Lesson 6
Classes and Data Abstraction

Classes

- Object-oriented design (OOD): a problem solving methodology
- Objects: components of a solution
- Class: a collection of a fixed number of components
- Member: a component of a class

Classes (cont'd.)

- Class definition:
  - Defines a data type; no memory is allocated
  - Don't forget the semicolon after the closing brace
- Syntax:

```
class classIdentifier
{
    classMembersList
};
```

Classes (cont'd.)

- Class member can be a variable or a function
- If a member of a `class` is a variable
  - It is declared like any other variable
  - You cannot initialize a variable when you declare it
- If a member of a `class` is a function
  - Function prototype is listed
  - Function members can (directly) access any member of the `class`

Classes (cont’d.)

- Three categories of class members:
  - `private` (default)
    - Member cannot be accessed outside the `class`
  - `public`
    - Member is accessible outside the class
  - `protected`

Unified Modeling Language
Class Diagrams

- Unified Modeling Language (UML) notation: used to graphically describe a class and its members
  - +: member is public
  - −: member is private
  - #: member is protected

Unified Modeling Language Class Diagrams (cont'd.)

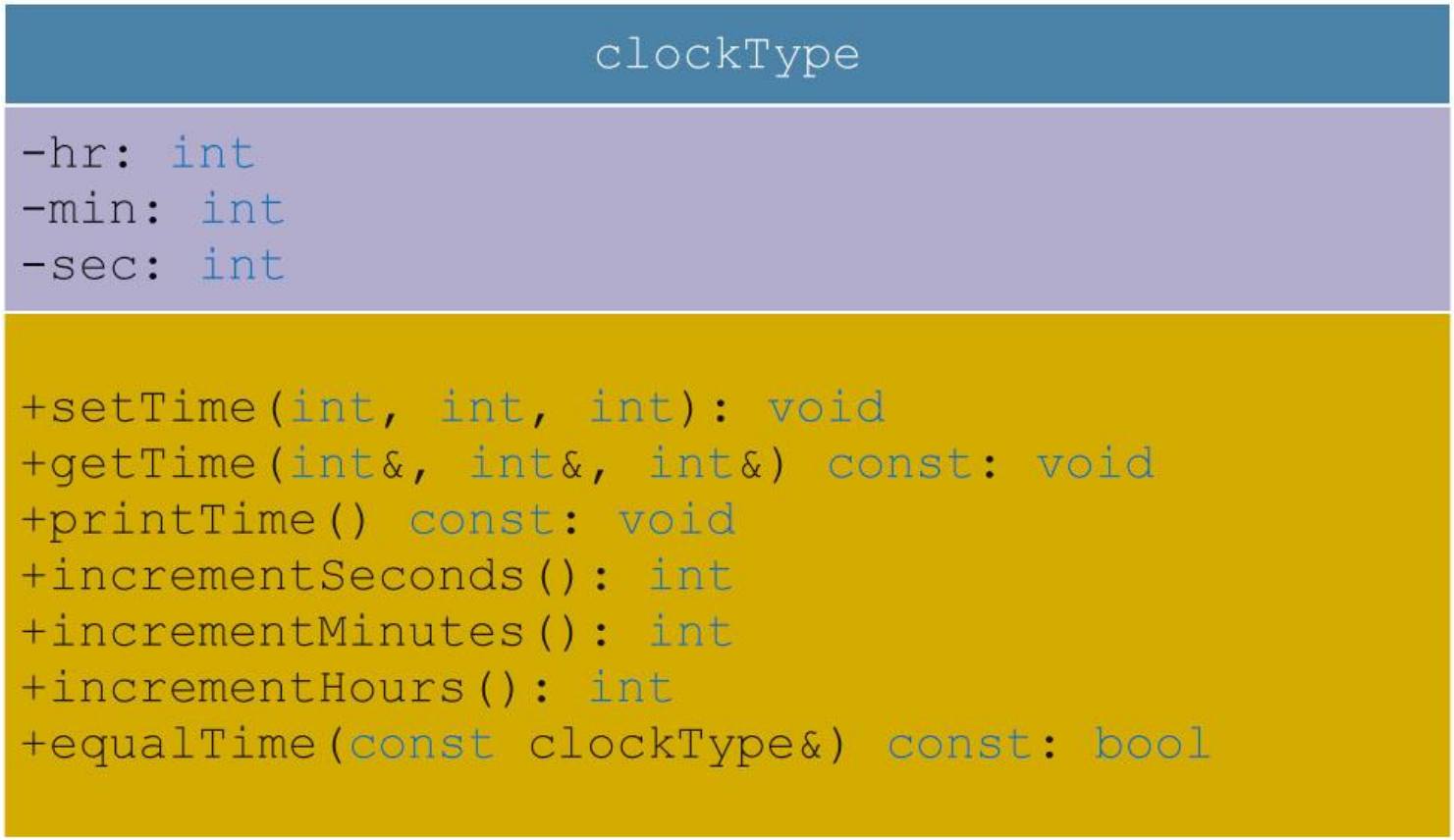


FIGURE 10-1 UML class diagram of the `class clockType`

Variable (Object) Declaration

- Once defined, you can declare variables of that `class` type

```
