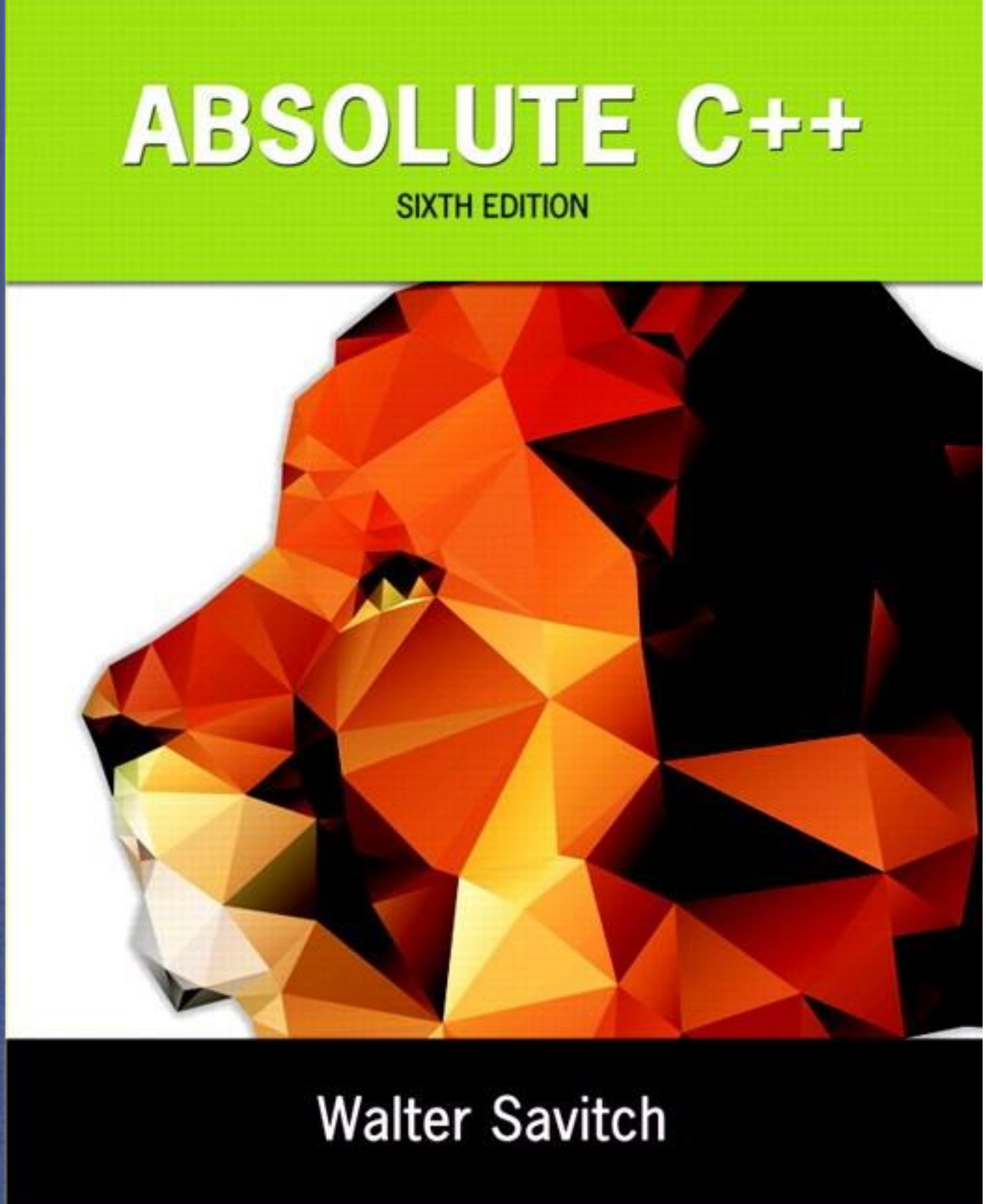


Chapter 14

Inheritance

Learning Objectives

- Inheritance Basics
  - Derived classes, with constructors
  - protected: qualifier
  - Redefining member functions
  - Non-inherited functions
- Programming with Inheritance
  - Assignment operators and copy constructors
  - Destructors in derived classes
  - Multiple inheritance

Introduction to Inheritance

- Object-oriented programming
  - Powerful programming technique
  - Provides abstraction dimension called *inheritance*
- General form of class is defined
  - Specialized versions then inherit properties of general class
  - And add to it/modify it's functionality for it's appropriate use

