getObjectCount() const
13         { return objectCount; }
14 };
15
16 // Definition of the static member variable, written
17 // outside the class.
18 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:**

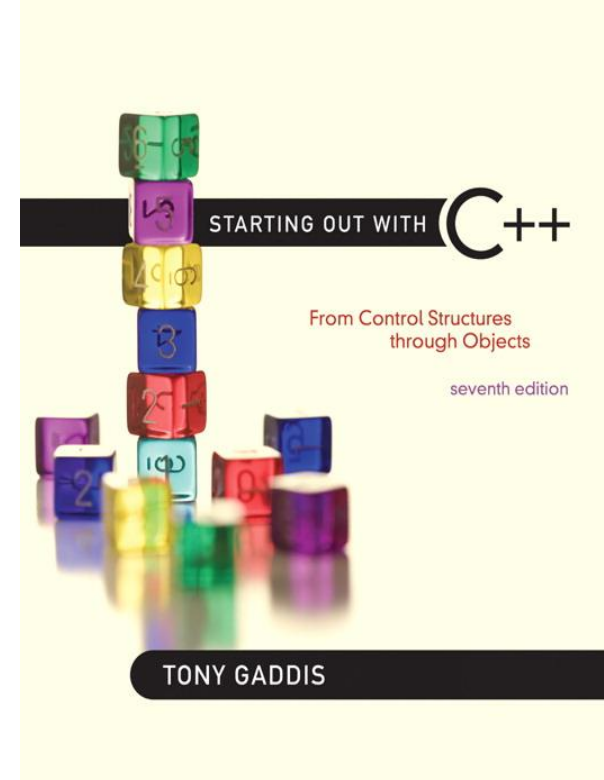
```
friend void SomeClass::setNum(int num)  
// setNum function from SomeClass  
// class is a friend of this class
```

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

```
1 // This program demonstrates memberwise assignment.
2 #include <iostream>
3 #include "Rectangle.h"
4 using namespace std;
5
6 int main()
7 {
8     // Define two Rectangle objects.
9     Rectangle box1(10.0, 10.0); // width = 10.0, length = 10.0
10    Rectangle box2 (20.0, 20.0); // width = 20.0, length = 20.0
11
12    // Display each object's width and length.
13    cout << "box1's width and length: " << box1.getWidth()
14         << " " << box1.getLength() << endl;
15    cout << "box2's width and length: " << box2.getWidth()
16         << " " << box2.getLength() << endl << endl;
17
18    // Assign the members of box1 to box2.
19    box2 = box1;
20
21    // Display each object's width and length again.
22    cout << "box1's width and length: " << box1.getWidth()
23         << " " << box1.getLength() << endl;
24    cout << "box2's width and length: " << box2.getWidth()
25         << " " << box2.getLength() << endl;
26
27    return 0;
28 }
```

Program 14-5

(continued)

