Chapter 12

Separate Compilation and Namespaces

Adapted from Savitch, “Problem Solving with C++”

12.1

Separate Compilation

Adapted from Savitch, “Problem Solving with C++”

Separate Compilation

- C++ allows you to divide a program into parts
  - Each part can be stored in a separate file
  - Each part can be compiled separately
  - A class definition can be stored separately from a program.
    - This allows you to use the class in multiple programs

ADT Review

- An ADT (abstract data type) is a class defined to separate the interface and the implementation
  - All member variables are private
  - The class definition along with the function and operator declarations are grouped together as the interface of the ADT
  - Group the implementation of the operations together and make them unavailable to the programmer using the ADT
  - So you can change the implementation without needing to change any program that uses the class in any way

The ADT Interface

- The interface of the ADT includes
  - The class definition
  - The declarations of the basic operations which can be one of the following
    - Public member functions
    - Friend functions
    - Ordinary functions
    - Overloaded operators
  - The function comments

The ADT Implementation

- The implementation of the ADT includes
  - The function definitions
    - The public member functions
    - The private member functions
    - Non-member functions
    - Private helper functions
  - Overloaded operator definitions
  - Member variables
  - Other items required by the definitions

Separate Files

- In C++ the ADT interface and implementation can be stored in separate files
  - The interface file stores the ADT interface
    - i.e., header files (with .h suffix)
  - The implementation file stores the ADT implementation
    - i.e., C++ files (with .cpp suffix)

A Minor Compromise

- The public part of the class definition is part of the ADT interface
- The private part of the class definition is part of the ADT implementation
  - This would hide it from those using the ADT
- C++ does not allow splitting the public and private parts of the class definition across files
  - The entire class definition is usually in the interface file

Case Study: DigitalTime

- The interface file of the DigitalTime ADT class contains the class definition
  - The values of the class are:
    - Time of day, such as 9:30, in 24 hour notation
  - The public members are part of the interface
  - The private members are part of the implementation
  - The comments in the file should provide all the details needed to use the ADT

Naming The Interface File

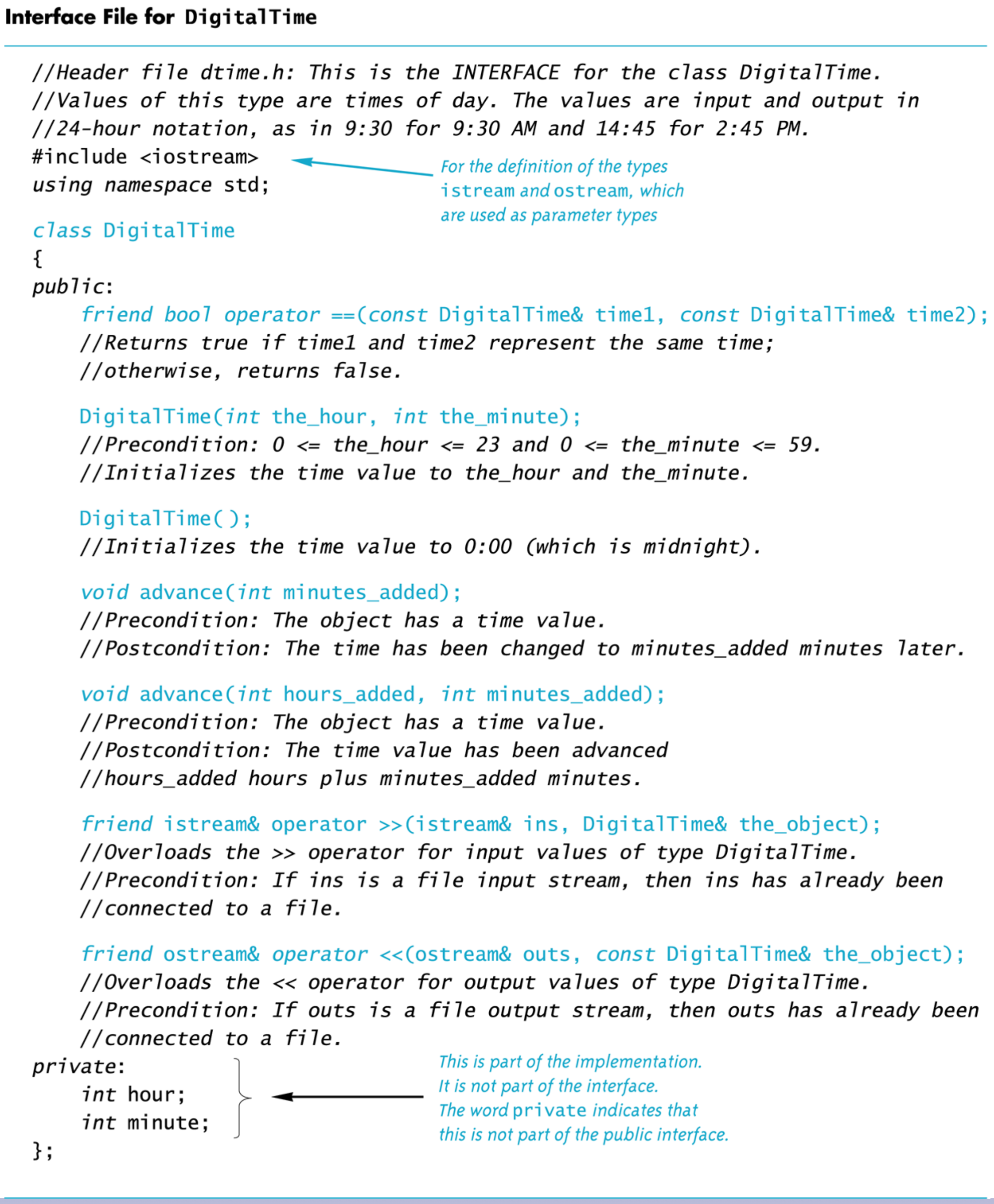
- The DigitalTime ADT interface is stored in a file named dtime.h
  - The .h suffix means this is a header file
  - Interface files are always header files
- A program using dtime.h must include it using an include directive

```
#include "dtime.h"
```

Display 12.1

Display 12.1

Back Next



Interface File for DigitalTime

```
//Header file dtime.h: This is the INTERFACE for the class DigitalTime.
//Values of this type are times of day. The values are input and output in
//24-hour notation, as in 9:30 for 9:30 AM and 14:45 for 2:45 PM.
#include <iostream>
using namespace std;

class DigitalTime
{
public:
    friend bool operator ==(const DigitalTime& time1, const DigitalTime& time2);
    //Returns true if time1 and time2 represent the same time;
    //otherwise, returns false.

    DigitalTime(int the_hour, int the_minute);
    //Precondition: 0 <= the_hour <= 23 and 0 <= the_minute <= 59.
    //Initializes the time value to the_hour and the_minute.

    DigitalTime( );
    //Initializes the time value to 0:00 (which is midnight).

    void advance(int minutes_added);
    //Precondition: The object has a time value.
    //Postcondition: The time has been changed to minutes_added minutes later.

    void advance(int hours_added, int minutes_added);
    //Precondition: The object has a time value.
    //Postcondition: The time value has been advanced
    //hours_added hours plus minutes_added minutes.

    friend istream& operator >>(istream& ins, DigitalTime& the_object);
    //Overloads the >> operator for input values of type DigitalTime.
    //Precondition: If ins is a file input stream, then ins has already been
    //connected to a file.

    friend ostream& operator <<(ostream& outs, const DigitalTime& the_object);
    //Overloads the << operator for output values of type DigitalTime.
    //Precondition: If outs is a file output stream, then outs has already been
    //connected to a file.
private:
    int hour;
    int minute;
};
```

For the definition of the types istream *and* ostream*, which are used as parameter types*

This is part of the implementation. It is not part of the interface. The word private *indicates that this is not part of the public interface.*

#include " " or < > ?