Inheritance Basics

- New class inherited from another class
- Base class
  - "General" class from which others derive
- Derived class
  - New class
  - Automatically has base class's:
    - Member variables
    - Member functions
  - Can then add additional member functions and variables

Derived Classes

- Consider example:
  Class of "Employees"
- Composed of:
  - Salaried employees
  - Hourly employees
- Each is "subset" of employees
  - Another might be those paid fixed wage each month or week

Derived Classes

- Don’t "need" type of generic "employee"
  - Since no one’s just an "employee"
- General concept of employee helpful!
  - All have names
  - All have social security numbers
  - Associated functions for these "basics" are same among all employees
- So "general" class can contain all these "things" about employees

Employee Class

- Many members of "employee" class apply to all types of employees
  - Accessor functions
  - Mutator functions
  - Most data items:
    - SSN
    - Name
    - Pay
- We won’t have "objects" of this class, however

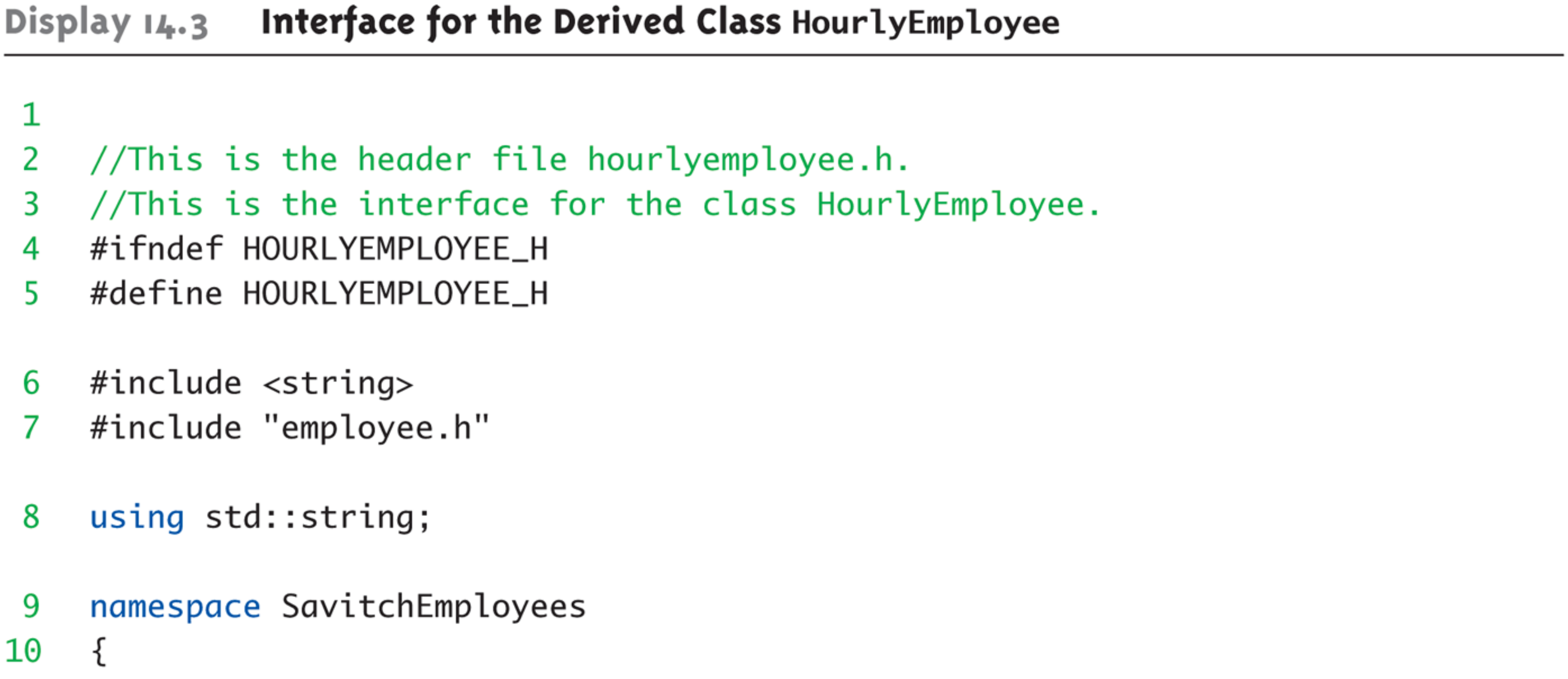
Employee Class

- Consider printCheck() function:
  - Will always be "redefined" in derived classes
  - So different employee types can have different checks
  - Makes no sense really for "undifferentiated" employee
  - So function printCheck() in Employee class says just that
    - Error message stating "printCheck called for undifferentiated employee!! Aborting…"

