Note: *C How to Program*, Chapter 18is a copy of *C++ How to Program* Chapter 10. We have not renumbered the PowerPoint Slides.

Chapter 10 Classes: A Deeper Look, Part 2

C++ How to Program, 8/e

10.2 `const` (Constant) Objects and `const` Member Functions

- You may use keyword `const` to specify that an object is not modifiable and that any attempt to mod-ify the object should result in a compilation error.
- C++ disallows member function calls for `const` objects unless the member functions themselves are also declared `const`.
  - True even for *get member functions that do not modify the object.*
- A member function is specified as `const` *both in its prototype and in its definition.*

```
1  // Fig. 10.1: Time.h
2  // Time class definition with const member functions.
3  // Member functions defined in Time.cpp.
4  #ifndef TIME_H
5  #define TIME_H
6
7  class Time
8  {
9  public:
10    Time( int = 0, int = 0, int = 0 ); // default constructor
11
12    // set functions
13    void setTime( int, int, int ); // set time
14    void setHour( int ); // set hour
15    void setMinute( int ); // set minute
16    void setSecond( int ); // set second
17
```

Fig. 10.1 | `Time` class definition with `const` member functions. (Part 1 of 2.)

```
18    // get functions (normally declared const)
19    int getHour() const; // return hour
20    int getMinute() const; // return minute
21    int getSecond() const; // return second
22
23    // print functions (normally declared const)
24    void printUniversal() const; // print universal time
25    void printStandard(); // print standard time (should be const)
26 private:
27    int hour; // 0 - 23 (24-hour clock format)
28    int minute; // 0 - 59
29    int second; // 0 - 59
30 }; // end class Time
31
32 #endif
```

Fig. 10.1 | `Time` class definition with `const` member functions. (Part 2 of 2.)

```
1  // Fig. 10.2: Time.cpp
2  // Time class member-function definitions.
3  #include <iostream>
4  #include <iomanip>
5  #include <stdexcept>
6  #include "Time.h" // include definition of class Time
7  using namespace std;
8
9  // constructor function to initialize private data;
10 // calls member function setTime to set variables;
11 // default values are 0 (see class definition)
12 Time::Time( int hour, int minute, int second )
13 {
14    setTime( hour, minute, second );
15 } // end Time constructor
16
17 // set hour, minute and second values
18 void Time::setTime( int hour, int minute, int second )
19 {
20    setHour( hour );
21    setMinute( minute );
22    setSecond( second );
23 } // end function setTime
24
```

Fig. 10.2 | Time class member-function definitions. (Part 1 of 5.)

```
25 // set hour value
26 void Time::setHour( int h )
27 {
28    if ( h >= 0 && h < 24 )
29       hour = h;
30    else
31       throw invalid_argument( "hour must be 0-23" );
32 } // end function setHour
33
34 // set minute value
35 void Time::setMinute( int m )
36 {
37    if ( m >= 0 && m < 60 )
38       minute = m;
39    else
40       throw invalid_argument( "minute must be 0-59" );
41 } // end function setMinute
42
```

Fig. 10.2 | Time class member-function definitions. (Part 2 of 5.)

```
43  // set second value
44  void Time::setSecond( int s )
45  {
46     if ( s >= 0 && s < 60 )
47        second = s;
48     else
49        throw invalid_argument( "second must be 0-59" );
50  } // end function setSecond
51
52  // return hour value
53  int Time::getHour() const // get functions should be const
54  {
55     return hour;
56  } // end function getHour
57
58  // return minute value
59  int Time::getMinute() const
60  {
61     return minute;
62  } // end function getMinute
63
```

Fig. 10.2 | Time class member-function definitions. (Part 3 of 5.)

```
64  // return second value
65  int Time::getSecond() const
66  {
67     return second;
68  } // end function getSecond
69
```

Fig. 10.2 | Time class member-function definitions. (Part 4 of 5.)

```
70 // print Time in universal-time format (HH:MM:SS)
71 void Time::printUniversal() const
72 {
73    cout << setfill( '0' ) << setw( 2 ) << hour << ":"
74       << setw( 2 ) << minute << ":" << setw( 2 ) << second;
75 } // end function printUniversal
76
77 // print Time in standard-time format (HH:MM:SS AM or PM)
78 void Time::printStandard() // note lack of const declaration
79 {
80    cout << ( ( hour == 0 || hour == 12 ) ? 12 : hour % 12 )
81       << ":" << setfill( '0' ) << setw( 2 ) << minute
82       << ":" << setw( 2 ) << second << ( hour < 12 ? " AM" : " PM" );
83 } // end function printStandard
```

