Structures and Classes

Learning Objectives

- Structures
  - Structure types
  - Structures as function arguments
  - Initializing structures
- Classes
  - Defining, member functions
  - Public and private members
  - Accessor and mutator functions
  - Structures vs. classes

Structures

- 2nd aggregate data type: struct
- Recall: aggregate meaning "grouping"
  - Recall array: collection of values of same type
  - Structure: collection of values of different types
- Treated as a single item, like arrays
- Major difference: Must first "define" struct
  - Prior to declaring any variables

Structure Types

- Define struct globally (typically)
- No memory is allocated
  - Just a "placeholder" for what our struct will "look like"
- Definition:

```
struct CDAccountV1    ←Name of new struct "type"
{
        double balance; ← member names
        double interestRate;
        int term;
};
```

Declare Structure Variable

- With structure type defined, now declare variables of this new type:

```
CDAccountV1 account;
```

  - Just like declaring simple types
  - Variable *account* now of type CDAccountV1
  - It contains "member values"
    - Each of the struct "parts"

Accessing Structure Members

- Dot Operator to access members
  - account.balance
  - account.interestRate
  - account.term
- Called "member variables"
  - The "parts" of the structure variable
  - Different structs can have same name member variables
    - No conflicts

Structure Example: A Structure Definition (1 of 3)

Display 6.1 A Structure Definition

```
1  //Program to demonstrate the CDAccountV1 structure type.
2  #include <iostream>
3  using namespace std;

4  //Structure for a bank certificate of deposit:
5  struct CDAccountV1
6  {
7      double balance;
8      double interestRate;
9      int term;//months until maturity
10 };

11 void getData(CDAccountV1& theAccount);
12 //Postcondition: theAccount.balance, theAccount.interestRate, and
13 //theAccount.term have been given values that the user entered at the keyboar
```

An improved version of this structure will be given later in this chapter.

Structure Example: A Structure Definition (2 of 3)

```
14  int main( )
15  {
16      CDAccountV1 account;
17      getData(account);

18      double rateFraction, interest;
19      rateFraction = account.interestRate/100.0;
20      interest = account.balance*(rateFraction*(account.term/12.0));
21      account.balance = account.balance + interest;

22      cout.setf(ios::fixed);
23      cout.setf(ios::showpoint);
24      cout.precision(2);
25      cout << "When your CD matures in "
26           << account.term << " months,\n"
27           << "it will have a balance of $"
28           << account.balance << endl;

29      return 0;
30  }
```

(continued)

Structure Example: A Structure Definition (3 of 3)

Display 6.1 A Structure Definition

```
31  //Uses iostream:
32  void getData(CDAccountV1& theAccount)
33  {
34      cout << "Enter account balance: $";
35      cin >> theAccount.balance;
36      cout << "Enter account interest rate: ";
37      cin >> theAccount.interestRate;
38      cout << "Enter the number of months until maturity: ";
39      cin >> theAccount.term;
40  }
```

SAMPLE DIALOGUE

Enter account balance: **$100.00**
Enter account interest rate: **10.0**
Enter the number of months until maturity: **6**
When your CD matures in 6 months,
it will have a balance of $105.00

Structure Pitfall

- Semicolon after structure definition
  - ; MUST exist:

```
struct WeatherData
{
  double temperature;
  double windVelocity;
}; ← REQUIRED semicolon!
```

  - Required since you "can" declare structure variables in this location

Structure Assignments

- Given structure named CropYield
- Declare two structure variables:
  CropYield apples, oranges;
  - Both are variables of "struct type CropYield"
  - Simple assignments are legal:
    apples = oranges;
    - Simply copies each member variable from apples into member variables from oranges

Structures as Function Arguments

- Passed like any simple data type
  - Pass-by-value
  - Pass-by-reference
  - Or combination
- Can also be returned by function
  - Return-type is structure type
  - Return statement in function definition sends structure variable back to caller

Initializing Structures

- Can initialize at declaration
  - Example:

```
struct Date
{
        int month;
        int day;
        int year;
};
Date dueDate = {12, 31, 2003};
```

