COSC 220: Computer Science II

Module 3

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   1.1 Abstract Data Types
   1.2 Array of Structures
   1.3 Structures as Function Arguments
   1.4 Pointers to Structures
   1.5 Enumerated Data Types
2. Classes

1.1 Abstract Data Types

- An abstract data type (ADT) is a new **data type** created by the programmer
  - Compared with primitive data types, such as `int`, `bool`, `char`, etc.

- An ADT specifies
  - the **primitive data types** it contains
  - **operations** that can be performed on these data types

What does "abstract" mean here?

Abstract Data Types

- Abstraction: a definition that captures general characteristics without details
- For example
  - A student has attributes such as `studentID`, `name`, `yearInSchool`, `gpa`, etc.
  - ADT enables us to define a new data type named `Student` that represents all the students
    - Each variable of this `Student` data type represents a student (an instance of the `Student` category)

How to define an abstract data type?

Combining Data into Structures

- Structure:
  - C++ allows you to group multiple **member variables** together into a single item known as structure
- General Format:

```
struct StructName
{
   dataType1 memberName1;
   dataType2 memberName2;
   . . .
};
```

  - Must have `;` after closing `}`
  - `StructName` commonly begin with uppercase letter
  - Multiple members of same type can be in comma-separated list:

```
string name, address;
```

Example

```
struct Student
{
   int studentID;
   string name;
   short yearInSchool;
   double gpa;
};
```

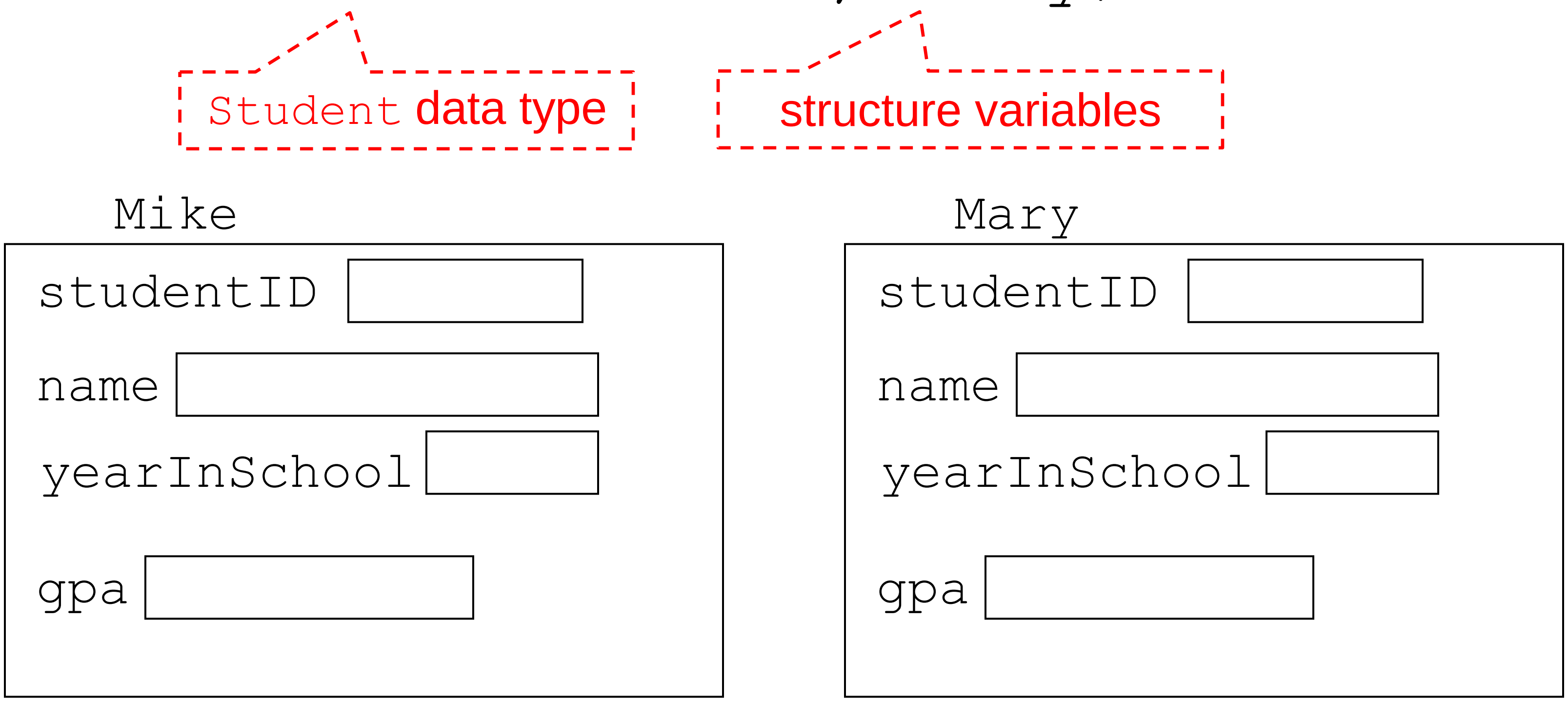
structure tag

structure members

Defining Variables

- To define structure variables, use *`StructName`* as <u>data type name</u>:

```
Student Mike, Mary;
```



Note: Each **structure variable** is an instance that contains all the **member variables**.