Fig. 10.2 | Time class member-function definitions. (Part 5 of 5.)

```
1  // Fig. 10.3: fig10_03.cpp
2  // Attempting to access a const object with non-const member functions.
3  #include "Time.h" // include Time class definition
4
5  int main()
6  {
7     Time wakeUp( 6, 45, 0 ); // non-constant object
8     const Time noon( 12, 0, 0 ); // constant object
9
10                              // OBJECT      MEMBER FUNCTION
11    wakeUp.setHour( 18 );     // non-const   non-const
12
13    noon.setHour( 12 );       // const       non-const
14
15    wakeUp.getHour();         // non-const   const
16
17    noon.getMinute();         // const       const
18    noon.printUniversal();    // const       const
19
20    noon.printStandard();     // const       non-const
21 } // end main
```

Fig. 10.3 | const objects and const member functions. (Part 1 of 2.)

10.3 Composition: Objects as Members of Classes

- Composition
  - Sometimes referred to as a has-a relationship
  - A class can have objects of other classes as members
- An object's constructor can pass arguments to member-object constructors via member initializers.


```
1  // Fig. 10.8: Date.h
2  // Date class definition; Member functions defined in Date.cpp
3  #ifndef DATE_H
4  #define DATE_H
5
6  class Date
7  {
8  public:
9     static const int monthsPerYear = 12; // number of months in a year
10    Date( int = 1, int = 1, int = 1900 ); // default constructor
11    void print() const; // print date in month/day/year format
12    ~Date(); // provided to confirm destruction order
13 private:
14    int month; // 1-12 (January-December)
15    int day; // 1-31 based on month
16    int year; // any year
17
18    // utility function to check if day is proper for month and year
19    int checkDay( int ) const;
20 }; // end class Date
21
22 #endif
```

Fig. 10.8 | Date class definition.

```
1  // Fig. 10.9: Date.cpp
2  // Date class member-function definitions.
3  #include <iostream>
4  #include <stdexcept>
5  #include "Date.h" // include Date class definition
6  using namespace std;
7
8  // constructor confirms proper value for month; calls
9  // utility function checkDay to confirm proper value for day
10 Date::Date( int mn, int dy, int yr )
11 {
12    if ( mn > 0 && mn <= monthsPerYear ) // validate the month
13       month = mn;
14    else
15       throw invalid_argument( "month must be 1-12" );
16
17    year = yr; // could validate yr
18    day = checkDay( dy ); // validate the day
19
20    // output Date object to show when its constructor is called
21    cout << "Date object constructor for date ";
22    print();
23    cout << endl;
24 } // end Date constructor
```

Fig. 10.9 | Date class member-function definitions. (Part 1 of 3.)

```
25
26 // print Date object in form month/day/year
27 void Date::print() const
28 {
29    cout << month << '/' << day << '/' << year;
30 } // end function print
31
32 // output Date object to show when its destructor is called
33 Date::~Date()
34 {
35    cout << "Date object destructor for date ";
36    print();
37    cout << endl;
38 } // end ~Date destructor
39
```

Fig. 10.9 | Date class member-function definitions. (Part 2 of 3.)

```
40  // utility function to confirm proper day value based on
41  // month and year; handles leap years, too
42  int Date::checkDay( int testDay ) const
43  {
44     static const int daysPerMonth[ monthsPerYear + 1 ] =
45        { 0, 31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31 };
46
47     // determine whether testDay is valid for specified month
48     if ( testDay > 0 && testDay <= daysPerMonth[ month ] )
49        return testDay;
50
51     // February 29 check for leap year
52     if ( month == 2 && testDay == 29 && ( year % 400 == 0 ||
53        ( year % 4 == 0 && year % 100 != 0 ) ) )
54        return testDay;
55
56     throw invalid_argument( "Invalid day for current month and year" );
57  } // end function checkDay
```

