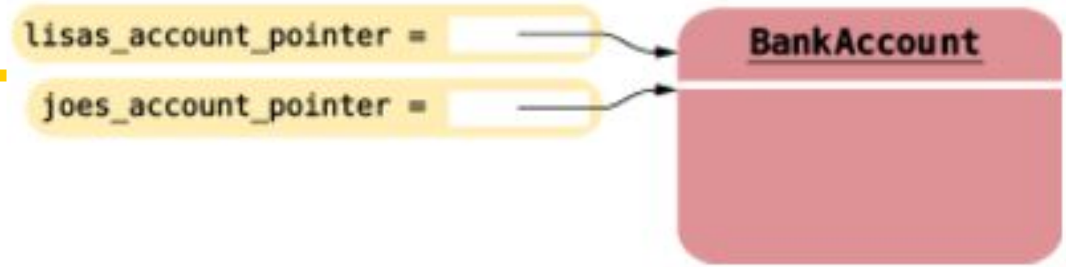
Topic 10

1. Object oriented programming
2. Implementing a simple class
3. Specifying the public interface
4. Designing the data representation
5. Member functions
6. Constructors
7. Problem solving: tracing objects
8. Problem solving: discovering classes
9. Separate compilation
10. Pointers to objects
11. Problem solving: patterns for object data

Pointers to Objects



Pointers to objects permit us to dynamically allocate them and to share objects.

```
CashRegister* register_pointer = new CashRegister;
BankAccount* lisas_account_pointer = new
   BankAccount(1000);
```

The `new` operator returns a pointer to the allocated object.

Now we can copy the pointer, without copying the object:

```
BankAccount* joes_account_pointer =
lisas_account_pointer;
```

Remember to call the `delete` operator on the pointer before exiting the program, to reclaim the dynamic memory:

```
delete joes_account_pointer;
```

Pointers and the -> Operator

Given:

```
CashRegister* register_pointer = new  CashRegister;
```

To invoke a member function on that object, you could call

```
(*register_pointer).add_item(1.95);
```

The parentheses are necessary because in C++ the dot operator takes precedence over the * operator. The expression without the parentheses would be a syntax error:

```
*register_pointer.add_item(1.95);// Error
```

The preferred syntax is the arrow operator:

```
register_pointer->add_item(1.95);
```

The `this` Pointer

Each member function of every class has a built-in parameter, called ***`this`***, a pointer to the *implicit parameter*. (The object)

If you call

```
... register1.add_item(1.95) ...
```

then the **`this`** pointer has type **`CashRegister*`** and points to the **`register1`** object.

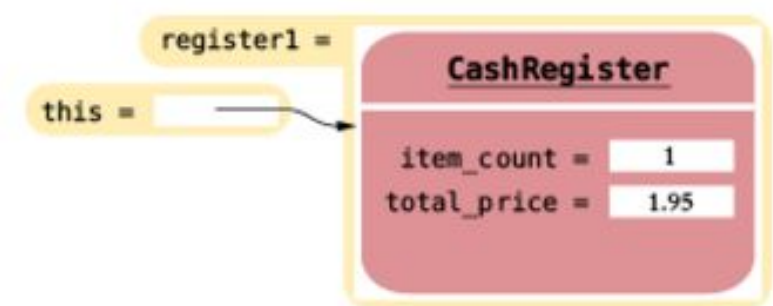


Figure 11 The this Pointer

The `this` Pointer: Example

You can use the `this` pointer inside the definition of a member function. For example,

```
void CashRegister::add_item(double price)
{
   this->item_count++;
   this->total_price = this->total_price +
  price;
}
```

However, you don't really need the `this` pointer in this case, as you saw in previous versions of the function.

The `this` Pointer: Motivation

The real reason to use the `this` pointer is to clarify duplicate variable nams, as either the data members or other explicit parameters to a function. For example, we might add a constructor to the class that carries over the previous day's `total_price`:

```
CashRegister::CashRegister(double total_price)
{
    item_count =0;
    this->total_price = total_price;
}
```

However, we recommend just giving the explicit parameter a different name (such as **`initial_total_price`**), to avoid the confusion that the above code might create.