Accessing Structure Members

- Use the dot `(.)` operator to refer to member variables (or members) of `struct` variables:

```
Student stu1;
cin >> stu1.studentID;
getline(cin, stu1.name);
stu1.yearInSchool = 2;
stu1.gpa = 3.75;
```

- To display the contents of a `struct` variable, must display each member separately, using the dot operator

```
cout << stu1; // won't work
cout << stu1.studentID << endl;
cout << stu1.name << endl;
cout << stu1.yearInSchool;
cout << " " << stu1.gpa;
```

Note: With the dot operator, you can use member variables just like regular variable.

Example

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

const double PI = 3.14159;

struct Circle{
    double radius, diameter, area;
};

int main(){
    Circle c;

    cout << "Enter the diameter of a circle: ";
    cin >> c.diameter;
    c.radius = c.diameter / 2;
    c.area = PI * pow(c.radius,2.0);

    cout << "The radius of the circle is: " << c.radius << endl;
    cout << "The area of the circle is: " << c.area << endl;
    return 0;
}
```

Output:
Enter the diameter of a circle: 10
The radius of the circle is: 5
The area of the circle is: 78.5397

Initializing a `struct` variable

- `struct` variable can be initialized when defined:

```
Student s = {11465, "Joan", 2, 3.75};
```

- Can also be initialized member-by-member after definition:

```
s.name = "Joan";
s.gpa = 3.75;
```

1.2 Array of Structures

- An array of structures is an array that contains multiple same-type structures

```
struct BookInfo{
    string title, author, publisher;
    double price;
}

BookInfo bookList[20];
```

- Individual structures are accessible using subscript notation
- Members within a structure are accessible using dot notation

```
bookList[5].title
```

1.3 Structures as Function Arguments

- May pass members of `struct` variables to functions

```
struct Rectangle{
    double length, width, area;
};

double multiply(double x, double y){
    return x * y;
}

Rectangle box = {3.0, 4.0};
box.area = multiply(box.length, box.width);
```

Structures as Function Arguments

- May pass entire `struct` variables to functions:

```
struct Rectangle{
    double length, width, area;
};

void showRect(Rectangle r){
    cout << r.length << endl;
    cout << r.width << endl;
    cout << r.area << endl;
}

Rectangle box = {3.0, 4.0, 12.0};
showRect(box);
```

Structures as Function Arguments

- Can use reference parameter if function needs to modify contents of structure variable

```
struct Rectangle{
    double length, width, area;
};

void rectArea(Rectangle &r){
    cout << "Enter the box length and width: ";
    cin >> r.length >> r.width;
    r.area = r.length * r.width;
}

int main(){
    Rectangle box;
    rectArea(box);
    cout << "The box length is: " << box.length << endl;
    cout << "The box width is: " << box.width << endl;
    cout << "The box area is: " << box.area << endl;
}
```

```
Enter the box length and width: 3.0 4.0
The box length is: 3
The box width is: 4
The box area is: 12
```

In-class practice

- Programming challenges 1 (Page 659)
  - Write a program that uses a structure named `MovieData` to store the following information about a movie:
    - Title
    - Director
    - Year Released
    - Running Time (in minutes)
  - The program should create two `MovieData` variables, store values in their members, and pass each one, in turn, to a function that displays the information about the movie in a clearly formatted manner.

Reference code: spc11-1.cpp

1.4 Pointers to Structures

- A structure variable has an address
- A pointer to structure is a variable that can hold the address of a structure:

```
Student *stuPtr;
```

- Can use **&** operator to assign address:

```
stuPtr = &stu1;
```

- Structure pointer can be a function parameter

Accessing Structure Members via Pointer

- Must use `()` to dereference pointer variable
  - As the dot operator "." has higher precedence than the indirection operator "*"

```
cout << (*stuPtr).studentID;
```

- Can use structure pointer operator "->" to eliminate `()` and use clearer notation

```
cout << stuPtr->studentID;
```

Example

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

struct Student{
    string name;
    int idNum, creditHours;
    double gpa;
};

void getData(Student *);  //Function prototype

int main(){
    Student freshman;
    getData(&freshman);

    cout << "\nThe student's information: \n";
    cout << "Name: " << freshman.name << endl;
    cout << "ID Number: " << freshman.idNum << endl;
    cout << "Credit Hours: " << freshman.creditHours << en
dl;
    cout << "GPA: " << freshman.gpa << endl;
    return 0;
}
```

Example (continue)

```
void getData(Student *s){
    cout << "Input student name: ";
    getline(cin, s->name);
    cout << "Input student ID number: ";
    cin >> s->idNum;
    cout << "Input student credit hours: ";
    cin >> s->creditHours;
    cout << "Input student GPA: ";
    cin >> s->gpa;
}
```