clockType     myClock;
```

- A `class` variable is called a class object or class instance

FIGURE 10-2 Objects `myClock` and `yourClock`

Accessing Class Members

- Once an object is declared, it can access the `public` members of the class
- Syntax:

```
classObjectName.memberName
```

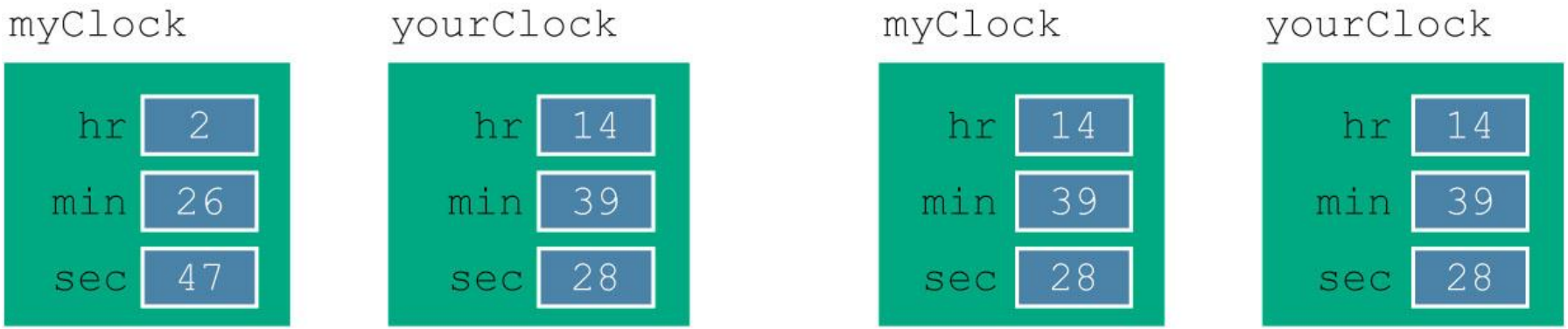
The dot (.) is the member access operator.

- If an object is declared in the definition of a member function of the `class`, it can access the `public` and `private` members

Built-in Operations on Classes

- Most of C++'s built-in operations do not apply to classes
  - Arithmetic operators cannot be used on class objects unless the operators are overloaded
  - Cannot use relational operators to compare two class objects for equality
- Built-in operations that are valid for class objects:
  - Member access (.)
  - Assignment (=)

Assignment Operator and Classes



(a) `myClock` and `yourClock` before executing `myClock = yourClock;`

(b) `myClock and yourClock` after executing `myClock = yourClock;`

FIGURE 10-3 `myClock` and `yourClock` before and after executing the statement `myClock = yourClock;`

Class Scope

- An object can be automatic or static
  - Automatic: created when the declaration is reached and destroyed when the surrounding block is exited
  - Static: created when the declaration is reached and destroyed when the program terminates
- Object has the same scope as other variables

Class Scope (cont'd.)