Practice It: Object Pointers

Given

```
int n; string* p = nullptr;
```

Write the statements to implement the tasks. Answers shown in small font:

Task	Statement	Explanation
Dynamically allocates a string object and save the address in the pointer variable p.	`p = new string;`	The new operator allocates a new object from the free store and returns its address.
Deallocates the object that was allocated in the previous task.	`delete p;`	The delete operator deallocates the memory block with the given address.
Dynamically allocate a string object with contents "Hi"and save the address in the pointer variable p.	`p = new string("Hi");`	You need to call a constructor to initialize the string object.
Invoke the length member function on the object that was allocated in the previous step and save the result in the integer variable n.	`n = p->length();`	Use the -> operator to call a member function on a pointer to an object.

Practice It: Object Pointers and `this`

Write the constructor implementation of a Point class:

```
class Point
{
public:
   Point(int x, int y);
   // Member functions omitted
private:
   int x;
   int y;
};

Point::Point(int x, int y)
{
  _____________________
  _____________________
}
```

Topic 11

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Keeping a Total

- Many classes need to track a quantity that can go up or down as functions are called. Keep a data member that represents the current total.

```
double total_price;
```

- Examples of what must be done to the total:

```
void CashRegister::add_item(double price)
{
   total_price = total_price + price;
}
void CashRegister::clear()
{
   total_price = 0;
}
double CashRegister::get_total()
{
   return total_price;
}
```

Counting Events

- For classes that need to count events, some examples:

```
int item_count;  //Keep a counter
```

Increment the counter in those member functions that correspond to the events that you want to count.

```
void CashRegister::add_item(double price)
{
   total_price = total_price + price;
   item_count++;
}
```

You may need to clear the counter:

```
void CashRegister::clear()
{
   total_price = 0;
   item_count = 0;
}
```

There may or may not be a member function that reports the count to the class user.

Collecting Values

- Some objects collect numbers, strings, or other objects. For example, each multiple-choice question has a number of choices. A cash register may need to store all prices of the current sale. Use a `vector` to store these, and a member function to add to the list:

```
class Question
{
   . . .
private:
   vector<string> choices;
   . . .
};
void Question::add(string choice)
{
   choices.push_back(choice);
}
```

Managing Properties of an Object

A property is a value of an object that an object user can set and retrieve. For example, a Student object may have a name and an ID.

An object property needs a getter and setter member functions. Provide a data member to store the property's value:

```
class Student
{
public:
   Student(string name_, int id_);
   string get_name() const;
   int get_id() const;
   void set_name(string new_name);
private:
   string name;
   int id;
};

void Student::set_name(string new_name) // Includes Error checking
{
   if (new_name.length() > 0) { name = new_name; }
}
```

Some properties should not change after initialization in the constructor, and thus need no setter function. For example, a student's ID.

Modeling Objects with Distinct States(1)

Some objects' behavior depends on what happened in the past. For example, a Fish object may look for food when it is hungry and ignore food after it has eaten.

Such an object needs a state variable to remember whether it has recently eaten.

Supply a data member that models the state, together with some constants for the state values:

```
class Fish
{
public:
    const int NOT_HUNGRY = 0;
    cont int SOMEWHAT_HUNGRY = 1;
    const int VERY_HUNGRY = 2;
    void eat();
    void move();

private:
    int hungry = NOT_HUNGRY;
};
```

Modeling Objects with Distinct States(2)

Determine which member functions change the state. If a fish has just eaten food, it won't be hungry. But as the fish moves, it will get hungrier.

```
void Fish::eat()
{
   hungry = NOT_HUNGRY;
   . . .
}
void Fish::move()
{
   if (hungry == VERY_HUNGRY)
   {
      cout << "Looking for food" << endl;
   } else . . .
   if (hungry < VERY_HUNGRY) { hungry++; }
}
```

Finally, determine where the state affects behavior. A fish that is very hungry will want to look for food first.