Input student name: Frank Smith
Input student ID number: 4876
Input student credit hours: 12
Input student GPA: 3.9

The student's information:
Name: Frank Smith
ID Number: 4876
Credit Hours: 12
GPA: 3.9

Dynamically Allocating a Structure

- Can use a structure pointer and the **`new`** operator to dynamically allocate a structure

```
struct Circle {
    double radius, diameter, area;
};

Circle *cirPtr = nullptr;
cirPtr = new Circle;
cirPtr -> radius = 10;
cirPtr -> diameter = 20;
cirPtr -> area = 314.159;
```

1.5 Enumerated Data Types

- An enumerated data type is a programmer-defined data type. It consists of values known as ***enumerators***, which represent integer constants.
- Example:

```
enum Day { MONDAY, TUESDAY,
           WEDNESDAY, THURSDAY,
           FRIDAY };
```

  - The identifiers `MONDAY`, `TUESDAY`, `WEDNESDAY`, `THURSDAY`, and `FRIDAY` are *enumerators*. They represent the values that belong to the `Day` data type.

Note: The *enumerators* are not strings and aren't enclosed in quotes. They are identifiers.

Enumerated Data Types

- Once you have created an enumerated data type in your program, you can define variables of that type. Example:

```
Day workDay;
```

- We may assign any of the enumerators `MONDAY`, `TUESDAY`, `WEDNESDAY`, `THURSDAY`, or `FRIDAY` to a variable of the `Day` type. Example:

```
workDay = WEDNESDAY;
```

Enumerated Data Types

- An *enumerator* is an integer named constant
- Internally, the compiler assigns integer values to the enumerators, beginning at 0.

```
enum Day { MONDAY, TUESDAY,
           WEDNESDAY, THURSDAY,
           FRIDAY };
```

In memory...

```
MONDAY    = 0
TUESDAY   = 1
WEDNESDAY = 2
THURSDAY  = 3
FRIDAY    = 4
```

Example

- Using the `Day` declaration, the following code...

```
cout << MONDAY << " "
     << WEDNESDAY << " “
     << FRIDAY << endl;
```

...will produce this output:

```
0 2 4
```

Assigning an integer to an `enum` Variable

- You cannot directly assign an integer value to an `enum` variable. This will not work:

```
workDay = 3; // Error!
```

- Instead, you must cast the integer:

```
workDay = static_cast<Day>(3);
```

- However, you CAN assign an enumerator to an `int` variable.
  - This following code assigns 3 to `x`.

```
int x;
x = THURSDAY;
```