Program Output

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

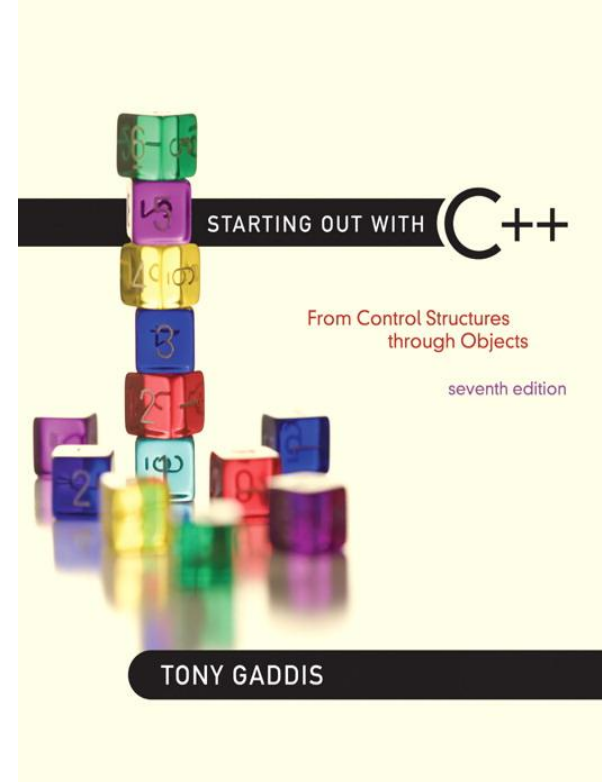
```
box2's width and length: 20 20
```

```
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

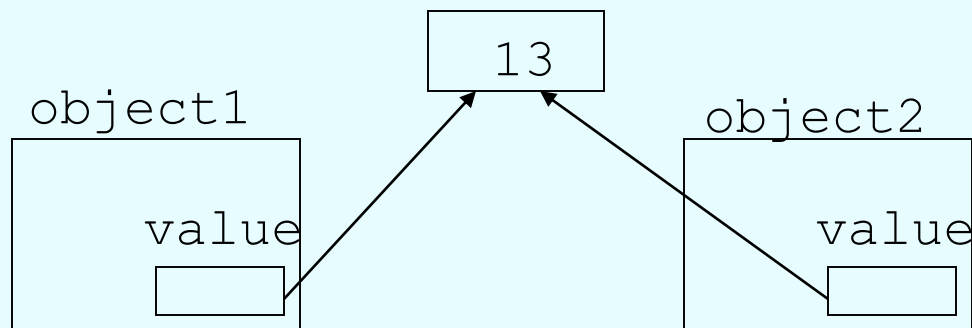
Problem: what if object contains a pointer?

```
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:

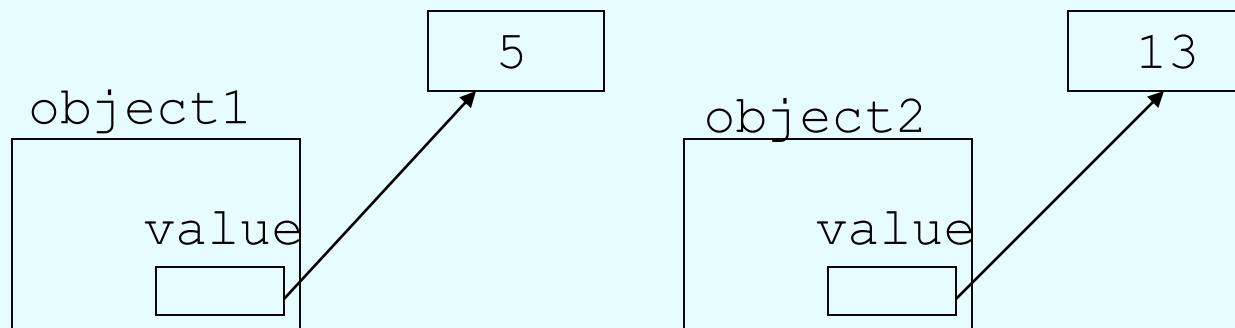
```
SomeClass::SomeClass(const SomeClass &obj)
{
    value = new int;
    *value = obj.value;
}
```

- 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)

```
1 #ifndef STUDENTTESTSCORES_H
2 #define STUDENTTESTSCORES_H
3 #include <string>
4 using namespace std;
5
6 const double DEFAULT_SCORE = 0.0;
7
8 class StudentTestScores
9 {
10 private:
11     string studentName; // The student's name
12     double *testScores; // Points to array of test scores
13     int numTestScores; // Number of test scores
14
15     // Private member function to create an
16     // array of test scores.
17     void createTestScoresArray(int size)
18     { numTestScores = size;
19       testScores = new double[size];
20       for (int i = 0; i < size; i++)
21           testScores[i] = DEFAULT_SCORE; }
22
23 public:
24     // Constructor
25     StudentTestScores(string name, int numScores)
26     { studentName = name;
```