Deriving from Employee Class

- Derived classes from Employee class:
  - Automatically have all member variables
  - Automatically have all member functions
- Derived class said to "inherit" members from base class
- Can then redefine existing members and/or add new members

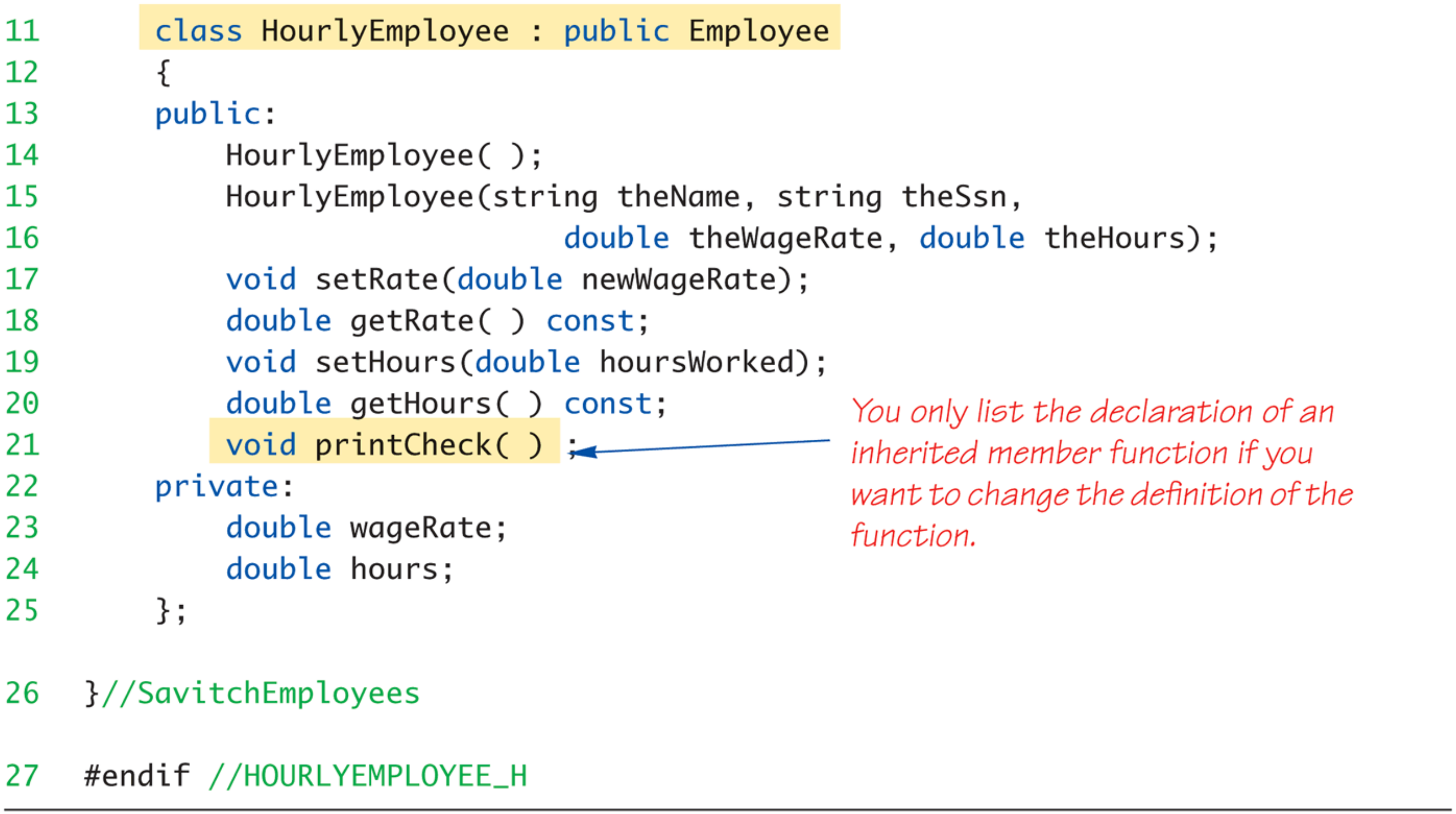
Display 14.3 Interface for the Derived Class HourlyEmployee (1 of 2)