2. Classes

2.1 Procedural and Object-Oriented Programming

2.2 Introduction to Classes

2.3 Constructors

2.4 Destructors

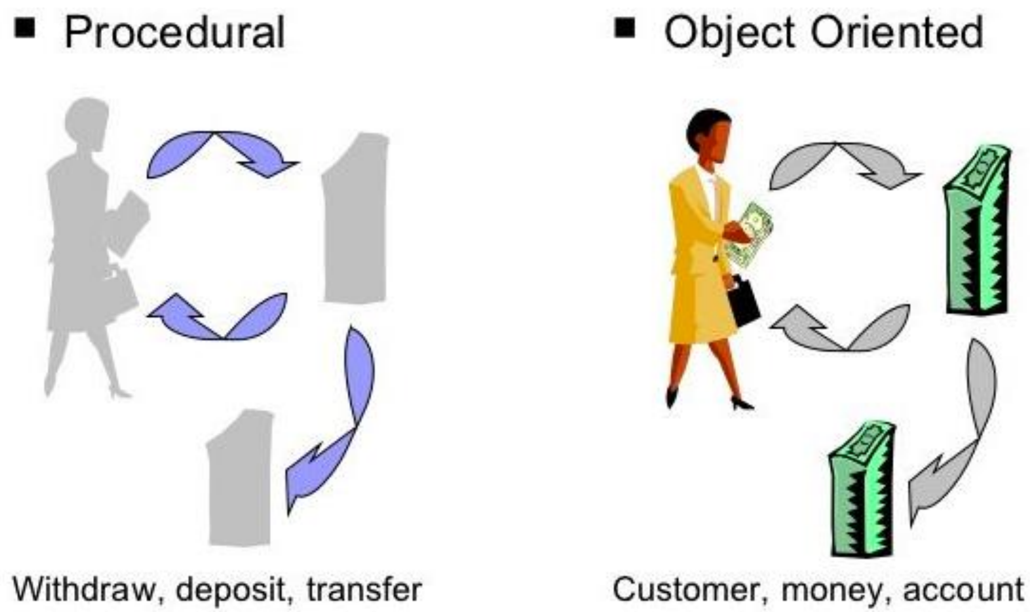
2.5 Overloading Constructors

2.6 Copy Constructors

2.7 Operator Overloading

2.1 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



https://www.alphansotech.com/procedural-vs-object-oriented-programming

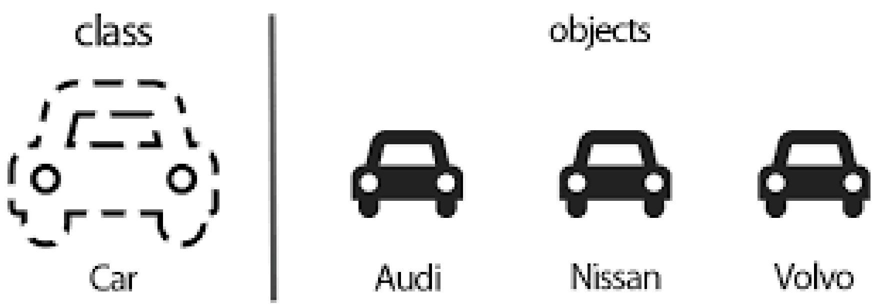
Procedural and Object-Oriented Programming

Procedural Programming	Object-Oriented Programming
• Program is divided into parts called **functions**	• Program is divided into parts called **objects**
• Top down design	• Object focused design
• Limited code reuse	• Code reuse
• Complex code	• Complex design
• Global data focused	• Protected data
• Less secure	• More secure

 https://www.slideshare.net/HarisBinZahid/procedural-vs-object-oriented-programming

Classes and Objects

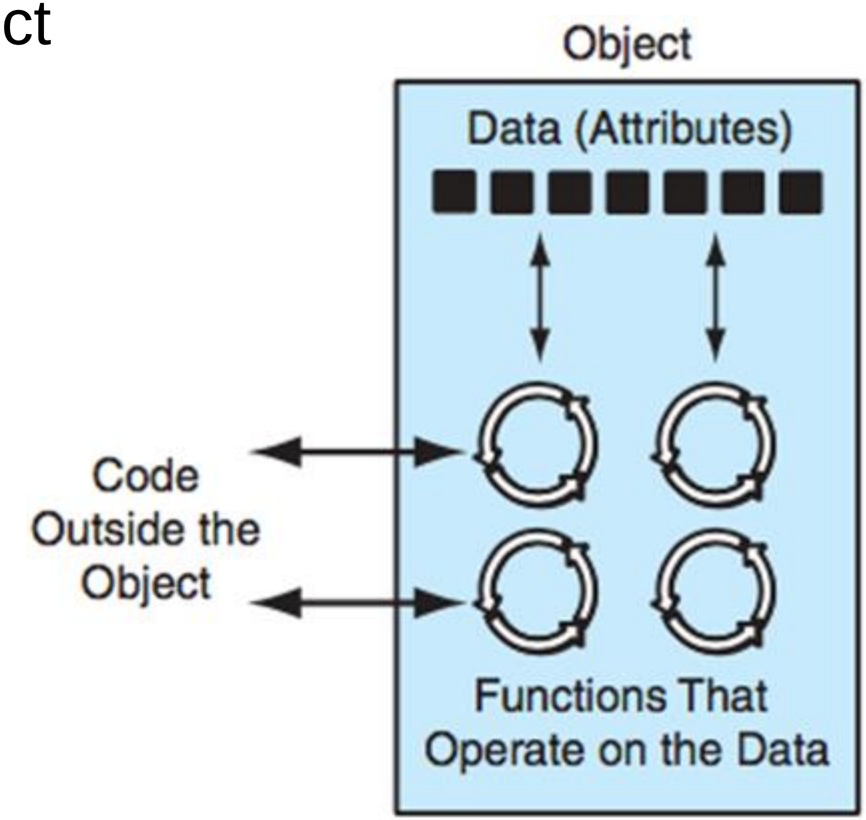
- class: A `class` is a code template for creating objects. It specifies the attributes (member variables) and behaviors (member functions) that a particular type of objects may have
- object: An object is an instance of a `class`. It has all the attributes and behaviors defined in the `class`



A Class is like a template and objects are built from the template

Encapsulation and Data Hiding

- Encapsulation: combine data and code into a single object
- Data hiding: hide data from code that is outside the object
- Public interface: data and functions of an object that are available outside of the object
- Imagine the "simple" interface to drive a vehicle: it "hides" very complex functionality from the user
  - The interfaces are **public** members (attributes & functions)
  - The information is hided in **private** members



http://faculty.salisbury.edu/~jtanderson/teaching/cosc220/sp20/index.html

2.2 Introduction to Classes

- Class declaration:

```
class ClassName
{
    declaration;
    // ... More declarations;
};
```

Example:

```
class Rectangle {
    double width;
    double length;
};
```

- The declaration statements are for the **variables (attributes)** and **functions (behaviors)**, which are members of that class
- The members of a class are `private` by default, i.e. these private members can't be accessed by code outside the class

How to define members that can be accessed from outside the class?