- A member of the `class` is local to the `class`
- Can access a `class` member outside the `class` by using the `class` object name and the member access operator (**.**)

Functions and Classes

- Objects can be passed as parameters to functions and returned as function values
- As parameters to functions
  - Objects can be passed by value or by reference
- If an object is passed by value
  - Contents of data members of the actual parameter are copied into the corresponding data members of the formal parameter

Reference Parameters and Class Objects (Variables)

- Passing by value might require a large amount of storage space and a considerable amount of computer time to copy the value of the actual parameter into the formal parameter
- If a variable is passed by reference
  - The formal parameter receives only the address of the actual parameter

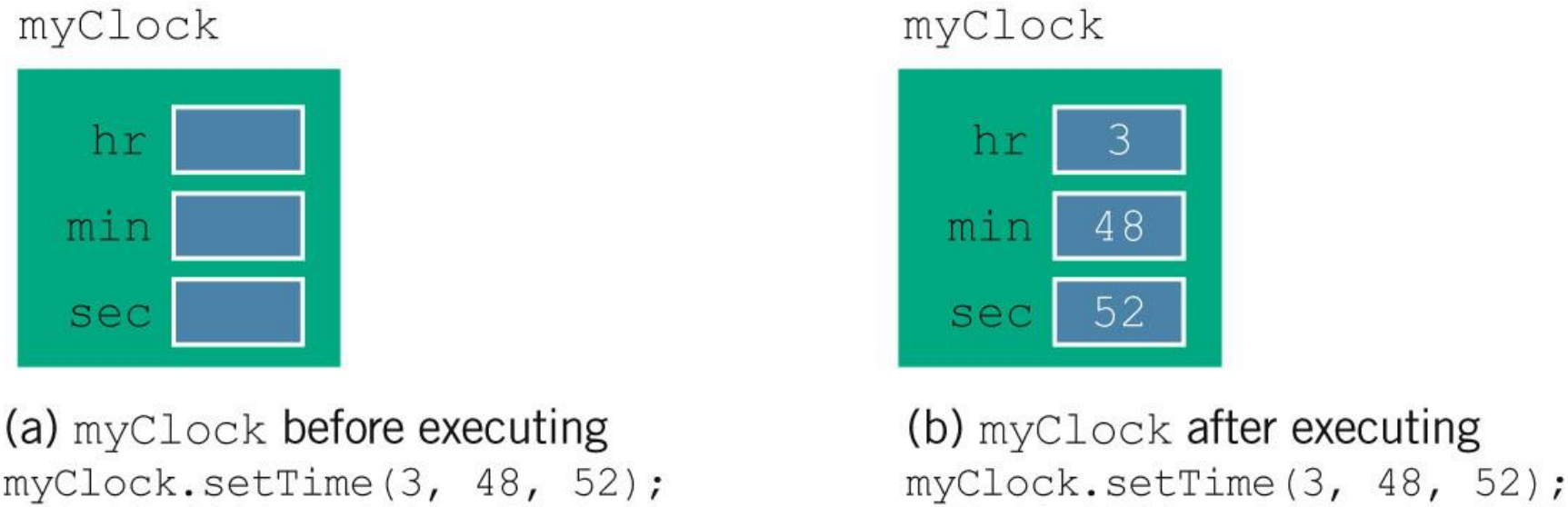
Reference Parameters and Class Objects (Variables) (cont'd.)

- Pass by reference is an efficient way to pass a variable as a parameter
  - Problem: when passing by reference, the actual parameter changes when formal parameter changes
  - Solution: use `const` in the formal parameter declaration

Implementation of Member Functions

- Must write the code for functions defined as function prototypes
- Prototypes are left in the class to keep the class smaller and to hide the implementation
- To access identifiers local to the class, use the scope resolution operator ::

Implementation of Member Functions (cont'd.)



(a) `myClock` before executing `myClock.setTime(3, 48, 52);`

(b) `myClock` after executing `myClock.setTime(3, 48, 52);`

FIGURE 10-4 `myClock` before and after executing the statement `myClock.setTime(3, 48, 52);`

Implementation of Member Functions (cont'd.)