Fig. 10.9 | Date class member-function definitions. (Part 3 of 3.)


```
1  // Fig. 10.10: Employee.h
2  // Employee class definition showing composition.
3  // Member functions defined in Employee.cpp.
4  #ifndef EMPLOYEE_H
5  #define EMPLOYEE_H
6
7  #include <string>
8  #include "Date.h" // include Date class definition
9  using namespace std;
10
```

Fig. 10.10 | Employee class definition showing composition. (Part 1 of 2.)

```
11  class Employee
12  {
13  public:
14     Employee( const string &, const string &,
15        const Date &, const Date & );
16     void print() const;
17     ~Employee(); // provided to confirm destruction order
18  private:
19     string firstName; // composition: member object
20     string lastName; // composition: member object
21     const Date birthDate; // composition: member object
22     const Date hireDate; // composition: member object
23  }; // end class Employee
24
25  #endif
```

Fig. 10.10 | Employee class definition showing composition. (Part 2 of 2.)

```
1  // Fig. 10.11: Employee.cpp
2  // Employee class member-function definitions.
3  #include <iostream>
4  #include "Employee.h" // Employee class definition
5  #include "Date.h" // Date class definition
6  using namespace std;
7
8  // constructor uses member initializer list to pass initializer
9  // values to constructors of member objects
10 Employee::Employee( const string &first, const string &last,
11    const Date &dateOfBirth, const Date &dateOfHire )
12    : firstName( first ), // initialize firstName
13      lastName( last ), // initialize lastName
14      birthDate( dateOfBirth ), // initialize birthDate
15      hireDate( dateOfHire ) // initialize hireDate
16 {
17    // output Employee object to show when constructor is called
18    cout << "Employee object constructor: "
19       << firstName << ' ' << lastName << endl;
20 } // end Employee constructor
21
```

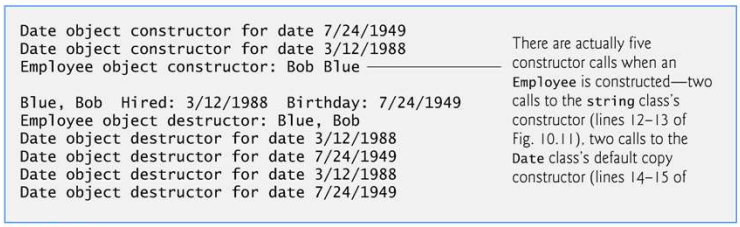
Fig. 10.11 | Employee class member-function definitions, including constructor with a member initializer list. (Part 1 of 2.)

```
22  // print Employee object
23  void Employee::print() const
24  {
25     cout << lastName << ", " << firstName << "  Hired: ";
26     hireDate.print();
27     cout << "  Birthday: ";
28     birthDate.print();
29     cout << endl;
30  } // end function print
31
32  // output Employee object to show when its destructor is called
33  Employee::~Employee()
34  {
35     cout << "Employee object destructor: "
36        << lastName << ", " << firstName << endl;
37  } // end ~Employee destructor
```

Fig. 10.11 | Employee class member-function definitions, including constructor with a member initializer list. (Part 2 of 2.)

```
1  // Fig. 10.12: fig10_12.cpp
2  // Demonstrating composition--an object with member objects.
3  #include <iostream>
4  #include "Employee.h" // Employee class definition
5  using namespace std;
6
7  int main()
8  {
9     Date birth( 7, 24, 1949 );
10    Date hire( 3, 12, 1988 );
11    Employee manager( "Bob", "Blue", birth, hire );
12
13    cout << endl;
14    manager.print();
15 } // end main
```

Fig. 10.12 | Demonstrating composition—an object with member objects. (Part 1 of 2.)



```
Date object constructor for date 7/24/1949
Date object constructor for date 3/12/1988
Employee object constructor: Bob Blue

Blue, Bob  Hired: 3/12/1988  Birthday: 7/24/1949
Employee object destructor: Blue, Bob
Date object destructor for date 3/12/1988
Date object destructor for date 7/24/1949
Date object destructor for date 3/12/1988
Date object destructor for date 7/24/1949
```

There are actually five constructor calls when an `Employee` is constructed—two calls to the `string` class's constructor (lines 12–13 of Fig. 10.11), two calls to the `Date` class's default copy constructor (lines 14–15 of

Fig. 10.12 | Demonstrating composition—an object with member objects. (Part 2 of 2.)