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
  - Can be listed in any order and appear multiple times

```
class ClassName
{
    private:
        // Declarations of private members
    public:
        // Declarations of public members
};
```

Access specifiers are followed by a colon then followed by one or more member declarations

Example

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

Two `private` member variables (attributes), which can be accessed **ONLY** by the member functions in this class

1. Five `public` member functions (behaviors), which can be called from statements outside the class.
2. They are only declarations. The implementation of member functions will be introduced later.

Note: You may understand **encapsulation**, **data hiding**, **public interface** from this example.

Defining a Member Function

- When defining a member function:
  - Put prototype in class declaration
  - Define function **outside (after)** the class declaration, using class name and scope resolution operator (**::**)

`ReturnType ClassName::functionName(ParameterList)`

```
void Rectangle::setWidth(double w)
{
        width = w;
}

...
int Rectangle::getWidth() const
{
        return width;
}
```

Inline Member Functions

- Member functions can be defined
  - **in** class declaration (inline member functions)
  - **after** the class declaration (regular member functions)
- Inline appropriate for <u>short function bodies</u>:

```
int getWidth() const
{
        return width;
}
```

- Code for an inline function is copied into program in place of call – larger executable program, but no function call overhead, hence faster execution

Accessors and Mutators

- Mutator: a member function that stores a value in a private member variable, or changes its value in some way
- Accessor: function that retrieves a value from a private member variable. Accessors do not change an object's data, so they should be marked `const`. For example:

```
double getWidth() const;
double getLength() const;
double getArea() const;
```

Note: `const` appearing after the parentheses in a member function declaration specifies that the function will not change any data in the calling object

Defining an Instance of a Class

- An object is an instance of a class
- Object definition:

```
ClassName objectName;

Rectangle r;
```

- Access members using **dot operator**:

```
r.setWidth(5.2);
cout << r.getWidth();
```

- Compiler error if attempt to access `private` member using dot operator

Example

- Program 13-1
  - Refer to “Pr13-1.cpp”

Pointer to an Object

- Can define a pointer to an object. The pointer holds the address of this object.

```
Rectangle myRectangle;
Rectangle *rectPtr = nullptr;
rectPtr = &myRectangle;
```

- Pointer can access public members using "**->**" operator:

```
rectPtr->setLength(12.5);
cout << rectPtr->getLength() << endl;
```

Dynamically Allocating an Object

- We can also use a pointer to dynamically allocate an object.

```
// Define a Rectangle pointer.
Rectangle *rectPtr = nullptr;

// Dynamically allocate a Rectangle object.
rectPtr = new Rectangle;

// Store values in the object's width and length.
rectPtr->setWidth(10.0);
rectPtr->setLength(15.0);

// Delete the object from memory.
delete rectPtr;
rectPtr = nullptr;
```

In-class practice

- Define a `Car` class that contains
  - 3 `private` attributes (member variables) named `make`, `model`, and `year`
  - 3 `public` behaviors (member functions) named `setMake`, `setModel`, and `setYear` to set the values of above 3 attributes
  - 3 `public` behaviors named `getMake`, `getModel`, and `getYear` to return the values of above 3 attributes
- In the main program,
  - create a `Car` object named `myCar`
  - ask the user to input the make, model, and year of this car
  - call `setMake`, `setModel`, and `setYear` functions to store the input information
  - call `getMake`, `getModel`, and `getYear` to return these information and print it out
- Test your code

Reference code: Car.cpp

Separating Specification from Implementation

- Place class declaration in a header file that serves as the class specification file. Name the file ***`ClassName.h`***. For example, `Rectangle.h`
- Place member function definitions in class implementation file named ***`ClassName.cpp`***. For example, `Rectangle.cpp`. File should `#include` the class specification file
- Programs that use the class must `#include` the class specification file, and be compiled and linked with the class implementation file

Example: Rewrite Pr13-1 to Pr13-4

Rectangle.h

```
// Specification file for the Rectangle
class.
#ifndef RECTANGLE_H
#define RECTANGLE_H

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

#endif
```

Rectangle.cpp

```
// Implementation file for the Rectangle class.
#include "Rectangle.h"   // Enclosed in " ", not in < >
#include <iostream>      // Needed for cout
#include <cstdlib>       // For the exit function
using namespace std;

void Rectangle::setWidth(double w){
   if (w >= 0)
      width = w;
   else{
      cout << "Invalid width\n";
      exit(EXIT_FAILURE);
   }
}

void Rectangle::setLength(double len){
   … …
}
... ... // Other functions
```

Note: #ifndef checks whether the given token has been defined earlier in the file or in an included file; if not, it includes the code between the #define and #endif statements

 https://www.cprogramming.com/reference/preprocessor/ifndef.html

Example (Cont'd)