FIGURE 10-5 Objects myClock and yourClock

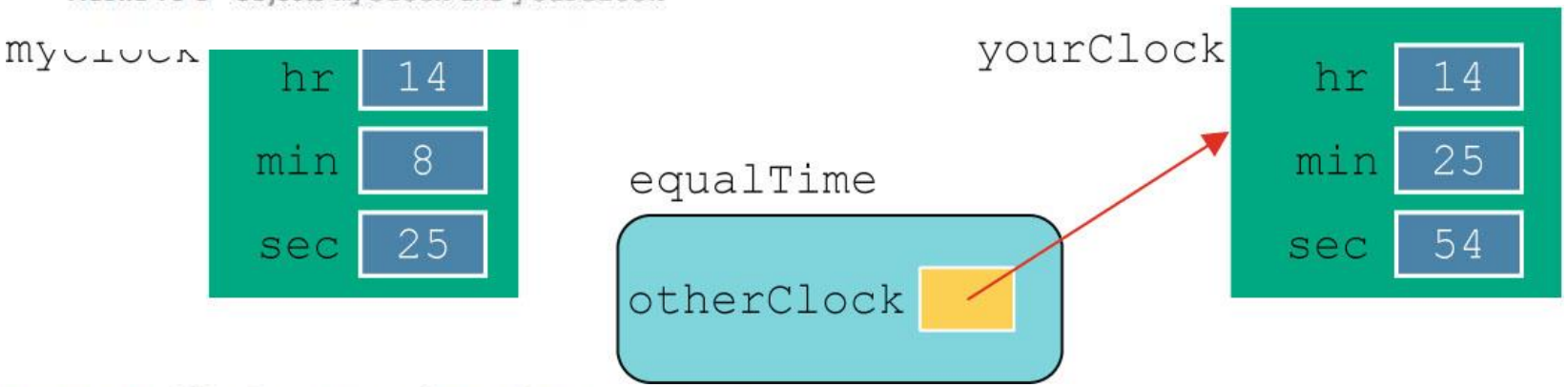


FIGURE 10-6 Object myClock and parameter otherClock

Implementation of Member Functions (cont'd.)

- Once a `class` is properly defined and implemented, it can be used in a program
  - A program that uses/manipulates objects of a class is called a client of that class
- When you declare objects of the `class clockType`, each object has its own copy of the member variables (`hr`, `min`, and `sec`)
  - Called instance variables of the class
  - Every object has its own instance of the data

Accessor and Mutator Functions

- Accessor function: member function that only accesses the value(s) of member variable(s)
- Mutator function: member function that modifies the value(s) of member variable(s)
- Constant function:
  - Member function that cannot modify member variables
  - Use `const` in function heading

Order of `public` and `private` Members of a Class

- C++ has no fixed order in which to declare `public` and `private` members
- By default, all members of a class are `private`
- Use the member access specifier `public` to make a member available for `public` access

Constructors

- Use constructors to guarantee that member variables of a class are initialized
- Two types of constructors:
  - With parameters
  - Without parameters (default constructor)
  - Name of a constructor = name of the class
  - A constructor has no type

Constructors (cont’d.)

- A class can have more than one constructor
  - Each must have a different formal parameter list
- Constructors execute automatically when a class object enters its scope
- They cannot be called like other functions
- Which constructor executes depends on the types of values passed to the class object when the class object is declared

Invoking a Constructor

- A constructor is automatically executed when a class variable is declared
- Because a class may have more than one constructor, you can invoke a specific constructor

Invoking the Default Constructor

- To invoke the default constructor:

```
className classObjectName;
```

- Example:

```
clockType yourClock;
```

Invoking a Constructor with Parameters

- Syntax:

```
className classObjectName(argument1, argument2, ...);
```

- Number and type of arguments should match the formal parameters (in the order given) of one of the constructors
  - Otherwise, C++ uses type conversion and looks for the best match
  - Any ambiguity causes a compile-time error

Constructors and Default Parameters

- A constructor can have default parameters
  - Rules for declaring formal parameters are the same as for declaring default formal parameters in a function
  - Actual parameters are passed according to same rules for functions
- Default constructor: a constructor with no parameters or with all default parameters

Classes and Constructors: A Precaution

- If a class has no constructor(s), C++ provides the default constructor
  - However, object declared is still uninitialized
- If a class includes constructor(s) with parameter(s), but not the default constructor
  - C++ does not provide the default constructor

In-line initialization of Data Members and the Default Constructor

- C++11 standard allows member initialization in class declarations
- Called in-line initialization
- Can eliminate the need for a default constructor
- Not all compilers recognize this feature

Arrays of Class Objects (Variables) and Constructors

- If you declare an array of class objects, the class should have the default constructor

```
clockType arrivalTimeEmp[100];
```

