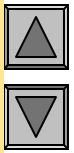
Lesson 4 - Outline

- **"`friend`" Functions / Classes**
- **"`this`" Pointer**
- **"`static`" Class Members**

"friend" Functions / Classes

- Can access **private** and **protected** members of a "grantor" class
- **friend** functions are not member of the "grantor" class
  - They are defined outside of class scope
- Properties of friendship
  - "Not symmetric" and "not transitive"
    - **B** isFriendOf **A** → **A** mayNotBeFriendOf **B**
    - **A** isFriendOf **B** ∧ **B** isFriend of **C** → **A** mayNotBeFriendOf **C**
- To declare a **friend** function / class

```
class grantorClass {
  friend retType friendFunc (...); //for a function
  friend class friendClass;        //for a class
  ...
};
```

Outline

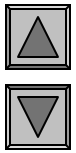

```
1  // Fig. 7.5: fig07_05.cpp
2  // Friends can access private members of a class.
3  #include <iostream>
4
5  using std::cout;
6  using std::endl;
7
8  // Modified Count class
9  class Count {
10    friend void setX( Count &, int ); // friend declaration
11 public:
12    Count() { x = 0; }                // constructor
13    void print() const { cout << x << endl; }  // output
14 private:
15    int x;  // data member
16 };
17
18 // Can modify private data of Count because
19 // setX is declared as a friend function of
20 void setX( Count &c, int val )
21 {
22    c.x = val; // legal: setX is a friend of Count
23 }
24
25 int main()
26 {
27    Count counter;
28
29    cout << "counter.x after instantiation: ";
30    counter.print();
```

`setX` a **`friend`** of class **`Count`** (can access **`private`** data).

`setX` is defined normally and is not a member function of **`Count`**.

Changing **`private`** variables allowed.

```
31    cout << "counter.x after call to setX friend function: ";
32    setX( counter, 8 );  // set x with a friend
33    counter.print();
34    return 0;
35 }
```



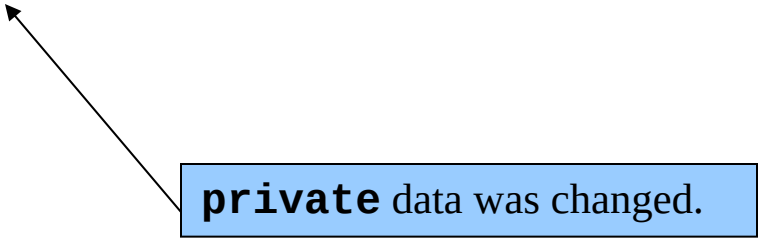
Outline

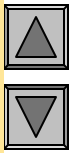
2. Modify object

3. Print results

Program Output

```
counter.x after instantiation: 0
counter.x after call to setX friend function: 8
```





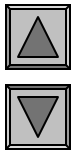
Outline

(Previous program without `friend` declared)

```
1  // Fig. 7.6: fig07_06.cpp
2  // Non-friend/non-member functions cannot access
3  // private data of a class.
4  #include <iostream>
5
6  using std::cout;
7  using std::endl;
8
9  // Modified Count class
10 class Count {
11 public:
12    Count() { x = 0; }                    // constructor
13    void print() const { cout << x << endl; }  // output
14 private:
15    int x;  // data member
16 };
17
18 // Function tries to modify private data of Count,
19 // but cannot because it is not a friend of Count.
20 void cannotSetX( Count &c, int val )
21 {
22    c.x = val;  // ERROR: 'Count::x' is not accessible
23 }
24
25 int main()
26 {
27    Count counter;
28
29    cannotSetX( counter, 3 ); // cannotSetX is not a friend
30    return 0;
31 }
```

`cannotSetX` is not a **`friend`** of class **Count**. It cannot access **`private`** data.