- To include a predefined header file use < and >

  #include <iostream>

  - < and > tells the compiler to look where the system stores predefined header files
- To include a header file you wrote, use " and "

  #include "dtime.h"

  - " and " usually cause the compiler to look in the current directory for the header file

The Implementation File

- Contains the definitions of the ADT functions
- Usually has the same name as the header file but a different suffix
    - Since our header file is named dtime.h, the implementation file is named dtime.cpp
    - Suffix depends on your system (some use .cpp, .cxx or .CPP)

#include "dtime.h"

- The implementation file requires an include directive to include the interface file:

```
#include "dtime.h"
```

Display 12.2 (1)

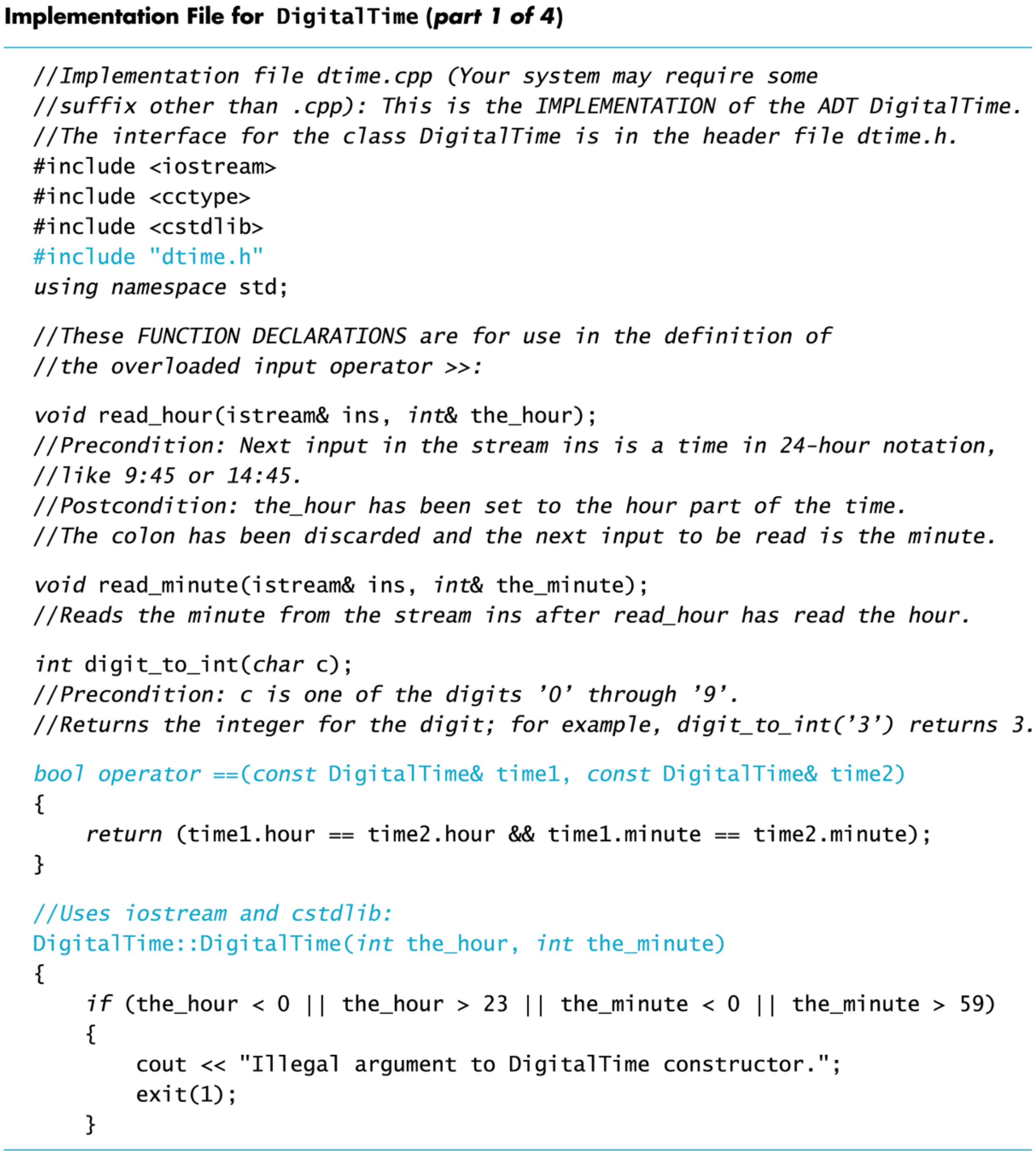
Display 12.2 (2)

Display 12.2 (3)

Display 12.2 (4)

Display 12.2 (1/4)