10.5 Using the `this` Pointer

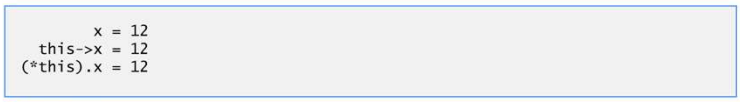
- How do member functions know *which* object's data members to manipulate? Every object has access to its own address through a pointer called `this` (a C++ keyword).
- The `this` pointer is not part of the object itself.
  - The `this` pointer is passed (by the compiler) as an implicit argument to each of the object's non-`static` member functions.
- Objects use the `this` pointer implicitly or explicitly to reference their data members and member functions.
- The type of the `this` pointer depends on the type of the object and whether the member function in which `this` is used is declared `const`.

```
1  // Fig. 10.14: fig10_14.cpp
2  // Using the this pointer to refer to object members.
3  #include <iostream>
4  using namespace std;
5
6  class Test
7  {
8  public:
9     Test( int = 0 ); // default constructor
10    void print() const;
11 private:
12    int x;
13 }; // end class Test
14
15 // constructor
16 Test::Test( int value )
17    : x( value ) // initialize x to value
18 {
19    // empty body
20 } // end constructor Test
21
```

Fig. 10.14 | using the this pointer to refer to object members. (Part 1 of 3.)

```
22 // print x using implicit and explicit this pointers;
23 // the parentheses around *this are required
24 void Test::print() const
25 {
26    // implicitly use the this pointer to access the member x
27    cout << "        x = " << x;
28
29    // explicitly use the this pointer and the arrow operator
30    // to access the member x
31    cout << "\n  this->x = " << this->x;
32
33    // explicitly use the dereferenced this pointer and
34    // the dot operator to access the member x
35    cout << "\n(*this).x = " << ( *this ).x << endl;
36 } // end function print
37
38 int main()
39 {
40    Test testObject( 12 ); // instantiate and initialize testObject
41
42    testObject.print();
43 } // end main
```

Fig. 10.14 | using the this pointer to refer to object members. (Part 2 of 3.)



```
        x = 12
  this->x = 12
(*this).x = 12
```

Fig. 10.14 | using the `this` pointer to refer to object members. (Part 3 of 3.)

10.5 Using the `this` Pointer (cont.)

- Another use of the `this` pointer is to enable cascaded member-function calls
  - invoking multiple functions in the same statement
- The program of Figs. 10.15–10.17 modifies class `Time`'s *set functions* `setTime`, `setHour`, `setMinute` *and* `setSecond` *such that each returns a reference to a* `Time` *object to enable cascaded member-function calls.*

```
1  // Fig. 10.15: Time.h
2  // Cascading member function calls.
3
4  // Time class definition.
5  // Member functions defined in Time.cpp.
6  #ifndef TIME_H
7  #define TIME_H
8
9  class Time
10 {
11 public:
12    Time( int = 0, int = 0, int = 0 ); // default constructor
13
14    // set functions (the Time & return types enable cascading)
15    Time &setTime( int, int, int ); // set hour, minute, second
16    Time &setHour( int ); // set hour
17    Time &setMinute( int ); // set minute
18    Time &setSecond( int ); // set second
19
```

Fig. 10.15 | Time class modified to enable cascaded member-function calls. (Part 1 of 2.)

```
20    // get functions (normally declared const)
21    int getHour() const; // return hour
22    int getMinute() const; // return minute
23    int getSecond() const; // return second
24
25    // print functions (normally declared const)
26    void printUniversal() const; // print universal time
27    void printStandard() const; // print standard time
28 private:
29    int hour; // 0 - 23 (24-hour clock format)
30    int minute; // 0 - 59
31    int second; // 0 - 59
32 }; // end class Time
33
34 #endif
```