  - Declaration provides initial data to all three member variables

Classes

- Similar to structures
  - Adds member FUNCTIONS
  - Not just member data
- Integral to object-oriented programming
  - Focus on objects
    - Object: Contains data and operations
    - In C++, variables of class type are objects

Class Definitions

- Defined similar to structures
- Example:

```
class DayOfYear    ← name of new class type
{
public:
        void output();        ← member function!
        int month;
        int day;
};
```

- Notice only member function's prototype
  - Function's implementation is elsewhere

Declaring Objects

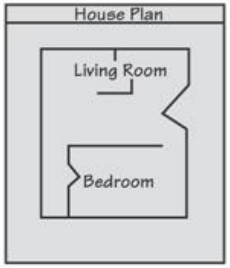
- Declared same as other variables
  - Predefined types, structure types
- Example:

  DayOfYear today, birthday;
  - Declares two objects of class type DayOfYear
- Objects include:
  - Data
    - Members month, day
  - Operations (member functions)
    - output()

Classes and Objects

- A Class is like a blueprint and objects are like houses built from the blueprint

Blueprint that describes a house.



Instances of the house described by the blueprint.

Class Member Access

- Members accessed same as structures
- Example:

  today.month
  today.day

  - And to access member function:
    today.output(); ← Invokes member function

Class Member Functions

- Must define or "implement" class member functions
- Like other function definitions
  - Can be after main() definition
  - Must specify class:
    void DayOfYear::output()
    {…}
    - :: is scope resolution operator
    - Instructs compiler "what class" member is from
    - Item before :: called type qualifier

Class Member Functions Definition

- Notice output() member function's definition (in next example)
- Refers to member data of class
  - No qualifiers
- Function used for all objects of the class
  - Will refer to "that object's" data when invoked
  - Example:
    today.output();
    - Displays "today" object's data

Class Example: Class With a Member Function (1 of 4)

Display 6.3 Class with a Member Function

```
1  //Program to demonstrate a very simple example of a class.
2  //A better version of the class DayOfYear will be given in Display 6.4.
3  #include <iostream>
4  using namespace std;

5  class DayOfYear
6  {
7  public:
8      void output( );
9      int month;
10     int day;
11 };

12 int main( )
13 {
14     DayOfYear today, birthday;
15     cout << "Enter today's date:\n";
16     cout << "Enter month as a number: ";
17     cin >> today.month;
18     cout << "Enter the day of the month: ";
19     cin >> today.day;
20     cout << "Enter your birthday:\n";
21     cout << "Enter month as a number: ";
22     cin >> birthday.month;
23     cout << "Enter the day of the month: ";
24     cin >> birthday.day;
```

Normally, member variables are `private` *and not* `public`*, as in this example. This is discussed a bit later in this chapter.*

Member function declaration

(continued)

Class Example: Class With a Member Function (2 of 4)

Display 6.3 Class with a Member Function

```
25      cout << "Today's date is ";
26      today.output( );
27      cout << endl;
28      cout << "Your birthday is ";
29      birthday.output( );
30      cout << endl;

31      if (today.month == birthday.month && today.day == birthday.day)
32          cout << "Happy Birthday!\n";
33      else
34          cout << "Happy Unbirthday!\n";
35      return 0;
36  }
37  //Uses iostream:
38  void DayOfYear::output( )
39  {
40      switch (month)
41      {
42          case 1:
43              cout << "January "; break;
44          case 2:
45              cout << "February "; break;
46          case 3:
47              cout << "March "; break;
48          case 4:
49              cout << "April "; break;
```

Calls to the member function `output`

Member function definition

Class Example: Class With a Member Function (3 of 4)

```
50          case 5:
51              cout << "May "; break;
52          case 6:
53              cout << "June "; break;
54          case 7:
55              cout << "July "; break;
56          case 8:
57              cout << "August "; break;
58          case 9:
59              cout << "September "; break;
60          case 10:
61              cout << "October "; break;
62          case 11:
63              cout << "November "; break;
64          case 12:
65              cout << "December "; break;
66          default:
67              cout << "Error in DayOfYear::output. Contact software vendor.";
68      }
69
70      cout << day;
71  }
```