Back Next



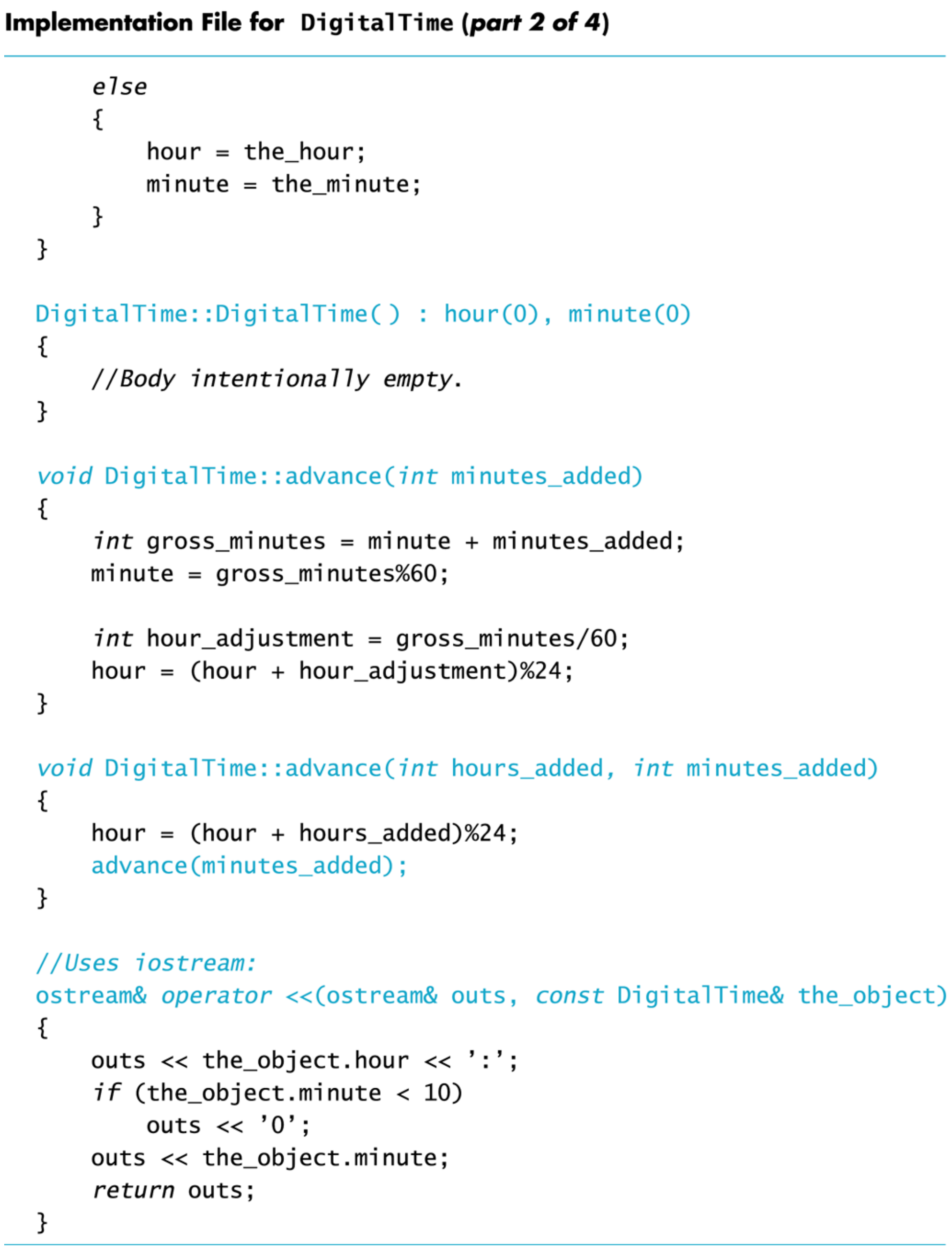
Implementation File for `DigitalTime` (*part 1 of 4*)

```
//Implementation file dtime.cpp (Your system may require some
//suffix other than .cpp): This is the IMPLEMENTATION of the ADT DigitalTime.
//The interface for the class DigitalTime is in the header file dtime.h.
#include <iostream>
#include <cctype>
#include <cstdlib>
#include "dtime.h"
using namespace std;

//These FUNCTION DECLARATIONS are for use in the definition of
//the overloaded input operator >>:

void read_hour(istream& ins, int& the_hour);
//Precondition: Next input in the stream ins is a time in 24-hour notation,
//like 9:45 or 14:45.
//Postcondition: the_hour has been set to the hour part of the time.
//The colon has been discarded and the next input to be read is the minute.

void read_minute(istream& ins, int& the_minute);
//Reads the minute from the stream ins after read_hour has read the hour.

int digit_to_int(char c);
//Precondition: c is one of the digits '0' through '9'.
//Returns the integer for the digit; for example, digit_to_int('3') returns 3.

bool operator ==(const DigitalTime& time1, const DigitalTime& time2)
{
    return (time1.hour == time2.hour && time1.minute == time2.minute);
}

//Uses iostream and cstdlib:
DigitalTime::DigitalTime(int the_hour, int the_minute)
{
    if (the_hour < 0 || the_hour > 23 || the_minute < 0 || the_minute > 59)
    {
        cout << "Illegal argument to DigitalTime constructor.";
        exit(1);
    }
```

Display 2.2 (2/4)

Back

Next

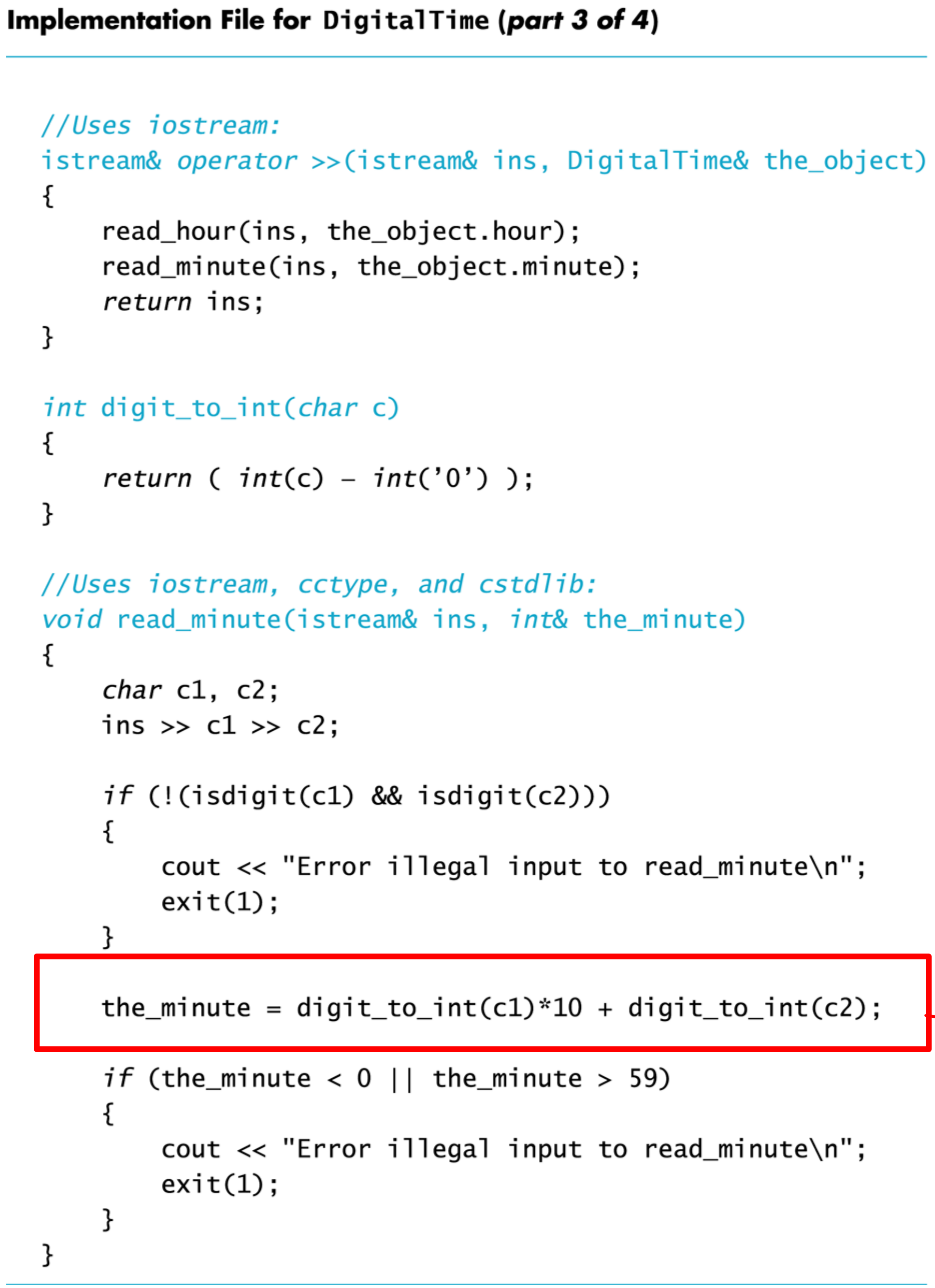


Implementation File for DigitalTime (*part 2 of 4*)

```
     else
     {
         hour = the_hour;
         minute = the_minute;
     }
}

DigitalTime::DigitalTime( ) : hour(0), minute(0)
{
     //Body intentionally empty.
}

void DigitalTime::advance(int minutes_added)
{
     int gross_minutes = minute + minutes_added;
     minute = gross_minutes%60;

     int hour_adjustment = gross_minutes/60;
     hour = (hour + hour_adjustment)%24;
}

void DigitalTime::advance(int hours_added, int minutes_added)
{
     hour = (hour + hours_added)%24;
     advance(minutes_added);
}

//Uses iostream:
ostream& operator <<(ostream& outs, const DigitalTime& the_object)
{
     outs << the_object.hour << ':';
     if (the_object.minute < 10)
         outs << '0';
     outs << the_object.minute;
     return outs;
}
```