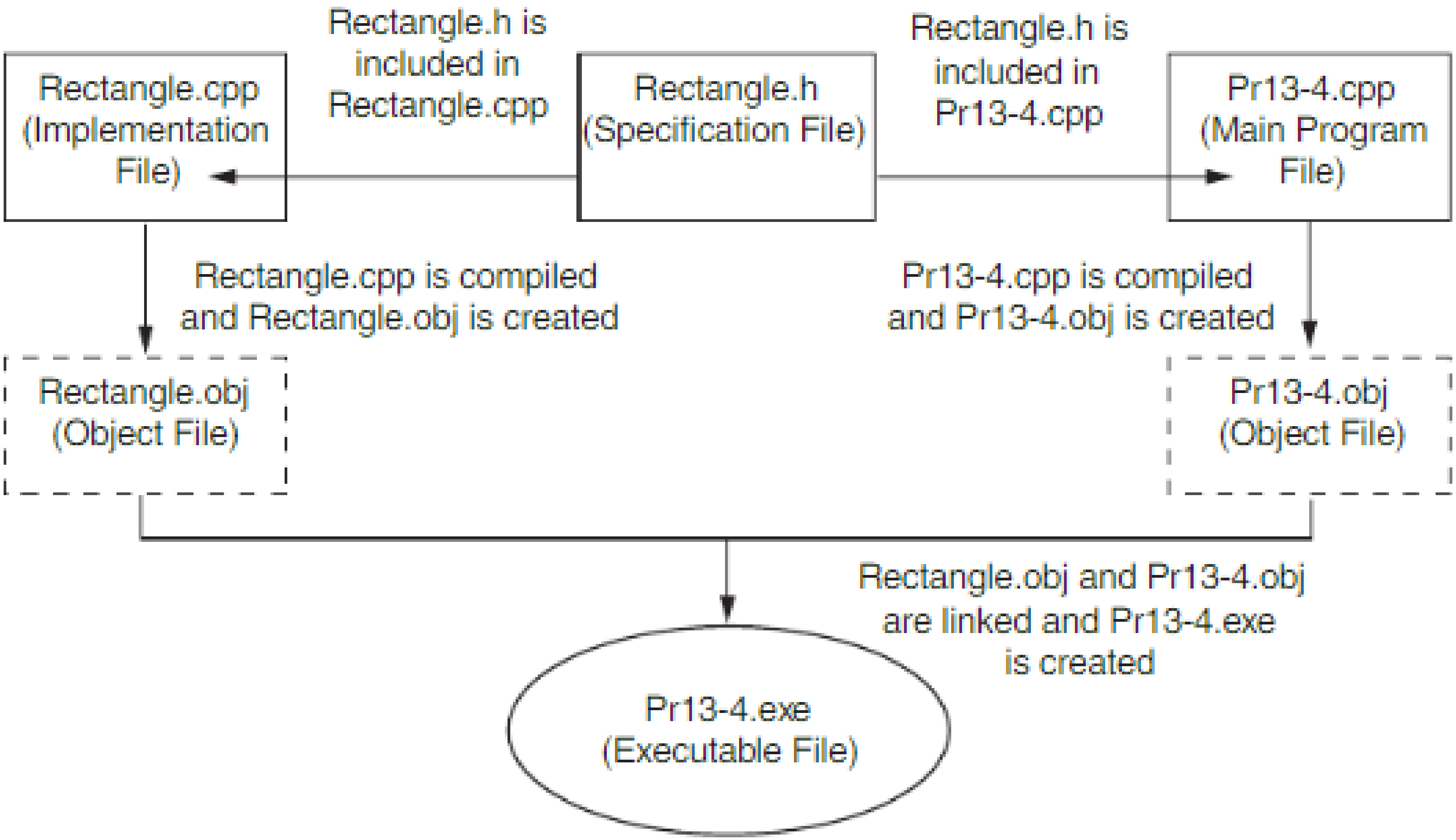
Main program

```
// This program uses the Rectangle class, which is declared in the Rectangle.h file.
// The Rectangle class's member functions are defined in the Rectangle.cpp file.
// This program should be compiled with those files in a project.
#include <iostream>
#include "Rectangle.h"  // Enclosed in " ", means the ".h" file is in current directory
using namespace std;

int main() {
   Rectangle box;     // Define an instance of the Rectangle class
   double rectWidth;  // Local variable for width
   double rectLength; // Local variable for length

   // Get the rectangle's width and length from the user.
   cout << "This program will calculate the area of a\n";
   cout << "rectangle. What is the width? ";
   cin >> rectWidth;
   cout << "What is the length? ";
   cin >> rectLength;
   … …
}
```

Note: Include class's header file in both implementation file and the main program file.