Class Example: Class With a Member Function (4 of 4)

Display 6.3 **Class with a Member Function**

SAMPLE DIALOGUE

```
Enter today's date:
Enter month as a number: 10
Enter the day of the month: 15
Enter your birthday:
Enter month as a number: 2
Enter the day of the month: 21
Today's date is October 15
Your birthday is February 21
Happy Unbirthday!
```

A Class's Place

- Class is full-fledged type!
  - Just like data types int, double, etc.
- Can have variables of a class type
  - We simply call them "objects"
- Can have parameters of a class type
  - Pass-by-value
  - Pass-by-reference
- Can use class type like any other type!

Encapsulation

- Any data type includes
  - Data (range of data)
  - Operations (that can be performed on data)
- Example:

  int data type has:
  Data: +-32,767
  Operations: +,-,*,/,%,logical,etc.
- Same with classes
  - But WE specify data, and the operations to be allowed on our data!

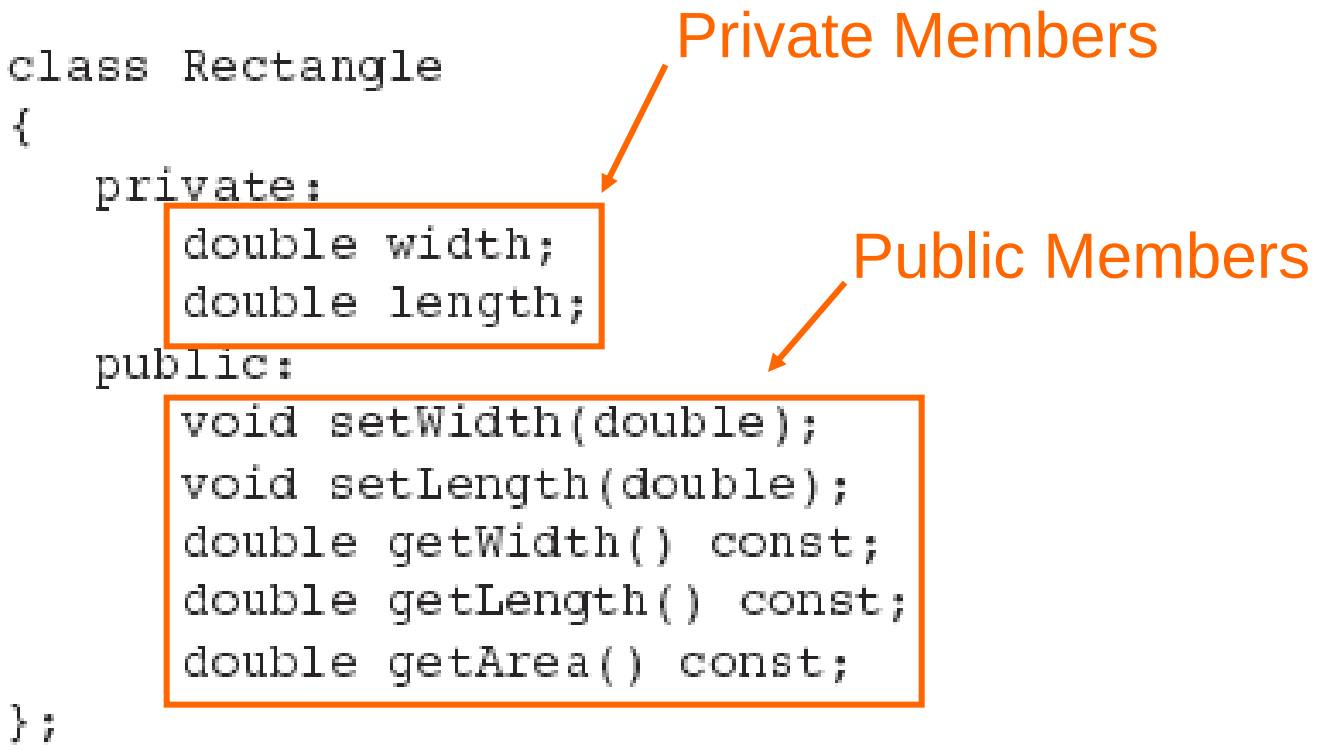
Class Example

```
class Rectangle
{
   private:
      double width;
      double length;
   public:
      void setWidth(double);
      void setLength(double);
      double getWidth() const;
      double getLength() const;
      double getArea() const;
};
```