Display 12.2 (3/4)

Back Next



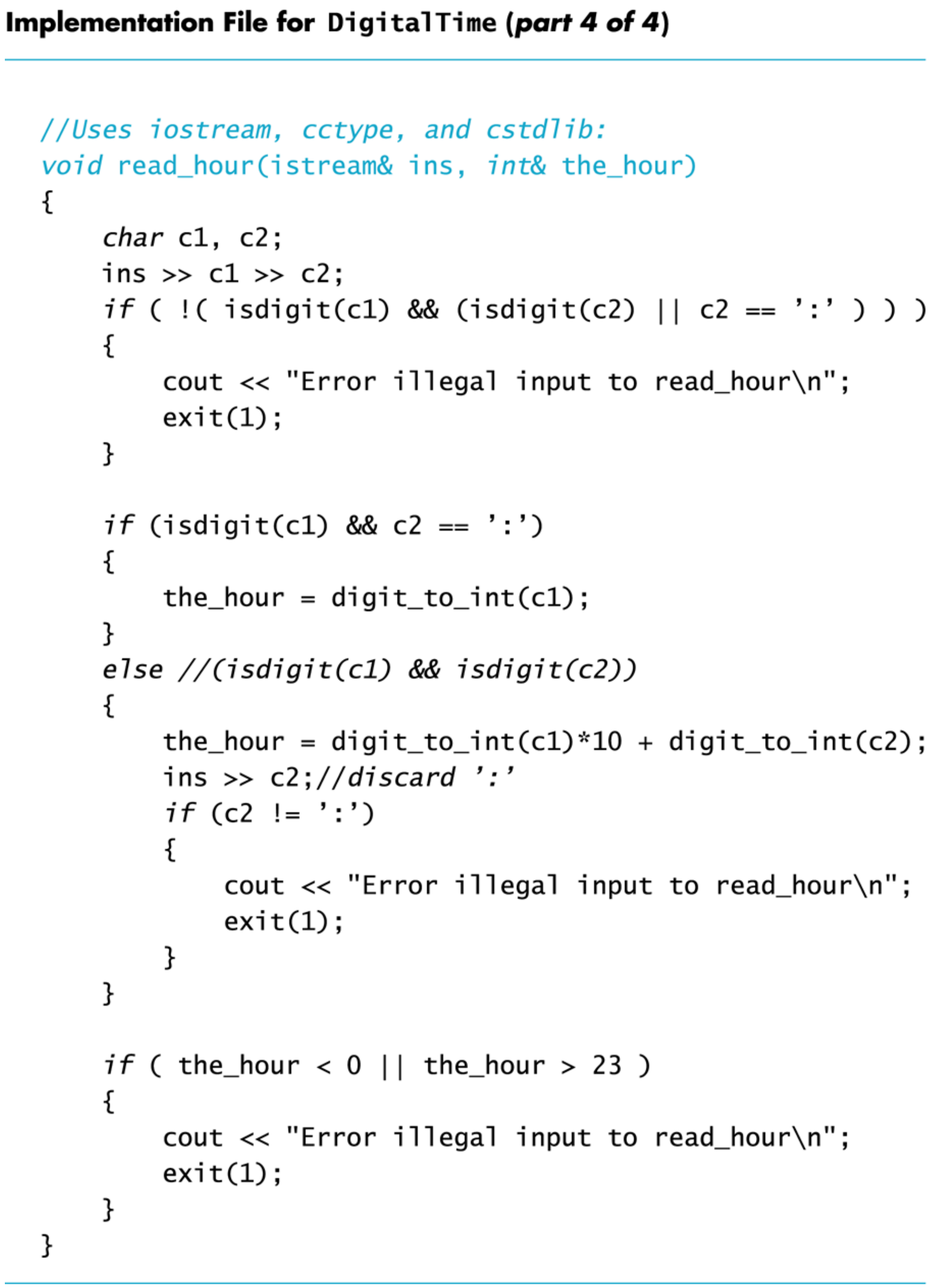
Implementation File for DigitalTime (*part 3 of 4*)

```
//Uses iostream:
istream& operator >>(istream& ins, DigitalTime& the_object)
{
    read_hour(ins, the_object.hour);
    read_minute(ins, the_object.minute);
    return ins;
}

int digit_to_int(char c)
{
    return ( int(c) – int(’0’) );
}

//Uses iostream, cctype, and cstdlib:
void read_minute(istream& ins, int& the_minute)
{
    char c1, c2;
    ins >> c1 >> c2;

    if (!(isdigit(c1) && isdigit(c2)))
    {
        cout << "Error illegal input to read_minute\n";
        exit(1);
    }

    the_minute = digit_to_int(c1)*10 + digit_to_int(c2);

    if (the_minute < 0 || the_minute > 59)
    {
        cout << "Error illegal input to read_minute\n";
        exit(1);
    }
}
```

Convert two digits to an integer

Display 12.2 (4/4)

Back
Next



Implementation File for DigitalTime (*part 4 of 4*)

```
//Uses iostream, cctype, and cstdlib:
void read_hour(istream& ins, int& the_hour)
{
    char c1, c2;
    ins >> c1 >> c2;
    if ( !( isdigit(c1) && (isdigit(c2) || c2 == ':' ) ) )
    {
        cout << "Error illegal input to read_hour\n";
        exit(1);
    }

    if (isdigit(c1) && c2 == ':')
    {
        the_hour = digit_to_int(c1);
    }
    else //(isdigit(c1) && isdigit(c2))
    {
        the_hour = digit_to_int(c1)*10 + digit_to_int(c2);
        ins >> c2;//discard ':'
        if (c2 != ':')
        {
            cout << "Error illegal input to read_hour\n";
            exit(1);
        }
    }

    if ( the_hour < 0 || the_hour > 23 )
    {
        cout << "Error illegal input to read_hour\n";
        exit(1);
    }
}
```