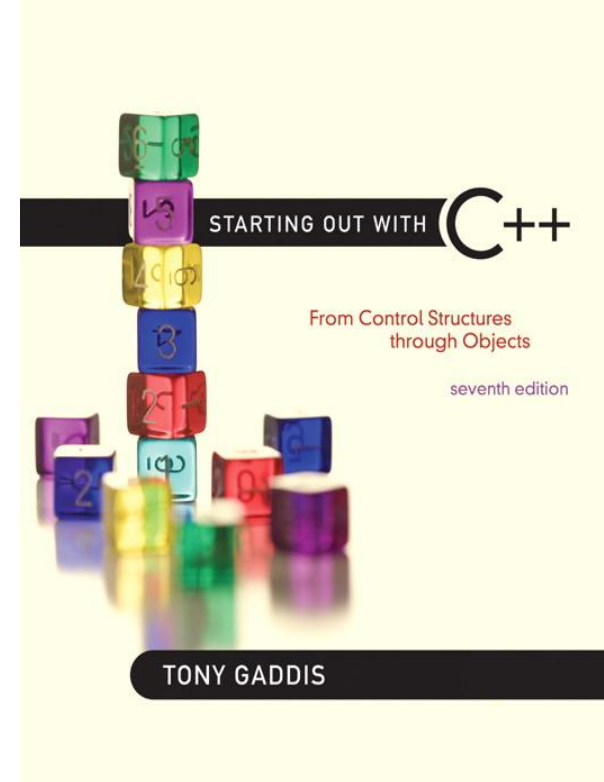
```

27     createTestScoresArray(numScores); }
28
29     // Copy constructor
30     StudentTestScores(const StudentTestScores &obj)
31     { studentName = obj.studentName;
32       numTestScores = obj.numTestScores;
33       testScores = new double[numTestScores];
34       for (int i = 0; i < numTestScores; i++)
35         testScores[i] = obj.testScores[i]; }
36
37     // Destructor
38     ~StudentTestScores()
39     { delete [] testScores; }
40
41     // The setTestScore function sets a specific
42     // test score's value.
43     void setTestScore(double score, int index)
44     { testScores[index] = score; }
45
46     // Set the student's name.
47     void setStudentName(string name)
48     { studentName = name; }
49
50     // Get the student's name.
51     string getStudentName() const
52     { return studentName; }

```

```
53
54     // Get the number of test scores.
55     int getNumTestScores() const
56     { return numTestScores; }
57
58     // Get a specific test score.
59     double getTestScore(int index) const
60     { return testScores[index]; }
61 };
62 #endif
```