`cannotSetX` tries to modify a **`private`** variable…



Outline

Program Output

```
Compiling...
Fig07_06.cpp
D:\books\2000\cpphtp3\examples\Ch07\Fig07_06\Fig07_06.cpp(22) :
   error C2248: 'x' : cannot access private member declared in
   class 'Count'
        D:\books\2000\cpphtp3\examples\Ch07\Fig07_06\
        Fig07_06.cpp(15) : see declaration of 'x'
Error executing cl.exe.

test.exe - 1 error(s), 0 warning(s)
```

Expected compiler error - cannot access **`private`** data

"this" Pointer

- Allows objects to access their own address
- Not part of the object itself
- Implicit first argument on non-static member function call to the object
- Implicitly reference member data and functions
- The type of the **this** pointer depends upon the type of the object and whether the member function using **this** is **const**
- In a non-**const** member function of **Employee**, **this** has type

```
Employee * const
```

  - Constant pointer to an **Employee** object
- In a **const** member function of **Employee**, this has type

```
const Employee * const
```

  - Constant pointer to a constant **Employee** object

"this" Pointer

- Examples using **this**
  - For a member function print data member **x**, either

```
this->x
```

or

```
( *this ).x
```

- Cascaded member function calls
  - Function returns a reference pointer to the same object

```
{ return *this; }
```

  - Other functions can operate on that pointer
  - Functions that do not return references must be called last

"this" Pointer

- Example of cascaded member function calls
  - Member functions **setHour**, **setMinute**, and **setSecond** all return ***this** (reference to an object)
  - For object **t**, consider

    ```
    t.setHour(1).setMinute(2).setSecond(3);
    ```

  - Executes **t.setHour(1)**, returns ***this** (reference to object) and the expression becomes

    ```
    t.setMinute(2).setSecond(3);
    ```

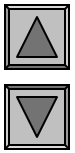
  - Executes **t.setMinute(2)**, returns reference and becomes

    ```
    t.setSecond(3);
    ```

  - Executes **t.setSecond(3)**, returns reference and becomes

    ```
    t;
    ```

  - Has no effect



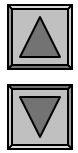
Outline


```
1  // Fig. 7.7: fig07_07.cpp
2  // Using the this pointer to refer to object members.
3  #include <iostream>
4
5  using std::cout;
6  using std::endl;
7
8  class Test {
9  public:
10    Test( int = 0 );              // default constructor
11    void print() const;
12 private:
13    int x;
14 };
15
16 Test::Test( int a ) { x = a; }  // constructor
17
18 void Test::print() const   // ( ) around *this
19 {
20    cout << "        x = " << x
21         << "\n  this->x = " << this->x
22         << "\n(*this).x = " << ( *this ).x << endl;
23 }
24
25 int main()
26 {
27    Test testObject( 12 );
28
29    testObject.print();
30
31    return 0;
32 }
```

Printing **x** directly.

Print **x** using the arrow **->** operator off the **this** pointer.

Printing **x** using the dot (**.**) operator. Parenthesis required because dot operator has higher precedence than *****. Without, interpreted incorrectly as ***(this.x)**.

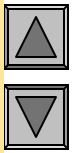


Outline

Program Output

```
       x = 12
  this->x = 12
(*this).x = 12
```

All three methods have the same result.

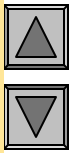


Outline

1. Class definition

```
1  // Fig. 7.8: time6.h
2  // Cascading member function calls.
3
4  // Declaration of class Time.
5  // Member functions defined in time6.cpp
6  #ifndef TIME6_H
7  #define TIME6_H
8
9  class Time {
10 public:
11    Time( int = 0, int = 0, int = 0 );  // default constructor
12
13    // set functions
14    Time &setTime( int, int, int ); // set hour, minute, second
15    Time &setHour( int );    // set hour
16    Time &setMinute( int );  // set min
17    Time &setSecond( int );  // set sec
18
19    // get functions (normally declared
20    int getHour() const;     // return
21    int getMinute() const;   // return minute
22    int getSecond() const;   // return second
23
24    // print functions (normally declared const)
25    void printMilitary() const;  // print military time
26    void printStandard() const;  // print standard time
27 private:
28    int hour;              // 0 - 23
29    int minute;            // 0 - 59
30    int second;            // 0 - 59
31 };
32
33 #endif
```

Notice the **`Time &`** - function returns a reference to a **`Time`** object. Specify object in function definition.