The Application File

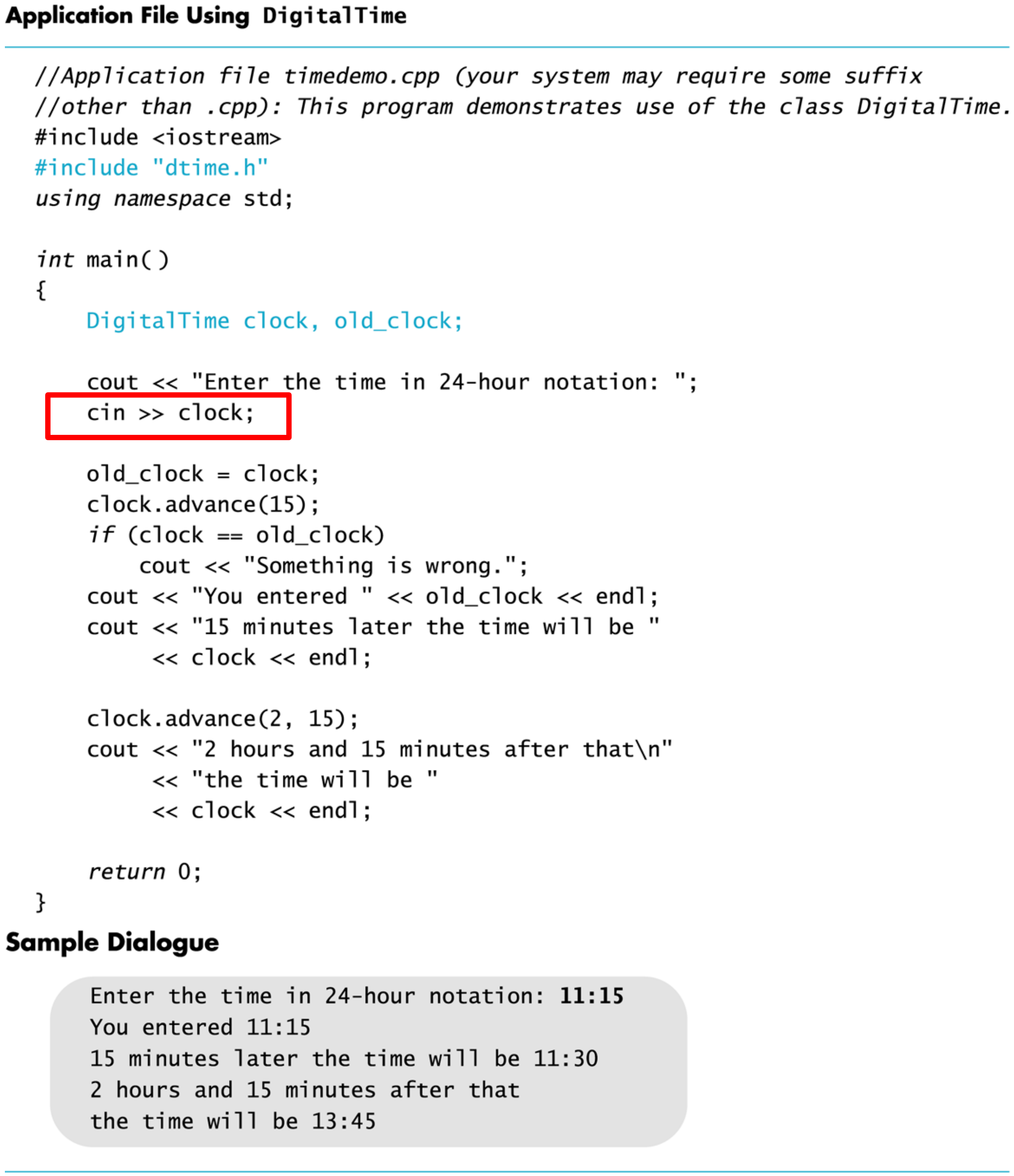
- The Application file is the file that contains the program that uses the ADT
  - It is also called a driver file, normally contains the main() module
  - Must use an include directive to include the interface file:

```
#include "dtime.h"
```

Display 12.3

Display 12.3

Back Next



Application File Using DigitalTime

```
//Application file timedemo.cpp (your system may require some suffix
//other than .cpp): This program demonstrates use of the class DigitalTime.
#include <iostream>
#include "dtime.h"
using namespace std;

int main( )
{
    DigitalTime clock, old_clock;

    cout << "Enter the time in 24-hour notation: ";
    cin >> clock;

    old_clock = clock;
    clock.advance(15);
    if (clock == old_clock)
        cout << "Something is wrong.";
    cout << "You entered " << old_clock << endl;
    cout << "15 minutes later the time will be "
         << clock << endl;

    clock.advance(2, 15);
    cout << "2 hours and 15 minutes after that\n"
         << "the time will be "
         << clock << endl;

    return 0;
}
```

Sample Dialogue

```
Enter the time in 24-hour notation: 11:15
You entered 11:15
15 minutes later the time will be 11:30
2 hours and 15 minutes after that
the time will be 13:45
```

Running The Program

- Basic steps required to run a program: (Details vary from system to system!)
  - Compile the implementation file
  - Compile the application file
  - Link the files to create an executable program using a utility called a linker
    - Linking is often done automatically

Compile dtime.h ?

- The interface file is not compiled separately
  - The preprocessor replaces any occurrence of #include "dtime.h" with the text of dtime.h before compiling
  - Both the implementation file and the application file contain #include "dtime.h"
    - The text of dtime.h is seen by the compiler in each of these files
    - There is no need to compile dtime.h separately

Why Three Files?

- Using separate files permits
  - The ADT to be used in other programs without rewriting the definition of the class for each
  - Implementation file to be compiled once even if multiple programs use the ADT
  - Changing the implementation file does not require changing the program using the ADT

Reusable Components

- An ADT coded in separate files can be used over and over
- The reusability of such an ADT class
  - Saves effort since it does not need to be
    - Redesigned
    - Recoded
    - Retested
  - Is likely to result in more reliable components