14.5



Operator Overloading

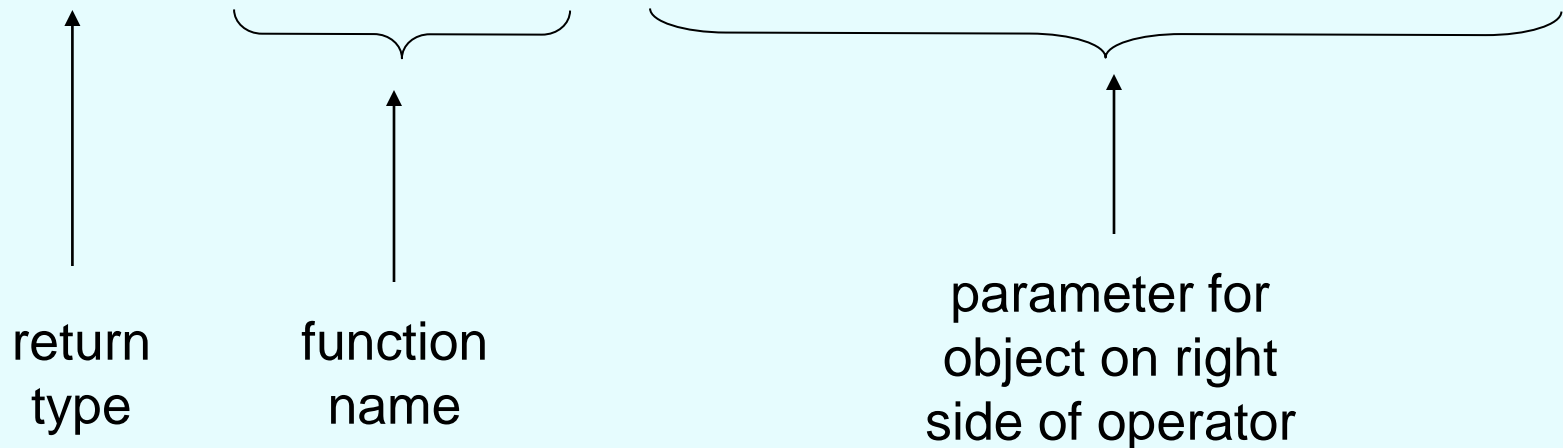
Operator Overloading

- 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)
```



- **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

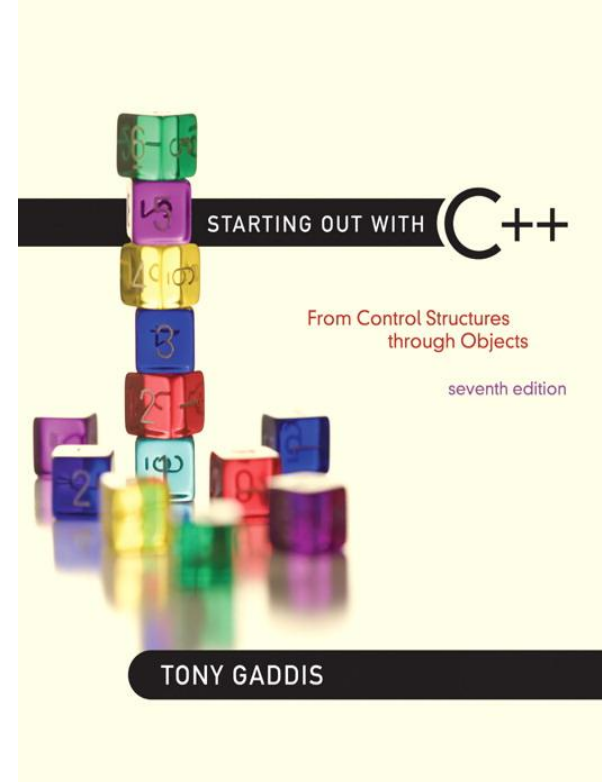
- `++`, `--` operators overloaded differently for prefix notation (in right-to-left) vs. postfix notation (in left-to-right)
- Overloaded relational operators should return a `bool` value
- Overloaded stream operators `>>`, `<<` must return reference to `istream`, `ostream` objects and take `istream`, `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`:

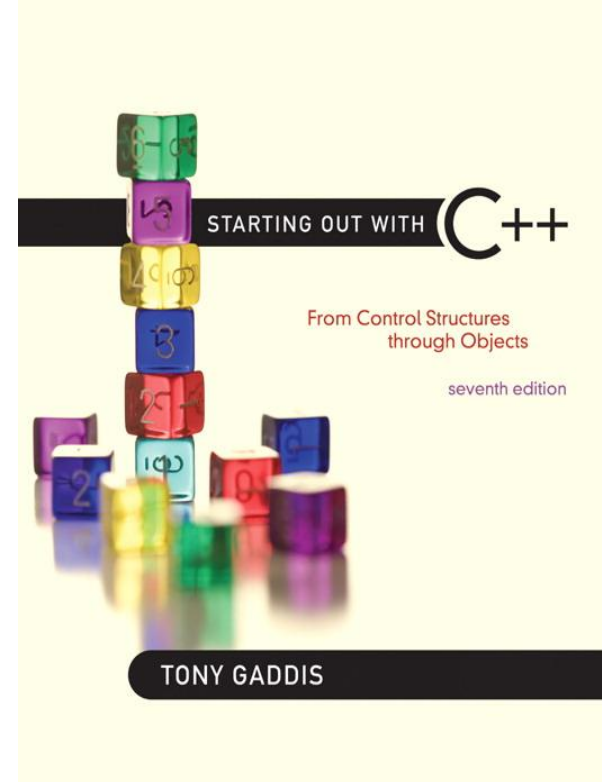
```
FeetInches::operator int()  
{return feet;}
```

- 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.