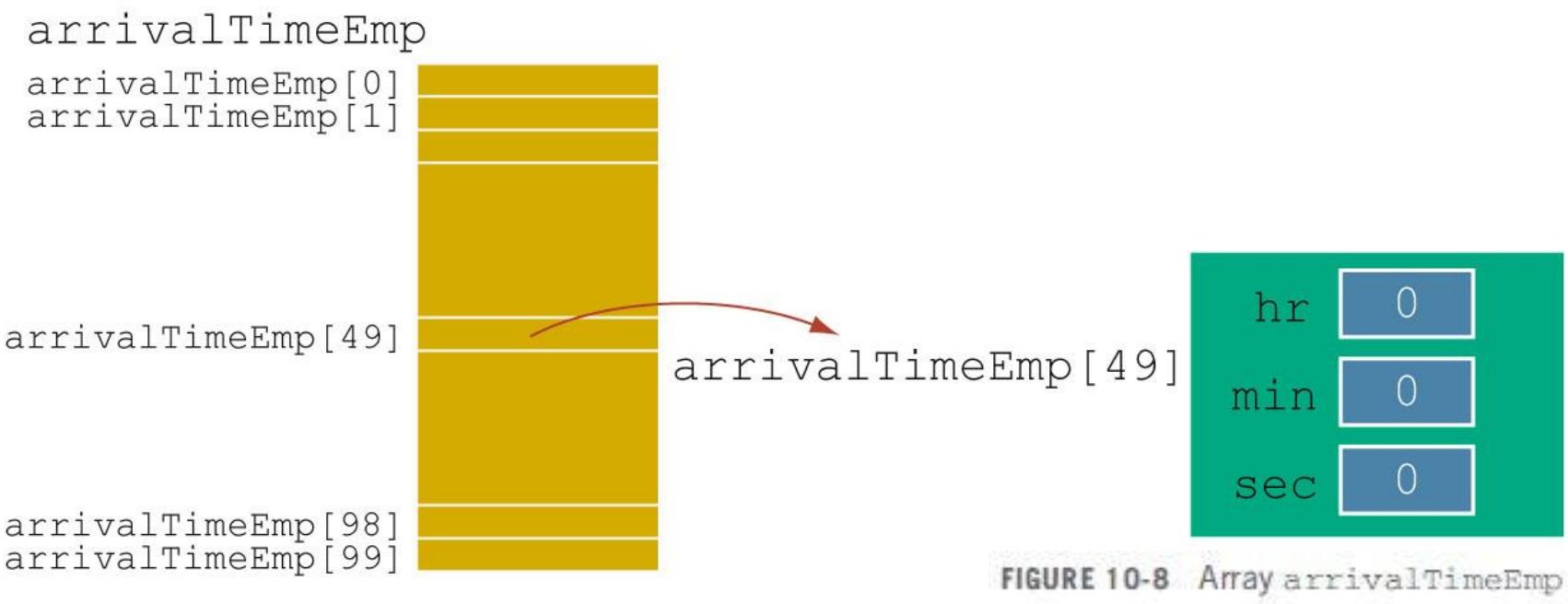


FIGURE 10-8 Array arrivalTimeEmp

Destructors

- Destructors are functions without any type
- The name of a destructor is the character '~' followed by class name
  - For example:

```
~clockType();
```

- A class can have only one destructor
  - The destructor has no parameters
- Destructor automatically executes when the class object goes out of scope

Data Abstract, Classes, and Abstract Data Types

- Abstraction
  - Separating design details from usage
  - Separating the logical properties from the implementation details
- Abstraction can also be applied to data
- Abstract data type (ADT): data type that separates the logical properties from the implementation details

A `struct` Versus a `class`

- By default, members of a `struct` are `public`
  - `private` specifier can be used in a `struct` to make a member private
- By default, the members of a `class` are `private`
- `class`es and `struct`s have the same capabilities

A `struct` Versus a `class` (cont'd.)

- In C++, the definition of a `struct` was expanded to include member functions, constructors, and destructors
- If all member variables of a `class` are `public` and there are no member functions
  - Use a `struct`

Information Hiding

- Information hiding: hiding the details of the operations on the data
- Interface (header) file: contains the specification details
  - File extension is `.h`
- Implementation file: contains the implementation details
  - File extension is `.cpp`
- In header file, include function prototypes and comments that briefly describe the functions
  - Specify preconditions and/or postconditions

Information Hiding (cont'd.)

- Implementation file must include header file via `include` statement
- In `include` statement:
  - User-defined header files are enclosed in double quotes
  - System-provided header files are enclosed between angular brackets