Fig. 10.15 | Time class modified to enable cascaded member-function calls. (Part 2 of 2.)

```
1  // Fig. 10.16: Time.cpp
2  // Time class member-function definitions.
3  #include <iostream>
4  #include <iomanip>
5  #include "Time.h" // Time class definition
6  using namespace std;
7
8  // constructor function to initialize private data;
9  // calls member function setTime to set variables;
10 // default values are 0 (see class definition)
11 Time::Time( int hr, int min, int sec )
12 {
13    setTime( hr, min, sec );
14 } // end Time constructor
15
16 // set values of hour, minute, and second
17 Time &Time::setTime( int h, int m, int s ) // note Time & return
18 {
19    setHour( h );
20    setMinute( m );
21    setSecond( s );
22    return *this; // enables cascading
23 } // end function setTime
```

Fig. 10.16 | Time class member-function definitions modified to enable cascaded member-function calls. (Part 1 of 5.)

```
24
25 // set hour value
26 Time &Time::setHour( int h ) // note Time & return
27 {
28    if ( h >= 0 && h < 24 )
29       hour = h;
30    else
31       throw invalid_argument( "hour must be 0-23" );
32
33    return *this; // enables cascading
34 } // end function setHour
35
36 // set minute value
37 Time &Time::setMinute( int m ) // note Time & return
38 {
39    if ( m >= 0 && m < 60 )
40       minute = m;
41    else
42       throw invalid_argument( "minute must be 0-59" );
43
44    return *this; // enables cascading
45 } // end function setMinute
46
```

Fig. 10.16 | Time class member-function definitions modified to enable cascaded member-function calls. (Part 2 of 5.)

```
47  // set second value
48  Time &Time::setSecond( int s ) // note Time & return
49  {
50     if ( s >= 0 && s < 60 )
51        second = s;
52     else
53        throw invalid_argument( "second must be 0-59" );
54
55     return *this; // enables cascading
56  } // end function setSecond
57
58  // get hour value
59  int Time::getHour() const
60  {
61     return hour;
62  } // end function getHour
63
```

Fig. 10.16 | Time class member-function definitions modified to enable cascaded member-function calls. (Part 3 of 5.)

```
64  // get minute value
65  int Time::getMinute() const
66  {
67     return minute;
68  } // end function getMinute
69
70  // get second value
71  int Time::getSecond() const
72  {
73     return second;
74  } // end function getSecond
75
76  // print Time in universal-time format (HH:MM:SS)
77  void Time::printUniversal() const
78  {
79     cout << setfill( '0' ) << setw( 2 ) << hour << ":"
80        << setw( 2 ) << minute << ":" << setw( 2 ) << second;
81  } // end function printUniversal
82
```

Fig. 10.16 | Time class member-function definitions modified to enable cascaded member-function calls. (Part 4 of 5.)

```
83  // print Time in standard-time format (HH:MM:SS AM or PM)
84  void Time::printStandard() const
85  {
86     cout << ( ( hour == 0 || hour == 12 ) ? 12 : hour % 12 )
87        << ":" << setfill( '0' ) << setw( 2 ) << minute
88        << ":" << setw( 2 ) << second << ( hour < 12 ? " AM" : " PM" );
89  } // end function printStandard
```

Fig. 10.16 | Time class member-function definitions modified to enable cascaded member-function calls. (Part 5 of 5.)

```
1  // Fig. 10.17: fig10_17.cpp
2  // Cascading member-function calls with the this pointer.
3  #include <iostream>
4  #include "Time.h" // Time class definition
5  using namespace std;
6
```

Fig. 10.17 | Cascading member-function calls with the this pointer. (Part 1 of 3.)

```
7  int main()
8  {
9     Time t; // create Time object
10
11    // cascaded function calls
12    t.setHour( 18 ).setMinute( 30 ).setSecond( 22 );
13
14    // output time in universal and standard formats
15    cout << "Universal time: ";
16    t.printUniversal();
17
18    cout << "\nStandard time: ";
19    t.printStandard();
20
21    cout << "\n\nNew standard time: ";
22
23    // cascaded function calls
24    t.setTime( 20, 20, 20 ).printStandard();
25    cout << endl;
26 } // end main
```

Fig. 10.17 | Cascading member-function calls with the `this` pointer. (Part 2 of 3.)

```
Universal time: 18:30:22
Standard time: 6:30:22 PM

New standard time: 8:20:20 PM
```

Fig. 10.17 | Cascading member-function calls with the `this` pointer. (Part 3 of 3.)