Display 14.3 Interface for the Derived Class HourlyEmployee

```

//This is the header file hourlyemployee.h.
//This is the interface for the class HourlyEmployee.
#ifndef HOURLYEMPLOYEE_H
#define HOURLYEMPLOYEE_H

#include <string>
#include "employee.h"

using std::string;

namespace SavitchEmployees
{
```

Display 14.3 Interface for the Derived Class HourlyEmployee (2 of 2)



```cpp
    class HourlyEmployee : public Employee
    {
    public:
        HourlyEmployee( );
        HourlyEmployee(string theName, string theSsn,
                           double theWageRate, double theHours);
        void setRate(double newWageRate);
        double getRate( ) const;
        void setHours(double hoursWorked);
        double getHours( ) const;
        void printCheck( ) ;
    private:
        double wageRate;
        double hours;
    };

}//SavitchEmployees

#endif //HOURLYEMPLOYEE_H
```

You only list the declaration of an inherited member function if you want to change the definition of the function.

HourlyEmployee Class Interface

- Note definition begins same as any other
  - #ifndef structure
  - Includes required libraries
  - Also includes employee.h!
- And, the heading:
  class HourlyEmployee : public Employee
  { …
  - Specifies "publicly inherited" from Employee class

HourlyEmployee Class Additions

- Derived class interface only lists new or "to be redefined" members
  - Since all others inherited are already defined
  - i.e.: "all" employees have ssn, name, etc.
- HourlyEmployee adds:
  - Constructors
  - wageRate, hours member variables
  - setRate(), getRate(), setHours(), getHours() member functions

HourlyEmployee Class Redefinitions

- HourlyEmployee redefines:
  - printCheck() member function
  - This "overrides" the printCheck() function implementation from Employee class
- It's definition must be in HourlyEmployee class's implementation
  - As do other member functions declared in HourlyEmployee's interface
    - New and "to be redefined"

Inheritance Terminology

- Common to simulate family relationships
- Parent class
  - Refers to base class
- Child class
  - Refers to derived class
- Ancestor class
  - Class that's a parent of a parent …
- Descendant class
  - Opposite of ancestor

Constructors in Derived Classes

- Base class constructors are NOT inherited in derived classes!
  - But they can be invoked within derived class constructor
    - Which is all we need!
- Base class constructor must initialize all base class member variables
  - Those inherited by derived class
  - So derived class constructor simply calls it
    - "First" thing derived class constructor does

Derived Class Constructor Example

- Consider syntax for HourlyEmployee constructor:

```
HourlyEmployee::HourlyEmployee(string theName,
                        string theNumber, double theWageRate,
                        double theHours)
               : Employee(theName, theNumber),
               wageRate(theWageRate), hours(theHours)
{
      //Deliberately empty
}
```

- Portion after : is "initialization section"
  - Includes invocation of Employee constructor

Another HourlyEmployee Constructor

- A second constructor:

```
HourlyEmployee::HourlyEmployee()
                : Employee(),   wageRate(0),
                                     hours(0)
{
     //Deliberately empty
}
```

- Default version of base class constructor is called (no arguments)
- Should always invoke one of the base class's constructors

Constructor: No Base Class Call

- Derived class constructor should always invoke one of the base class's constructors
- If you do not:
  - Default base class constructor automatically called
- Equivalent constructor definition:

```
HourlyEmployee::HourlyEmployee()
                              : wageRate(0), hours(0)
{ }
```

Pitfall: Base Class Private Data

- Derived class "inherits" private member variables
  - But still cannot directly access them
  - Not even through derived class member functions!
- Private member variables can ONLY be accessed "by name" in member functions of the class they're defined in

Pitfall: Base Class Private Member Functions

- Same holds for base class member functions
  - Cannot be accessed outside interface and implementation of base class
  - Not even in derived class member function definitions

Pitfall: Base Class Private Member Functions Impact

- Larger impact here vs. member variables
  - Member variables can be accessed indirectly via accessor or mutator member functions
  - Member functions simply not available
- This is "reasonable"
  - Private member functions should be simply "helper" functions
  - Should be used only in class they're defined

The protected: Qualifier

- New classification of class members
- Allows access "by name" in derived class
  - But nowhere else
  - Still no access "by name" in other classes
- In class it's defined → acts like private
- Considered "protected" in derived class
  - To allow future derivations
- Many feel this "violates" information hiding

