Classes

- A class is a data type whose variables are objects
  - Some pre-defined classes in C++ include `int`, `char`, `ifstream`
  - Of course, you can define your own classes too
- A class definition says two basic things
  - The kinds of values an object can hold
  - A description of the member functions

Example: class DayOfYear

- Decide on the values to represent
- This example's values are dates such as July 4 using an integer for the number of the month
  - Member variable month is int (Jan = 1, Feb = 2, etc.)
  - Member variable day is int
- Decide on the member functions needed
- Just one member function named output in the first version of this class

Simplest version of DayOfYear

- Like a struct with an added method
  - All parts public
  - Clients access month, day directly

```
class DayOfYear {
public:
    void output();
    int month;
    int day;
};
void DayOfYear::output() {
    cout << "month = " << month
         << ",  day = " << day << endl;
 }
```

Notes about '::' and '.'

- '::' used with classes to identify a member

```
void DayOfYear::output() { … }
```

  - Also used with namespaces – identifies scope
  - Called scope resolution operator
- '.' used with variables to identify object

```
DayOfYear birthday;
birthday.output( );
```

  - Object reference is passed to the method as an implicit parameter

What's wrong with DayOfYear?

- Most important: data are exposed to users
- Why is that a problem?
- Two major reasons:
  - No way to insure consistent object states – e.g. user could `birthday.month = 74;` // huh?
  - Developer can't change data names/meanings – e.g. can't change int to string for month, can't save Date instead of month, day, …
- What's the solution (in C++)?

An access specifier: `private`

- Private members of a class can only be referenced within the definitions of member functions (and `friends` – later)
  - If the program tries to access a private member, the compiler gives an error message
- Private members can be data or functions
  - Should have public set methods to change data
  - Need public get methods to access the data
- Btw: default for class is private (public for struct)

Better class DayOfYear

```
class DayOfYear {
public:
    void input( );
    void output( );
    void set(int new_month, int new_day);
    int get_month( );
    int get_day( );
private:
    void check_date( );
    int month;
    int day;
};
```