Multiple Classes

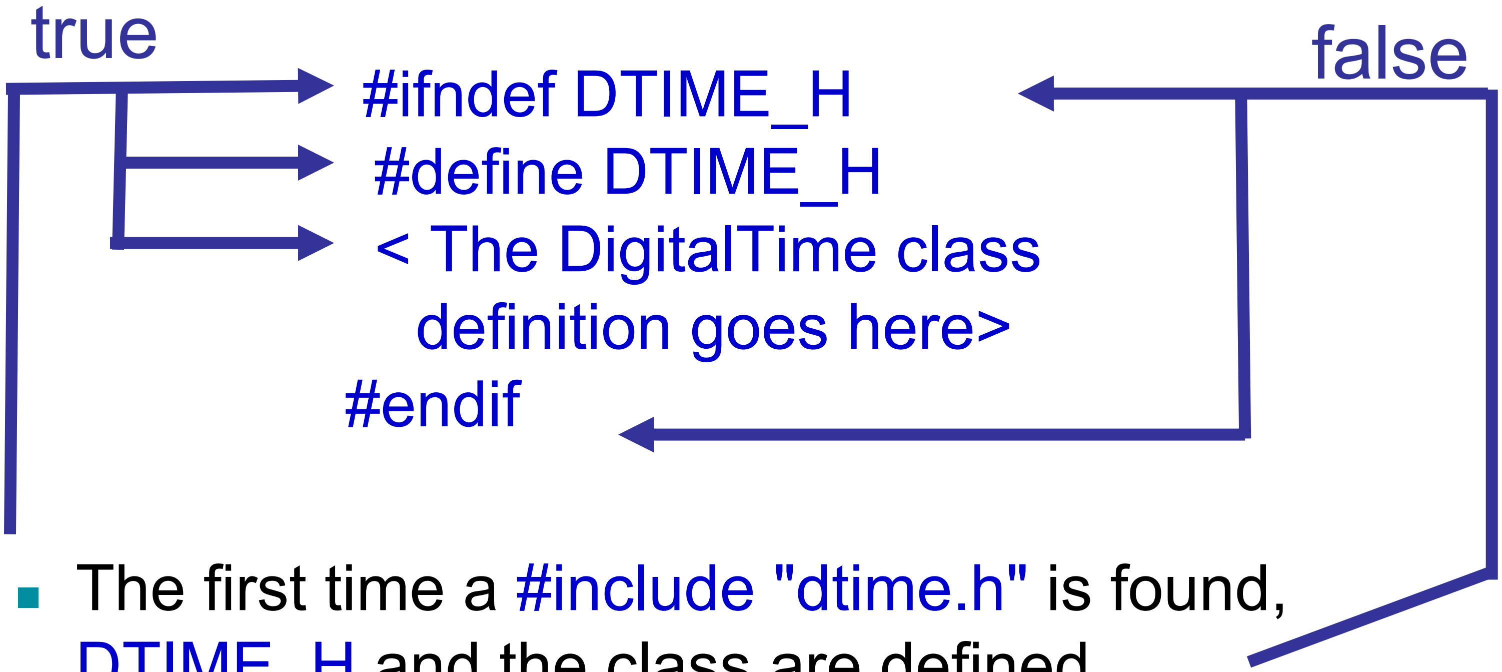
- A program may use several classes
  - Each could be stored in its own interface and implementation files
    - Some files can "include" other files, that include still others
  - It is possible that the same interface file could be included in multiple files
  - C++ does not allow multiple declarations of a class
  - The #ifndef directive can be used to prevent multiple declarations of a class

Introduction to #ifndef

- To prevent multiple declarations of a class, we can use these directives:
  - #define DTIME_H
    adds DTIME_H to a list indicating DTIME_H has been seen
  - #ifndef DTIME_H
    checks to see if DTIME_H has been defined
  - #endif
    If DTIME_H has been defined, skip to #endif
- It is called include guard.

Using #ifndef

- Consider this code in the interface file



```
#ifndef DTIME_H
 #define DTIME_H
 < The DigitalTime class
   definition goes here>
#endif
```

  - The first time a #include "dtime.h" is found, DTIME_H and the class are defined
  - The next time a #include "dtime.h" is found, all lines between #ifndef and #endif are skipped

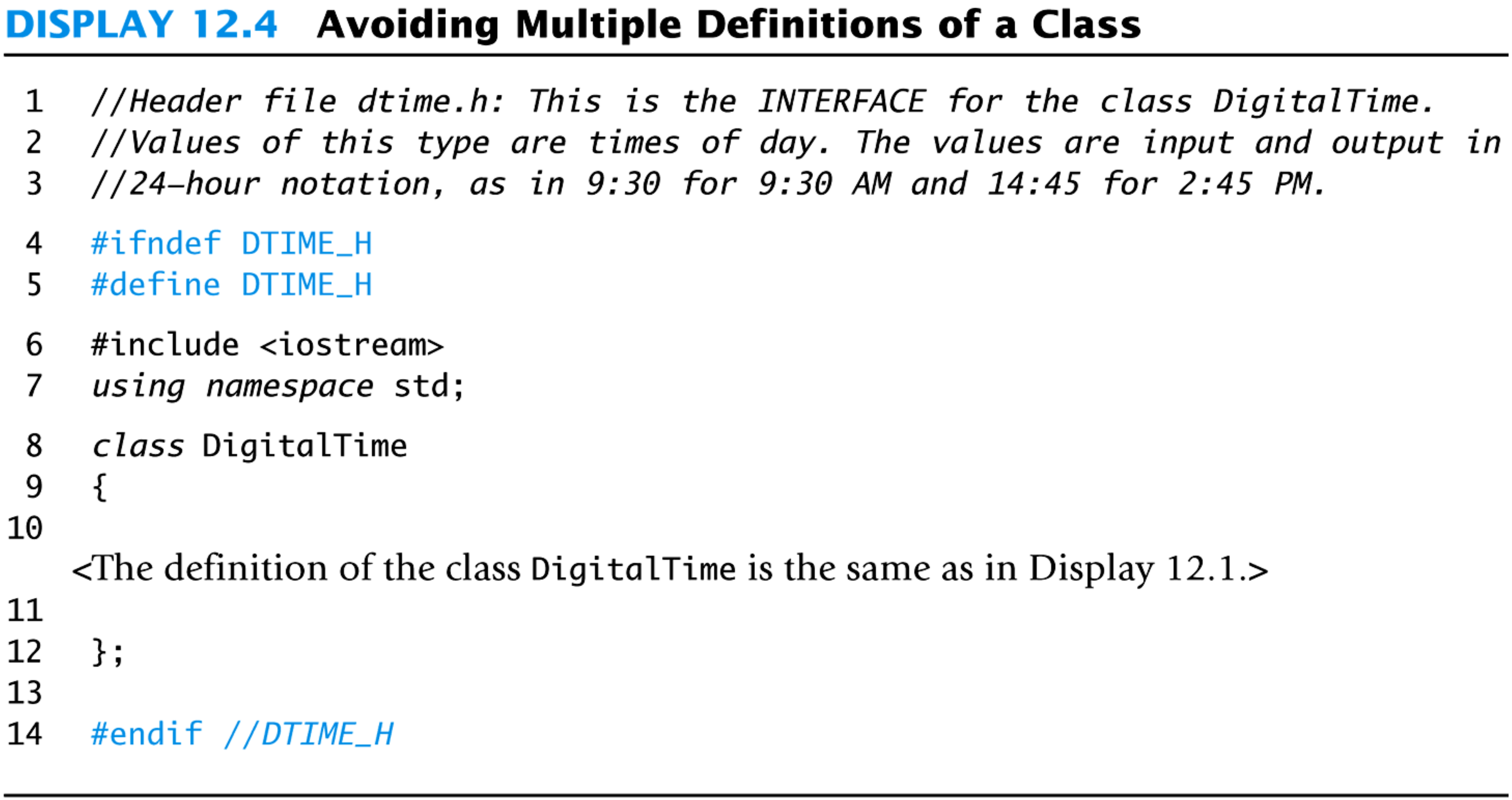
Why DTIME_H?

- DTIME_H is the normal convention for creating an identifier to use with #ifndef
  - It is the file name in all caps
  - Use ' _ ' instead of ' . ’
  - For example, if filename is myfile.h, the identifier is MYFILE_H
- You may use any other identifier, but will make your code more difficult to read

Display 12.4

Display 12.4

Back Next



DISPLAY 12.4 Avoiding Multiple Definitions of a Class

```
//Header file dtime.h: This is the INTERFACE for the class DigitalTime.
//Values of this type are times of day. The values are input and output in
//24-hour notation, as in 9:30 for 9:30 AM and 14:45 for 2:45 PM.

#ifndef DTIME_H
#define DTIME_H

#include <iostream>
using namespace std;

class DigitalTime
{

  <The definition of the class DigitalTime is the same as in Display 12.1.>

};

#endif //DTIME_H
```

Defining Libraries

- You can create your own libraries of functions
  - You do not have to define a class to use separate files
  - If you have a collection of functions…
    - Declare them in a header file with their comments
    - Define them in an implementation file
    - Use the library files just as you use your class interface and implementation files

Section 12.1 Conclusion

- Can you
  - Determine which belongs to the interface, implementation or application files?
    - Class definition
    - Declaration of a non-member function used as an operation of the ADT
    - Definition of a member function
    - The main part of the program
  - Describe the difference between a C++ class and an ADT?