Access Specifiers

- Used to control access to members of the class
- `public:` can be accessed by functions outside of the class
- `private:` can only be called by or accessed by functions that are members of the class

Class Example



Abstract Data Types

- "Abstract"
  - Programmers don’t know details
- Abbreviated "ADT"
  - Collection of data values together with set of basic operations defined for the values
- ADT’s often "language-independent"
  - We implement ADT’s in C++ with classes
    - C++ class "defines" the ADT
  - Other languages implement ADT’s as well

More Encapsulation

- Encapsulation
  - Means "bringing together as one"
- Declare a class → get an object
- Object is "encapsulation" of
  - Data values
  - Operations on the data (member functions)

Principles of OOP

- Information Hiding
  - Details of how operations work not known to "user" of class
- Data Abstraction
  - Details of how data is manipulated within ADT/class not known to user
- Encapsulation
  - Bring together data and operations, but keep "details" hidden

Public and Private Members

- Data in class almost always designated private in definition!
  - Upholds principles of OOP
  - Hide data from user
  - Allow manipulation only via operations
    - Which are member functions
- Public items (usually member functions) are "user-accessible"

Public and Private Example

- Modify previous example:

```
class DayOfYear
{
public:
        void input();
        void output();
private:
        int month;
        int day;
};
```

- Data now private
- Objects have no direct access

Public and Private Example 2

- Given previous example, declare object:
  DayOfYear today;

- Object *today* can ONLY access public members
  - cin >> today.month; // NOT ALLOWED!
  - cout << today.day; // NOT ALLOWED!

  - Must instead call public operations:
    - today.input();
    - today.output();

Public and Private Style

- Can mix & match public & private
- More typically place public first
  - Allows easy viewing of portions that can be USED by programmers using the class
  - Private data is "hidden", so irrelevant to users
- Outside of class definition, cannot change (or even access) private data

Accessor and Mutator Functions

- Object needs to "do something" with its data
- Call accessor member functions
  - Allow object to read data
  - Also called “*get”* member functions
  - Simple retrieval of member data
- Mutator member functions
  - Allow object to change data
  - Manipulated based on application

Separate Interface and Implementation

- User of class need not see details of how class is implemented
  - Principle of OOP → encapsulation
- User only needs "rules"
  - Called "interface" for the class
    - In C++ → public member functions and associated comments
- Implementation of class hidden
  - Member function definitions elsewhere
  - User need not see them

Structures versus Classes

- Structures
  - Typically all members public
  - No member functions
- Classes
  - Typically all data members private
  - Interface member functions public
- Technically, same
  - Perceptionally, very different mechanisms

Procedural and Object-Oriented Programming

- Procedural programming focuses on the process/actions that occur in a program

- Object-Oriented programming is based on the data and the functions that operate on it. Objects are instances of ADTs that represent the data and its functions

Limitations of Procedural Programming

- If the data structures change, many functions must also be changed

- Programs that are based on complex function hierarchies are:
  - difficult to understand and maintain
  - difficult to modify and extend
  - easy to break

Thinking Objects

- Focus for programming changes
  - Before → algorithms center stage
  - OOP → data is focus
- Algorithms still exist
  - They simply focus on their data
  - Are "made" to "fit" the data
- Designing software solution
  - Define variety of objects and how they interact

Summary 1

- Structure is collection of different types
- Class used to combine data and functions into single unit -> object
- Member variables and member functions
  - Can be public → accessed outside class
  - Can be private → accessed only in a member function's definition
- Class and structure types can be formal parameters to functions

Summary 2

- C++ class definition
  - Should separate two key parts
    - Interface: what user needs
    - Implementation: details of how class works