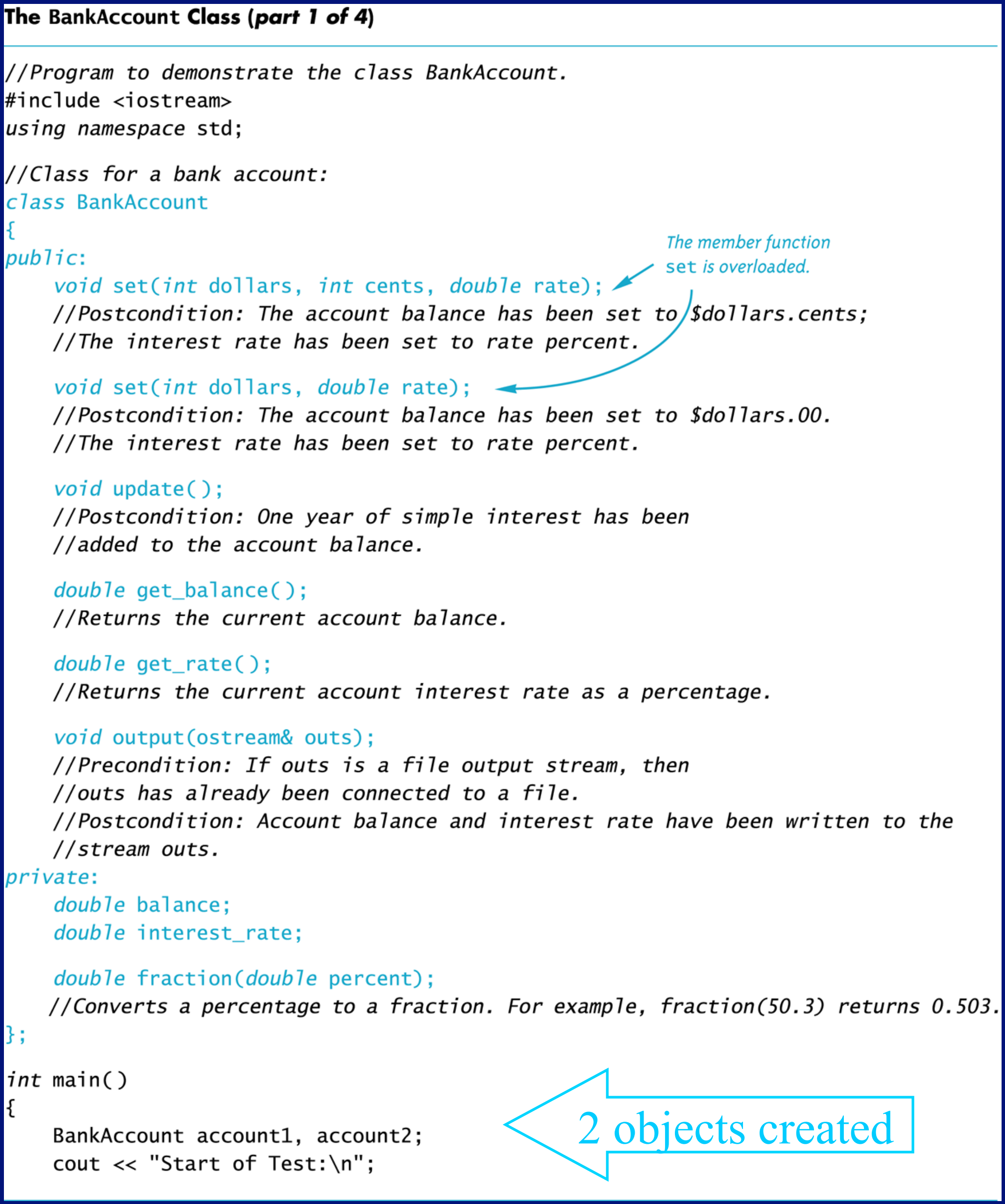
DISPLAY 10.4

Creating and assigning (=) objects

- Declaring an object *creates the object*
  `DayOfYear today, tomorrow;`
  // two objects are created on stack
- Different if declaring pointers (or references)
  `DayOfYear *soon, &r = today;` // no object
  `soon = new DayOfYear;` // now object on heap
- Assignment operator *copies object's data*
  `r = *soon;` // no new object–just copy on stack
  // original (`today`) object data overwritten

Another class example: BankAccount

- Has operations appropriate for a bank account (implemented with public member functions)
  - And a private utility function
- Stores an account balance and an interest rate



The BankAccount Class (*part 1 of 4*)

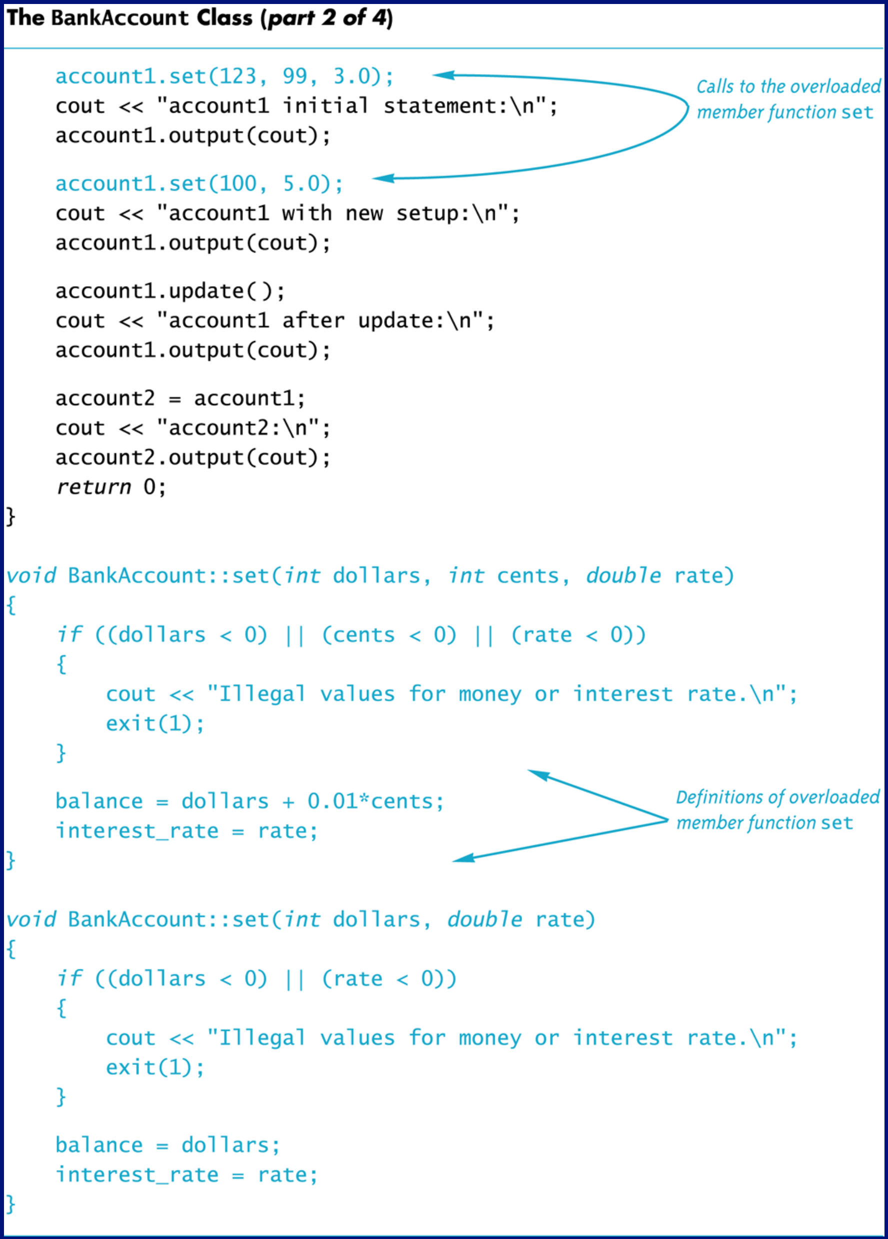
```
//Program to demonstrate the class BankAccount.
#include <iostream>
using namespace std;

//Class for a bank account:
class BankAccount
{
public:
    void set(int dollars, int cents, double rate);
    //Postcondition: The account balance has been set to $dollars.cents;
    //The interest rate has been set to rate percent.

    void set(int dollars, double rate);
    //Postcondition: The account balance has been set to $dollars.00.
    //The interest rate has been set to rate percent.

    void update();
    //Postcondition: One year of simple interest has been
    //added to the account balance.

    double get_balance();
    //Returns the current account balance.

    double get_rate();
    //Returns the current account interest rate as a percentage.

    void output(ostream& outs);
    //Precondition: If outs is a file output stream, then
    //outs has already been connected to a file.
    //Postcondition: Account balance and interest rate have been written to the
    //stream outs.
private:
    double balance;
    double interest_rate;

    double fraction(double percent);
    //Converts a percentage to a fraction. For example, fraction(50.3) returns 0.503.
};

int main()
{
    BankAccount account1, account2;
    cout << "Start of Test:\n";
```