Example (Cont'd)

- Steps of creating an executable file



2.3 Constructors

- A constructor is a member function that is automatically called when an object is created
- Purpose is to initialize attributes of an object
- Constructor function name is **same** as the class name
- Has no return type

```
ClassName::ClassName(ParameterList)
{
    // Statements;
}
```

Example (Rectangle class)

Rectangle.h

```
// Specification file for Rectangle class
// This version has a constructor.
#ifndef RECTANGLE_H
#define RECTANGLE_H

class Rectangle
{
  private:
    double width;
    double length;
  public:
    Rectangle();      // Constructor
    void setWidth(double);
    void setLength(double);
    double getWidth() const
      { return width; }
    double getLength() const
      { return length; }
    double getArea() const
      { return width * length; }
};
#endif
```

Rectangle.cpp

```
// Implementation file for the Rectangle class.
// This version has a constructor.
#include "Rectangle.h"
#include <iostream>      // Needed for cout
#include <cstdlib>       // Needed for the exit function
using namespace std;

Rectangle::Rectangle()
{
  width = 0.0;
  length = 0.0;
}

void Rectangle::setWidth(double w){
  if (w >= 0)
    width = w;
  else{
    cout << "Invalid width\n";
    exit(EXIT_FAILURE);
  }
}
… …
```

Default Constructors

- A default constructor is a constructor that **takes no arguments**.
- If you write a class with no constructor at all, C++ will write a default constructor for you, one that **does nothing**.
- A simple instantiation of a class (with no arguments) calls the default constructor:

```
Rectangle r;
```

Passing Arguments to Constructors

- To create a constructor that takes arguments:
  - Indicate parameters in the constructor declaration:

```
Rectangle(double, double);
```

  - Use parameters in the constructor implementation:

```
Rectangle::Rectangle(double w, double len)
{
   width = w;
   length = len;
}
```

  - Pass arguments to the constructor when you create an object

```
Rectangle r(10, 5);
```

Example

Rectangle.h

```
// Specification file for Rectangle class
// This version has a constructor.
#ifndef RECTANGLE_H
#define RECTANGLE_H

class Rectangle {
  private:
    double width;
    double length;
  public:
    Rectangle(double, double); //Constructor
    void setWidth(double);
    void setLength(double);

    double getWidth() const
      { return width; }
    double getLength() const
      { return length; }
    double getArea() const
      { return width * length; }
};
#endif
```

Rectangle.cpp

```
// Implementation file for the Rectangle class.
// The constructor accepts arguments.
#include "Rectangle.h"
#include <iostream>
#include <cstdlib>
using namespace std;

Rectangle::Rectangle(double w, double len) {
  width = w;
  length = len;
}

void Rectangle::setWidth(double w) {
  if (w >= 0)
    width = w;
  else
  {
    cout << "Invalid width\n";
    exit(EXIT_FAILURE);
  }
}
… …
```

Example (Cont'd)

Main program

```
// This program calls the Rectangle class constructor.
#include <iostream>
#include <iomanip>
#include "Rectangle.h"
using namespace std;

int main() {
   double houseWidth,   // To hold the room width
               houseLength;  // To hold the room length

   // Get the width of the house.
   cout << "In feet, how wide is your house? ";
   cin >> houseWidth;

   // Get the length of the house.
   cout << "In feet, how long is your house? ";
   cin >> houseLength;

   // Create a Rectangle object.
   Rectangle house(houseWidth, houseLength );
       … …
}
```

Using Default Arguments with Constructors

- A constructor may have default arguments
- The default value is listed in the parameter list of the function's declaration or the function header

```
Rectangle::Rectangle(double w, double len = 12.0)
{
    width = w;
    length = len;
}


Rectangle house(houseWidth);
```

When only one argument is passed to the constructor function, the default `12.0` will be assigned to `len`

More About Default Constructors

- If a constructor has default arguments for **all** its parameters, it can be called with no explicit arguments. Then it becomes the default constructor. For example:

```
Rectangle::Rectangle(double w = 10.0, double len = 12.0)
{
   width = w;
   length = len;
}
```

- In this case, the constructor can be called with no argument:

```
Rectangle r;
```

In-class practice

- Programming challenges 3 (Page 808)
  - Write a class named `Car` that has the following member variables:
    - `yearModel` – an `int` that holds the car's year model
    - `make` – a `string` that holds the make of the car
    - `speed` – an `int` that holds the car's current speed
  - In addition, the class should have the following constructor and other member functions:
    - Constructor – Accept the car's year model and make arguments to initial `yearModel` and `make` member variables; assign 0 to `speed`
    - Accessor – return the values of `yearModel`, `make`, and `speed`
    - `accelerate` – add 5 to the `speed` each time it is called
    - `brake` – subtract 5 from the `speed` each time it is called
  - Demonstrate the class in a program that creates a `Car` object, then call the `accelerate` function 5 times. After each call to the `accelerate` function, get the current `speed` of the car and display it. Then, call the `brake` function 5 times. After each call to the `brake` function, get the current `speed` of the car and display it

Reference code: spc13-3.cpp

2.4 Destructors

- A destructor is a member function that is automatically called when an object is destroyed
- Destructors perform shutdown procedures when the object goes out of existence.
  - For example: to free memory that was dynamically allocated by the class object
- Destructor name is `~ClassName`, *e.g.*, `~Rectangle`
- Has no return type; takes no arguments
- Only one destructor per class, *i.e.*, it cannot be overloaded