Redefinition of Member Functions

- Recall interface of derived class:
  - Contains declarations for new member functions
  - Also contains declarations for inherited member functions to be changed
  - Inherited member functions NOT declared:
    - Automatically inherited unchanged
- Implementation of derived class will:
  - Define new member functions
  - Redefine inherited functions as declared

Redefining vs. Overloading

- Very different!
- Redefining in derived class:
  - SAME parameter list
  - Essentially "re-writes" same function
- Overloading:
  - Different parameter list
  - Defined "new" function that takes different parameters
  - Overloaded functions must have different signatures

A Function’s Signature

- Recall definition of a "signature":
  - – Function’s name
  - – Sequence of types in parameter list
    - Including order, number, types
- Signature does NOT include:
  - – Return type
  - – const keyword
  - – &

Accessing Redefined Base Function

- When redefined in derived class, base class's definition not "lost"
- Can specify it's use:

```
Employee       JaneE;
HourlyEmployee SallyH;
JaneE.printCheck();  → calls Employee's
                                printCheck function
SallyH.printCheck();  → calls HourlyEmployee
                                printCheck function
SallyH.Employee::printCheck();  → Calls Employee's
                                printCheck function!
```

- Not typical here, but useful sometimes

Functions Not Inherited

- All "normal" functions in base class are inherited in derived class
- Exceptions:
  - Constructors (we’ve seen)
  - Destructors
  - Copy constructor
    - But if not defined, generates "default" one
    - Recall need to define one for pointers!
  - Assignment operator
    - If not defined → default

Assignment Operators and Copy Constructors

- Recall: overloaded assignment operators and copy constructors
  NOT inherited
  - But can be used in derived class definitions
  - Typically MUST be used!
  - Similar to how derived class constructor invokes base class constructor

Assignment Operator Example

- Given "Derived" is derived from "Base":

```
Derived& Derived::operator =(const Derived & rightSide)
{
        Base::operator =(rightSide);
        …
}
```

- Notice code line
  - Calls assignment operator from base class
    - This takes care of all inherited member variables
  - Would then set new variables from derived class…

Copy Constructor Example

- Consider:

  ```
  Derived::Derived(const Derived& Object)
                              : Base(Object), …
  {…}
  ```

- After : is invocation of base copy constructor
  - Sets inherited member variables of derived class object being created
  - Note Object is of type Derived; but it's also of type Base, so argument is valid

Destructors in Derived Classes

- If base class destructor functions correctly
  - Easy to write derived class destructor
- When derived class destructor is invoked:
  - Automatically calls base class destructor!
  - So no need for explicit call
- So derived class destructors need only be concerned with derived class variables
  - And any data they "point" to
  - Base class destructor handles inherited data automatically

Destructor Calling Order

- Consider:
  class B derives from class A
  class C derives from class B
  A ← B ← C
- When object of class C goes out of scope:
  - Class C destructor called 1st
  - Then class B destructor called
  - Finally class A destructor is called
- Opposite of how constructors are called

"Is a" vs. "Has a" Relationships

- Inheritance
  - Considered an "Is a" class relationship
  - e.g., An HourlyEmployee "is a" Employee
  - A Convertible "is a" Automobile
- A class contains objects of another class as it's member data
  - Considered a "Has a" class relationship
  - e.g., One class "has a" object of another class as it's data

Protected and Private Inheritance

- New inheritance "forms"
  - Both are rarely used
- Protected inheritance:

  class SalariedEmployee : protected Employee
  {…}
  - Public members in base class become protected in derived class
- Private inheritance:

  class SalariedEmployee : private Employee
  {…}
  - All members in base class become private in derived class

Multiple Inheritance

- Derived class can have more than one base class!
  - Syntax just includes all base classes separated by commas:
    class derivedMulti : public base1, base2
    {…}
- Possibilities for ambiguity are endless!
- Dangerous undertaking!
  - Some believe should never be used
  - Certainly should only be used be experienced programmers!

Summary 1

- Inheritance provides code reuse
  - Allows one class to "derive" from another, adding features
- Derived class objects inherit members of base class
  - And may add members
- Private member variables in base class cannot be accessed "by name" in derived
- Private member functions are not inherited

Summary 2

- Can redefine inherited member functions
  - To perform differently in derived class
- Protected members in base class:
  - Can be accessed "by name" in derived class member functions
- Overloaded assignment operator not inherited
  - But can be invoked from derived class
- Constructors are not inherited
  - Are invoked from derived class’s constructor