The member function set is overloaded.

2 objects created

Method overloading – `BankAccount::set`

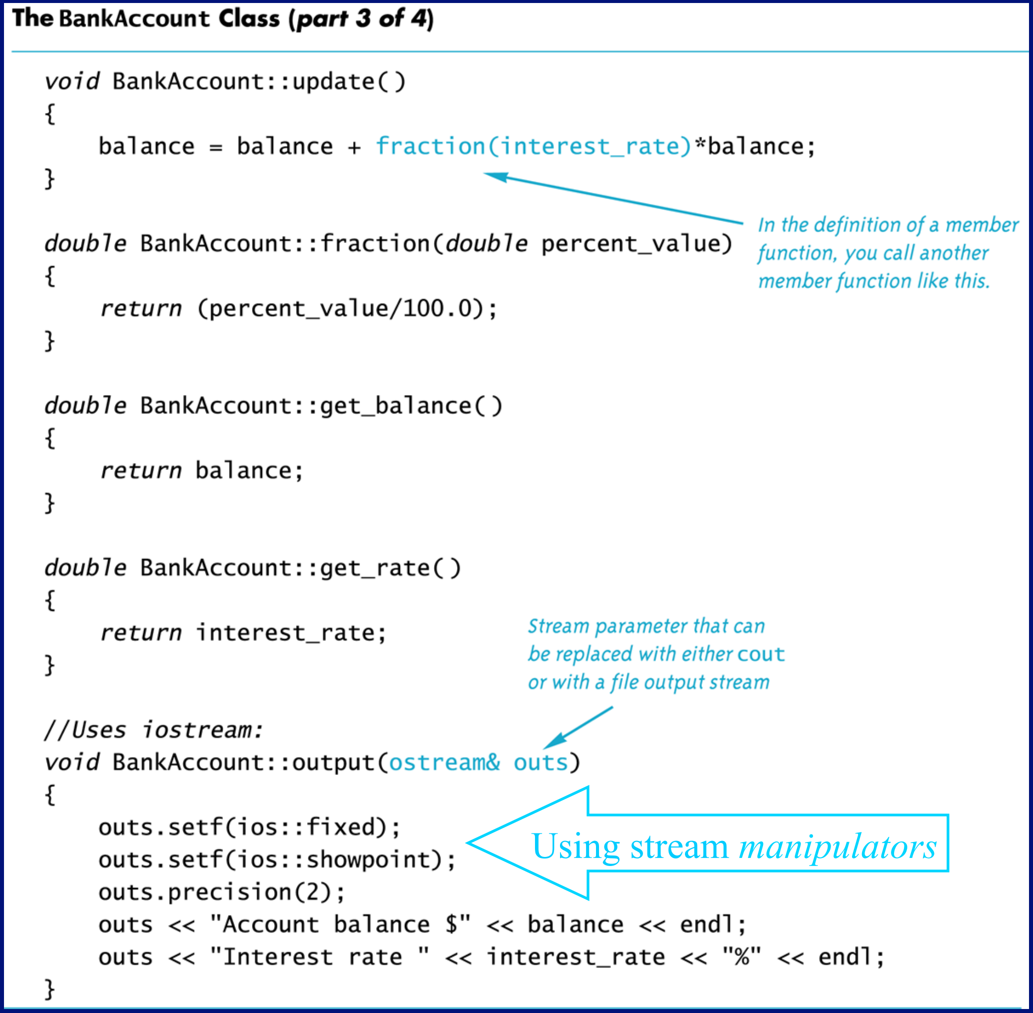
- A method's signature includes its name and its parameter list
- Can overload a name like set with a different parameter list
  - Number, types, order