Describing the Position of an Object

- Some objects move around during their lifetime, and they remember their current position. For example,
  - A train drives along a track and keeps track of the distance from the terminus.
  - A bug living on a grid crawls from one grid location to the next, in one of 4 directions.
- If the object moves along a line, represent the position as a distance.

```
double distance_from_terminus;
```

- If the object moves in a grid, remember its current location and direction in the grid:

```
int row, column;
int direction; // 0 = North, 1 = East, 2 = South, 3 = West
```

- When you model a physical object such as a cannonball, you need to track both the position and the velocity, possibly in 2 or 3 dimensions.

```
double z_position, z_velocity;
```

- There will be member functions that update the position. In the simplest case, you may be told by how much the object moves:

```
void Train::move(double distance_moved)
{
   distance_from_terminus = distance_from_terminus +
distance_moved;
}
```

Understand the concepts of objects and classes.

- A class describes a set of objects with the same behavior. An object is a collection of related data, like a `struct`, plus member functions that manipulate the data.

- Every class has a public interface: a collection of member functions through which the objects of the class can be manipulated.

- Encapsulation is the act of providing a public interface and private data and function internals, hiding implementation details.

- Encapsulation enables changes in the implementation without affecting users of a class.

Chapter Summary, Part 2

Understand data members and member functions of a simple class.

- The member functions of a class define the behavior of its objects.
- An object's data members represent the state of the object.
- Each object of a class has its own set of data members.
- A member function can access the data members of the object on which it acts.
- A private data member can only be accessed by the member functions of its own class.

Chapter Summary, Part 3

Formulate the public interface of a class in C++.

- You can use member function declarations and function comments to specify the public interface of a class.
- A mutator member function changes the object on which it operates.
- An accessor member function does not change the object on which it operates. Use const with accessors.

Choose data members to represent the state of an object.

- An object holds data members that are accessed by member functions.
- Private data members can only be accessed by member functions of the same class, and we usually make all data private.

Chapter Summary, Part 4

Implement member functions of a class.

•Use the `ClassName::` prefix when defining member functions.

•The implicit parameter is a reference to the object on which a member function is applied.

•Explicit parameters of a member function are listed in the function definition.

•When calling another member function on the same object, do not use the dot notation.

```
void CashRegister::add_items(int qnt, double prc)
{
   for (int i = 1; i <= qnt; i++)
   {
      add_item(prc); //calling another member function
   }
}
```

Chapter Summary, Part 5

Design and implement constructors.

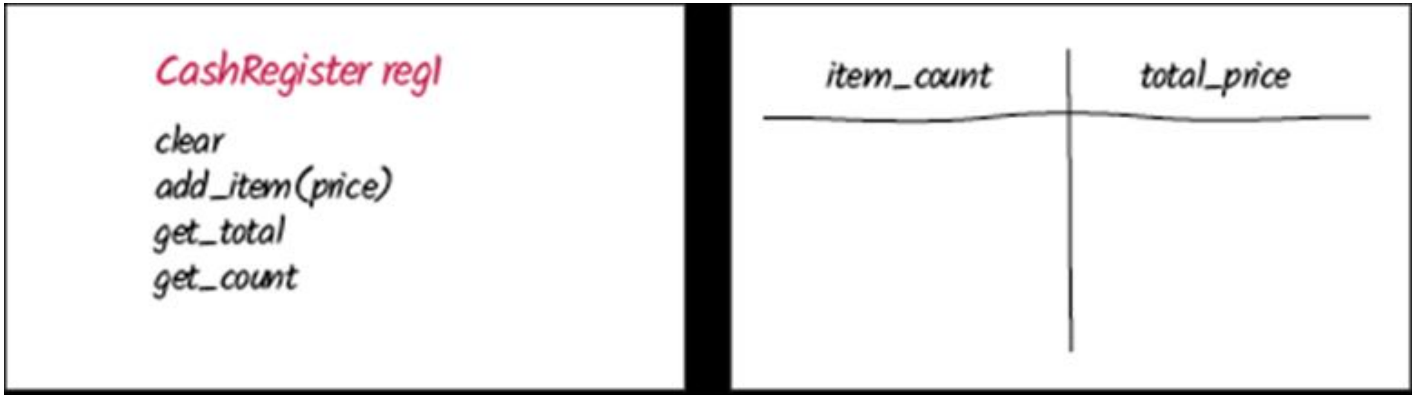
- A constructor is called automatically when an object is created.
- The name of a constructor is the same as the class name.
- A default constructor has no arguments.
- A class can have multiple constructors. ("overloaded")
- The compiler picks the constructor that matches the arguments.
- Be sure to initialize all number and pointer data members in a constructor.

```
class BankAccount
{
public:
   // "Default" constructor: Sets balance=0
   BankAccount();
   // Sets balance to initial_balance
   BankAccount(double initial_balance);
   // . . . Member functions omitted
private:
   double balance;
};
```