12.2

Namespaces

Adapted from Savitch, “Problem Solving with C++”

Namespaces

- A namespace is a collection of name definitions, such as class definitions and variable declarations
  - If a program uses classes and functions written by different programmers, it may be that the same name is used for different things
  - Namespaces help us deal with this problem

The Using Directive

- #include <iostream> places names such as cin and cout in the std namespace
- The program does not know about names in the std namespace until you add

  ```
  using namespace std;
  ```

  (if you do not use the std namespace, you can define cin and cout to behave differently)

The Global Namespace

- Code you write is in a namespace
  - it is in the *global namespace* unless you specify a namespace
  - The global namespace does not require the using directive

Name Conflicts

- If the same name is used in two namespaces
  - The namespaces cannot be used at the same time
  - Example: If my_function is defined in namespaces ns1 and ns2, the two versions of my_function could be used in one program by using local using directives this way:

```
{
  using namespace ns1;
  my_function( );
}
```

```
{
  using namespace ns2;
  my_function( );
}
```

Scope Rules For using

- A block is a list of statements enclosed in { }
- The scope of a using directive is the block in which it appears
- A using directive can be placed at the beginning of a file, outside any block, applies to the entire file

Creating a Namespace

- To place code in a namespace
  - Use a namespace grouping

```
namespace Name_Space_Name
 {
        Some_Code
 }
```

- To use the namespace created
  - Use the appropriate using directive

```
using namespace Name_Space_Name;
```

Namespaces:
Declaring a Function

- To add a function to a namespace
  - Declare the function in a namespace grouping

```
namespace myspace
{
        void greeting( );
}
```

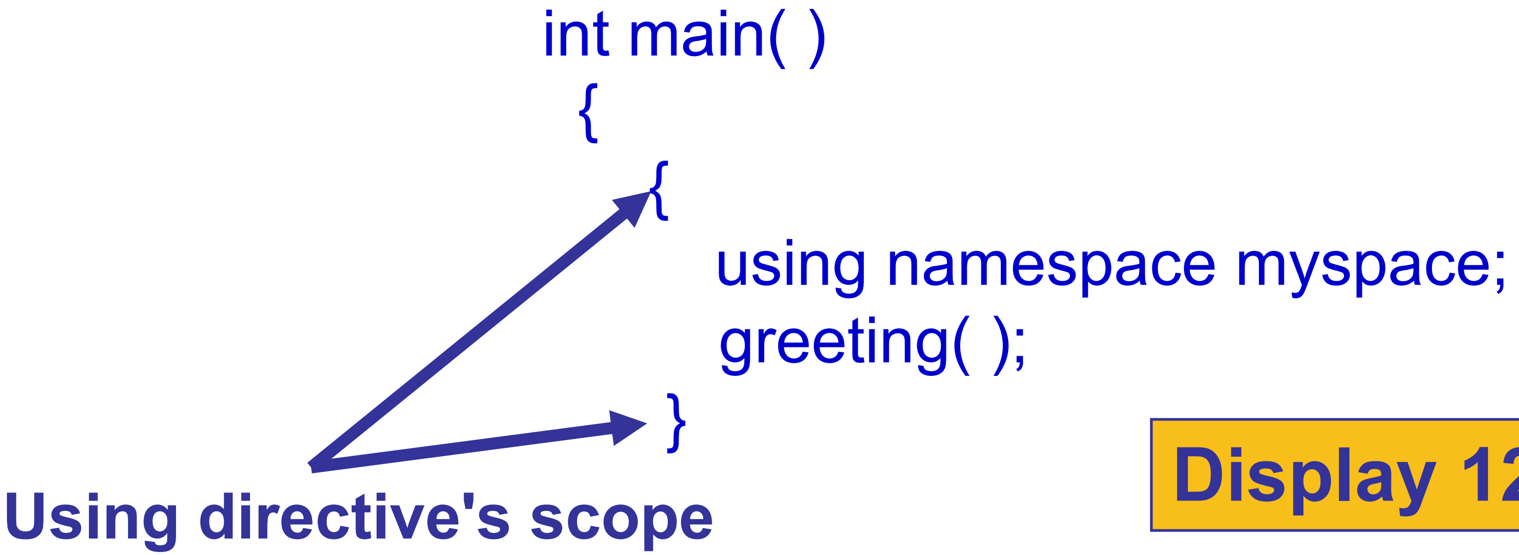
Namespaces:
Defining a Function

- To define a function declared in a namespace
  - Define the function in a namespace grouping

```
namespace myspace
 {
     void greeting( )
      {
          cout << "Hello from namespace savitch1.\n";
      }
  }
```

Namespaces:
Using a Function

- To use a function defined in a namespace
  - Include the using directive in the program where the namespace is to be used
  - Call the function as the function would normally be called



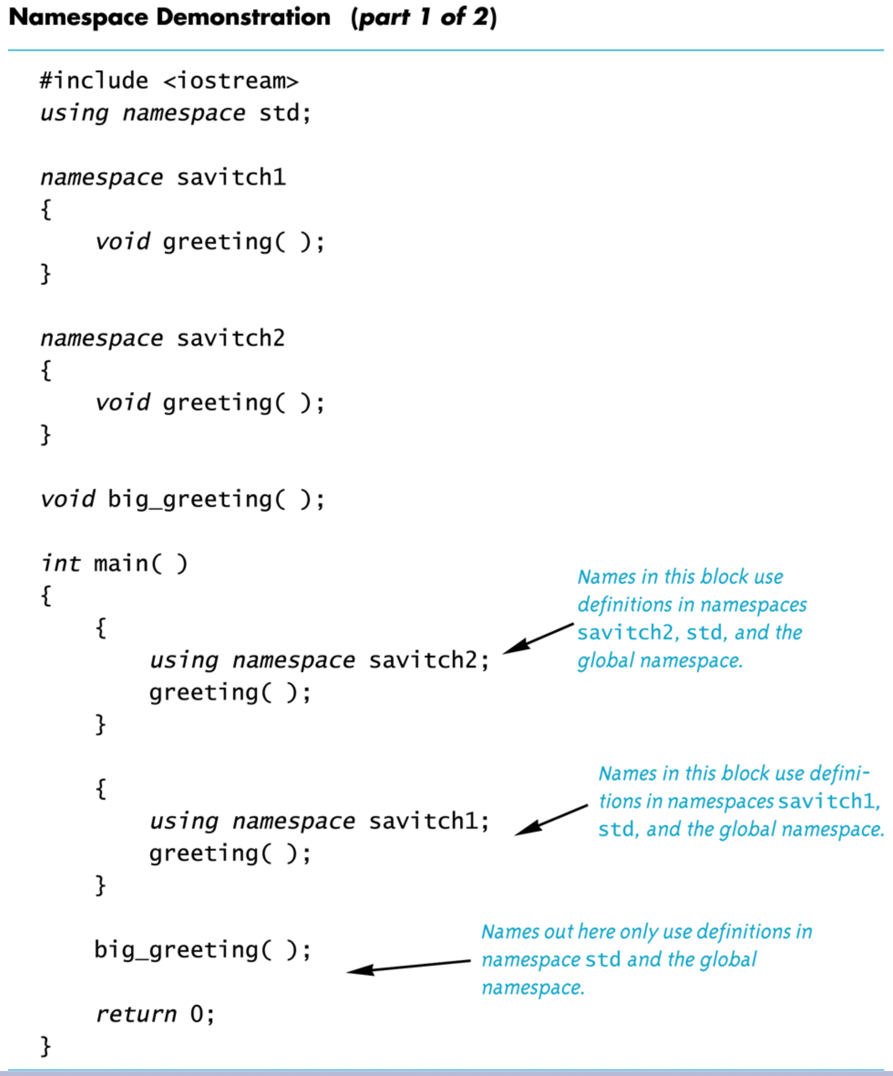
```
int main( )
 {
   {
      using namespace myspace;
      greeting( );
   }
```