Example (ContactInfo.h)

```
#ifndef CONTACTINFO_H
#define CONTACTINFO_H
#include <cstring>      // Needed for strlen and strcpy

class ContactInfo {
private:
       char *name;     // The contact's name
       char *phone;    // The contact's phone number
public:
       ContactInfo(char *n, char *p)    // Constructor
       { // Allocate enough memory for the name and phone number.
         name = new char[strlen(n) + 1];
         phone = new char[strlen(p) + 1];
         // Copy the name and phone number to the allocated memory.
         strcpy(name, n);
         strcpy(phone, p); }

       ~ContactInfo()          // Destructor
       { delete [] name;
         delete [] phone; }

       const char *getName() const
       { return name; }

       const char *getPhoneNumber() const
       { return phone; }
};
#endif
```

2.5 Overloading Constructors

- A class can have more than one constructor
- Overloaded constructors in a class **must** have different parameter lists:

```
Rectangle();
Rectangle(double);
Rectangle(double, double);
```

Example

```
class InventoryItem {
private:
   string description; // The item description
   double cost;        // The item cost
   int units;          // Number of units on hand
public:
   InventoryItem(){    // Constructor #1 (default constructor)
      description = "";
      cost = 0.0;
      units = 0; }

   InventoryItem(string desc){    // Constructor #2
      description = desc;
      cost = 0.0;
      units = 0; }

   InventoryItem(string desc, double c, int u){   // Constructor #3
      description = desc;
      cost = c;
      units = u; }
  … …
};
```

Member Function Overloading

- Non-constructor member functions can also be overloaded
- Must have unique parameter lists

```
void setCost(double c){ // cost stored in double
    cost = c;
}

void setCost(string c){ // cost stored in a string
    cost = stod(c);
}
```

`stod` function converts the string to a double

2.6 Operator Overloading

- **Operator overloading**: redefine how standard operators (**=**, **+**, **etc.**) work when used with class objects
  - The operands are objects

- An example of overloaded operators:
  - Floating-point division: `5.0 / 2 = 2.5`
  - Integer division: `5 / 2 = 2`

Operator Overloading

- 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

The `this` Pointer

- `this`: a built-in pointer that every class has
  - 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
- Assume `student1` and `student2` are two `StudentTestScores` objects (*page 835*)

```
cout << student1.getStudentName() << endl;
```

  - When run the above line, `this` pointer points to `student1`

```
cout << student2.getStudentName() << endl;
```

  - When run the above line, `this` pointer points to `student2`

Here `getStudentName` is a member function of `StudentTestScores` class

Overloading the = Operator

- Define a member function called **=** operator function

  - Prototype:

```
const SomeClass operator=(const SomeClass &right);
```

return type [1]

function name

parameter for object on right side of operator

[1] https://www.linuxtopia.org/online_books/programming_books/thinking_in_c++/Chapter08_014.html

Overloading the = Operator

- Define a member function called **=** operator function
  - **=** operator function implementation

```
// Overloaded = operator
const SomeClass SomeClass::operator=(const SomeClass &right){
    if (this != &right){  //left and right objects are not same
        value = new int;
        *value = *(right.value);
        }
     return *this;    // dereference the this pointer, giving
}                     // us the actual object that received the
                      // assignment
```

Overloading the = Operator

- Invoke the = operator function

```
SomeClass object1(5);
SomeClass object2;
object2 = object1;
object1.setVal(13);
cout << object1.getVal() << endl;
cout << object2.getVal() << endl;
```

Output:
13
5

- Operator can be invoked as a member function:

```
object2.operator=(object1);
```

Same as:

```
object2 = object1;
```


Example code: OperatorOverloading.cpp

Returning a Value

- Overloaded operator can return a value

```
class Point2d
{
private:
     int x, y;
...
public:
  double operator-(const point2d &right)
  { return sqrt(pow((x-right.x),2)
                + pow((y-right.y),2)); }
};

Point2d point1(2,2), point2(4,4);

// Compute and display distance between 2 points.
cout << point2 - point1 << endl; // displays 2.82843
```

Notes on Overloaded Operators

- Can change meaning of an operator
- Can **NOT** change the number of operands of the operator
- Only certain operators can be overloaded. Can **NOT** overload the following operators:

  `?:      .      .*      ::      sizeof`

  - Overloading prefix/postfix ++ operator (page 849)
  - Overloading relational operators (page 852)
  - Overloading << and >> operators (page 854)
  - Overloading `[]` operator (page 858)

Reading textbook

- Chapter 11, 13, 14

Reference

- The teaching materials of this course refer to:
  - Professor Xiaohong (Sophie) Wang. COSC 120 teaching materials
    - Salisbury University
  - Textbook:
    - Starting Out with C++: From Control Structures through Objects, by Tony Gaddis, Pearson (9th Edition)
    - Instructor materials of the above textbook (All rights reserved)