Chapter Summary, Part 6

Use the technique of object tracing for visualizing object behavior.

- Write the member functions on the front of a card, and the data member values on the back.
- Update the values of the data members when a mutator member function is called.



Chapter Summary, Part 7

Discover classes that are needed for solving a programming problem.

- To discover classes, look for nouns in the problem description.
- Concepts from the problem domain are good candidates for classes.
- Verbs in the description will inspire member functions required to manipulate the class data.
- A class aggregates another if its objects contain objects of the other class.
- Avoid parallel vectors by changing them into vectors of objects.

Separate the interface and implementation of a class in header and source files.

- The code of complex programs is distributed over multiple files.
- Header files contain the definitions of classes and declarations of nonmember functions.
- Source files contain function implementations.

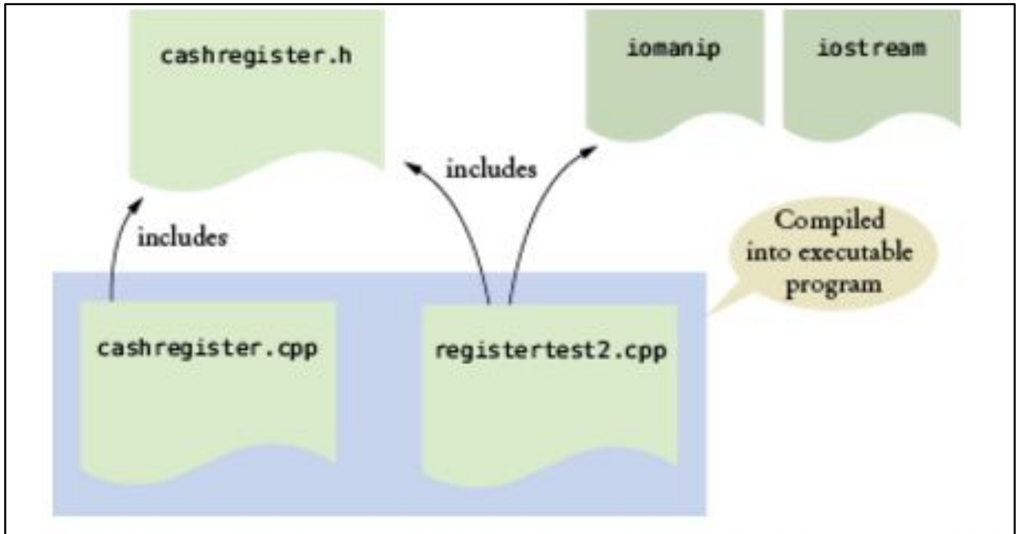


Figure 9 Compiling a Program from Multiple Source Files

Chapter Summary, Part 9

Use pointers to objects and manage dynamically allocated objects.

•Use the `new` operator to obtain an object that is located on the free store.

•The `new` operator returns a pointer to the allocated object.

•When an object allocated on the free store is no longer needed, use the `delete` operator to reclaim its memory.

•Use the `->` operator to invoke a member function through a pointer, or to access a private data member from the "`this`" pointer

•In a member function, the `this` pointer points to the implicit parameter.

Chapter Summary, Part 10

Use patterns to design the data representation of a class.

- An data member for the total is updated in member functions that increase or decrease the total amount.
- A counter that counts events is incremented in member functions that correspond to the events.
- An object can collect other objects in an array or vector.
- An object property can be accessed with a getter member function and changed with a setter member function.
- If your object can have one of several states that affect the behavior, supply a data member for the current state.
- To model a moving object, you need to store and update its position.