Using directive's scope

Display 12.5 (1-2)

Display 12.5 (1/2)

Back Next



Namespace Demonstration ***(part 1 of 2)***

```
#include <iostream>
using namespace std;

namespace savitch1
{
    void greeting( );
}

namespace savitch2
{
    void greeting( );
}

void big_greeting( );

int main( )
{
    {
        using namespace savitch2;
        greeting( );
    }

    {
        using namespace savitch1;
        greeting( );
    }

    big_greeting( );

    return 0;
}
```

Names in this block use definitions in namespaces `savitch2, std,` *and the global namespace.*

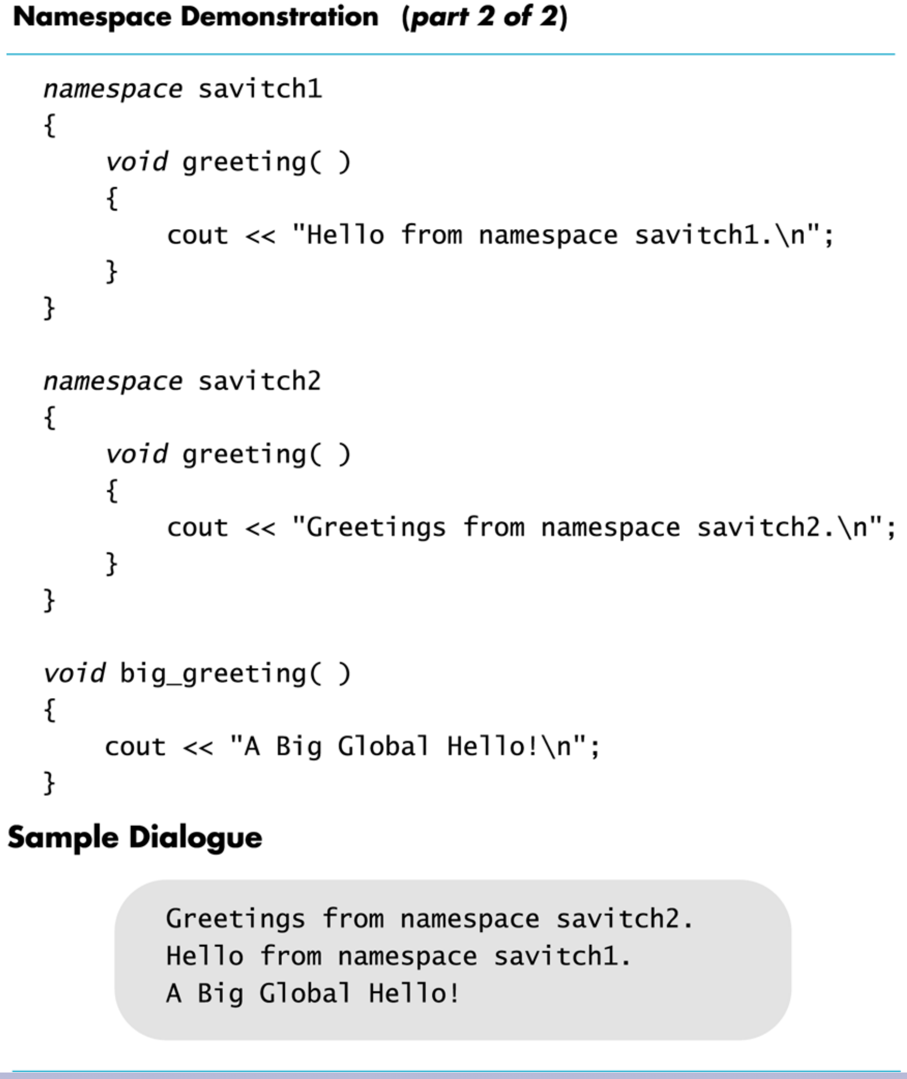
Names in this block use definitions in namespaces `savitch1, std,` *and the global namespace.*

Names out here only use definitions in namespace `std` *and the global namespace.*

Display 12.5 (2/2)

Back

Next



Namespace Demonstration ***(part 2 of 2)***

```
namespace savitch1
{
    void greeting( )
    {
        cout << "Hello from namespace savitch1.\n";
    }
}

namespace savitch2
{
    void greeting( )
    {
        cout << "Greetings from namespace savitch2.\n";
    }
}

void big_greeting( )
{
    cout << "A Big Global Hello!\n";
}
```

Sample Dialogue

```
Greetings from namespace savitch2.
Hello from namespace savitch1.
A Big Global Hello!
```

A Namespace Problem

- Suppose you have the namespaces below:

```
namespace ns1
{
        fun1( );
        my_function( );
 }
```

```
namespace ns2
{
        fun2( );
        my_function( );
}
```

- Is there an easier way to use both namespaces considering that my_function is in both?

Qualifying Names

- Using declarations (not directives) allow us to select individual functions to use from namespaces
  - using ns1::fun1;   //makes only fun1 in ns1 avail
    - The scope resolution operator identifies a namespace here
    - Means we are using only namespace ns1's version of fun1
  - If you only want to use the function once, call it like this

```
ns1::fun1( );
```

Qualifiying Parameter Names

- To qualify the type of a parameter with a using declaration
  - Use the namespace and the type name

    ```
    int get_number (std::istream input_stream)
     …
    ```

    - istream is the istream defined in namespace std
    - If istream is the only name needed from namespace std, then you do not need to use

      ```
      using namespace std;
      ```

Directive/Declaration (Optional)

- A using declaration (using std::cout;) makes only one name available from the namespace
- A using directive (using namespace std;) makes all the names in the namespace available

A Subtle Point (Optional)

- A using directive potentially introduces a name
- If ns1 and ns2 both define my_function,

```
using namespace ns1;
using namespace ns2;
```

is OK, provided my_function is never used!

A Subtle Point Continued

- A using declaration introduces a name into your code: no other use of the name can be made

```
using ns1::my_function;
using ns2::my_function;
```

is illegal, even if my_function is never used