The BankAccount Class ***(part 2 of 4)***

```
    account1.set(123, 99, 3.0);
    cout << "account1 initial statement:\n";
    account1.output(cout);

    account1.set(100, 5.0);
    cout << "account1 with new setup:\n";
    account1.output(cout);

    account1.update();
    cout << "account1 after update:\n";
    account1.output(cout);

    account2 = account1;
    cout << "account2:\n";
    account2.output(cout);
    return 0;
}

void BankAccount::set(int dollars, int cents, double rate)
{
    if ((dollars < 0) || (cents < 0) || (rate < 0))
    {
        cout << "Illegal values for money or interest rate.\n";
        exit(1);
    }

    balance = dollars + 0.01*cents;
    interest_rate = rate;
}

void BankAccount::set(int dollars, double rate)
{
    if ((dollars < 0) || (rate < 0))
    {
        cout << "Illegal values for money or interest rate.\n";
        exit(1);
    }

    balance = dollars;
    interest_rate = rate;
}
```

Calls to the overloaded member function set
Definitions of overloaded member function set

More implementing BankAccount

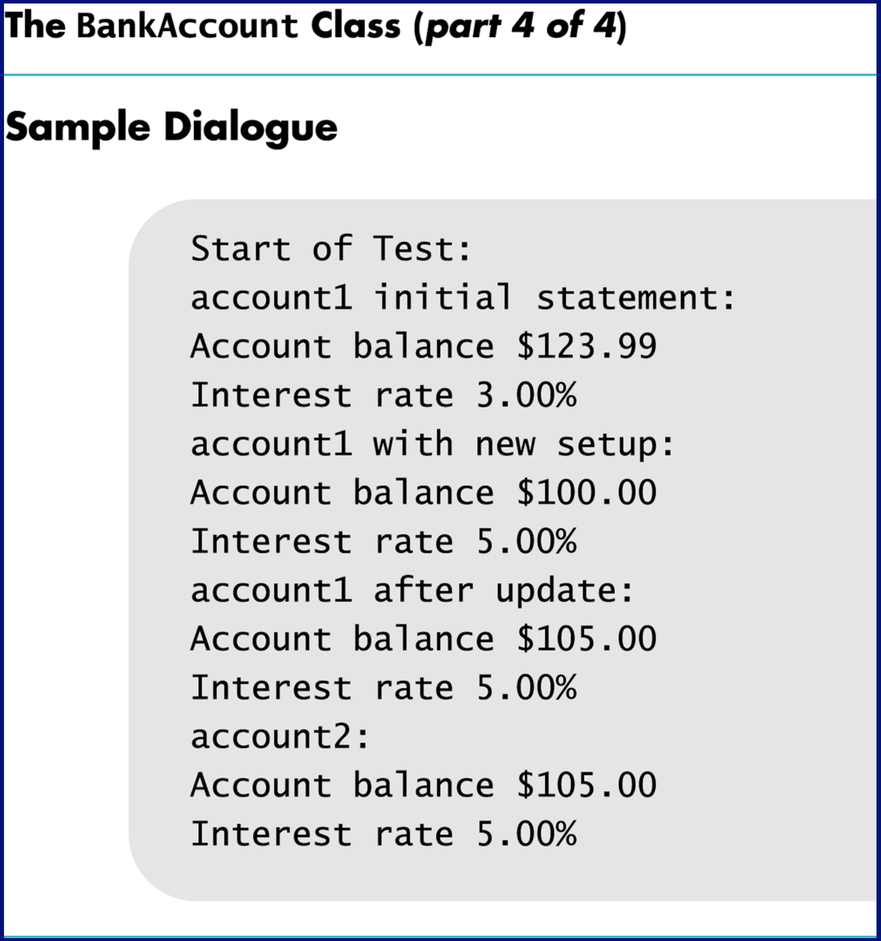


The BankAccount Class (*part 3 of 4*)

```
void BankAccount::update()
{
    balance = balance + fraction(interest_rate)*balance;
}

double BankAccount::fraction(double percent_value)
{
    return (percent_value/100.0);
}

double BankAccount::get_balance()
{
    return balance;
}

double BankAccount::get_rate()
{
    return interest_rate;
}

//Uses iostream:
void BankAccount::output(ostream& outs)
{
    outs.setf(ios::fixed);
    outs.setf(ios::showpoint);
    outs.precision(2);
    outs << "Account balance $" << balance << endl;
    outs << "Interest rate " << interest_rate << "%" << endl;
}
```

In the definition of a member function, you call another member function like this.
Stream parameter that can be replaced with either cout or with a file output stream
Using stream *manipulators*

Sample BankAccount results



The BankAccount **Class (*part 4 of 4*)**

Sample Dialogue

```
Start of Test:
account1 initial statement:
Account balance $123.99
Interest rate 3.00%
account1 with new setup:
Account balance $100.00
Interest rate 5.00%
account1 after update:
Account balance $105.00
Interest rate 5.00%
account2:
Account balance $105.00
Interest rate 5.00%
```

// excerpts from main:

```
account1.set(123,99,3);
```

// called with all 3 arguments

```
account1.set(100,5);
```

// called other version of set

```
account1.update();
```

```
account2 = account1;
```

Q: What if account2.update()?

Constructors

- A constructor (a.k.a. ctor) is a member function
  - Usually declared public
- One is *always* called when an object is created
- Main purpose – initialize instance variables
  - Also useful to allocate resources if needed
- Constructor's name must be the name of the class
- A constructor cannot return a value
  - No return type, not even void

A BankAccount constructor

- Declare in public part of class definition

```
BankAccount(int dollars, int cents, double rate);
```

- Implement essentially like other methods

```
BankAccount::BankAccount(int dollars, int cents,
                         double rate) {

    if ((dollars < 0) || (cents < 0) || ( rate < 0 )) {
        cout << "Illegal values for money or rate\n";
        exit(1);
    }

    balance = dollars + 0.01 * cents;
    interest_rate = rate;
}
```

Constructor call is automatic

- May not invoke (i.e., call) it directly:

  `account1.BankAccount(10, 50, 2);` // ERROR

- Instead invoke indirectly
  - On stack: `BankAccount account1(10, 50, 2);`
  - Or free store: … `new BankAccount(10, 50, 2);`
- But class must have a matching constructor
  - e.g., `BankAccount()` if just `new BankAccount;`
    - Default constructor is called – but oops: ERROR if explicit constructor is defined and not overloaded!

Overloading and the default ctor

- Another possible BankAccount ctor:
  ```
  BankAccount (double balance, double interest_rate);
  ```
- Or can have either one of the following. Why not both?
  ```
  BankAccount (double balance);
  BankAccount (double interest_rate);
  ```
- Also either explicitly define default ctor:
  ```
  BankAccount ( );
  ```
  Or implicitly via default arguments in other ctors:
  ```
  BankAccount (double balance = 0.0);
  ```
- Tip: good idea to always include a default ctor even if there is no need to initialize variables
  - So clients can: `BankAccount checking, savings;`
  - Important for inheritance reasons too (a future topic)

Base/member initialization list

- An initialization section in a constructor definition provides an alternative way to initialize member variables

```
BankAccount::BankAccount() : balance(0), interest_rate(0)
{ } // still need a body (even if intentionally empty like this case)
```

  - Can use parameter names too – even if same name as member!
- Note: order of initialization matches the order in which the variables are declared in the class, not their order in the list
- *Must* use such a list for constants and reference variables (since references are always constant)
  - Also must use to initialize private data in a base class (later topic)
- *Should* always use for user-defined types if default ctor not appropriate – to avoid extra ctor (and destructor) calls