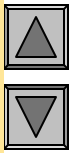
Outline

1. Load header file

1.1 Function definitions

```
34 // Fig. 7.8: time.cpp
35 // Member function definitions for Time class.
36 #include <iostream>
37
38 using std::cout;
39
40 #include "time6.h"
41
42 // Constructor function to initialize private data.
43 // Calls member function setTime to set variables.
44 // Default values are 0 (see class definition).
45 Time::Time( int hr, int min, int sec )
46    { setTime( hr, min, sec ); }
47
48 // Set the values of hour, minute, and second.
49 Time &Time::setTime( int h, int m, int s )
50 {
51    setHour( h );
52    setMinute( m );
53    setSecond( s );
54    return *this;   // enables cascading
55 }
56
57 // Set the hour value
58 Time &Time::setHour( int h )
59 {
60    hour = ( h >= 0 && h < 24 ) ? h : 0;
61
62    return *this;   // enables cascading
63 }
64
```

Returning ***this** enables cascading function calls

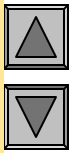


Outline

1.1 Function definitions

```
65 // Set the minute value
66 Time &Time::setMinute( int m )
67 {
68    minute = ( m >= 0 && m < 60 ) ? m : 0;
69
70    return *this;   // enables cascading
71 }
72
73 // Set the second value
74 Time &Time::setSecond( int s )
75 {
76    second = ( s >= 0 && s < 60 ) ? s : 0;
77
78    return *this;   // enables cascading
79 }
80
81 // Get the hour value
82 int Time::getHour() const { return hour; }
83
84 // Get the minute value
85 int Time::getMinute() const { return minute; }
86
87 // Get the second value
88 int Time::getSecond() const { return second; }
89
90 // Display military format time: HH:MM
91 void Time::printMilitary() const
92 {
93    cout << ( hour < 10 ? "0" : "" ) << hour << ":"
94         << ( minute < 10 ? "0" : "" ) << minute;
```

Returning **`*this`** enables cascading function calls



Outline

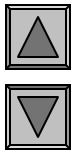

```
95 }
96
97 // Display standard format time: HH:MM:SS AM (or PM)
98 void Time::printStandard() const
99 {
100    cout << ( ( hour == 0 || hour == 12 ) ? 12 : hour % 12 )
101         << ":" << ( minute < 10 ? "0" : "" ) << minute
102         << ":" << ( second < 10 ? "0" : "" ) << second
103         << ( hour < 12 ? " AM" : " PM" );
104}
105// Fig. 7.8: fig07_08.cpp
106// Cascading member function calls together
107// with the this pointer
108#include <iostream>
109
110using std::cout;
111using std::endl;
112
113#include "time6.h"
114
115int main()
116{
117   Time t;
118
119   t.setHour( 18 ).setMinute( 30 ).setSe
120   cout << "Military time: ";
121   t.printMilitary();
122   cout << "\nStandard time: ";
123   t.printStandard();
124
125   cout << "\n\nNew standard time: ";
126   t.setTime( 20, 20, 20 ).printStandard();
```

`printStandard` does not return a reference to an object.

Notice cascading function calls.

Cascading function calls. **`printStandard`** must be called after **`setTime`** because **`printStandard`** does not return a reference to an object.

`t.printStandard().setTime();` would cause an error.



Outline

```
127   cout << endl;
128
129   return 0;
130}
```

Program Output

```
Military time: 18:30
Standard time: 6:30:22 PM

New standard time: 8:20:20 PM
```

"`static`" Class Members

- Shared by all objects of a class
  - Normally, each object gets its own copy of each variable
- Efficient when a single copy of data is enough
  - Only the **`static`** variable has to be updated
- May seem like global variables, but have class scope
  - only accessible to objects of same class
- Initialized at file scope
- Exist even if no instances (objects) of the class exist
- Both variables and functions can be **`static`**
- Can be **`public`**, **`private`** (or **`protected`**)

"static" Class Members

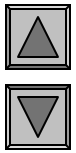
- **static** variables
  - Static variables are accessible through any object of the class
  - **public static** variables
    - Can also be accessed using scope resolution operator(**::**)

      Employee::count
  - **private static** variables
    - When no class member objects exist, can only be accessed via a **public static** member function
      - To call a **public static** member function combine the class name, the **::** operator and the function name

        Employee::getCount()

"`static`" Class Members

- **`Static`** functions
  - **`static`** member functions cannot access non-**`static`** data or functions
  - There is no **`this`** pointer for **`static`** functions, they exist independent of objects



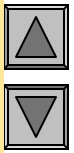
Outline

1. Class definition

1.2 Declare variables

```
1  // Fig. 7.9: employ1.h
2  // An employee class
3  #ifndef EMPLOY1_H
4  #define EMPLOY1_H
5
6  class Employee {
7  public:
8     Employee( ... );  // constructor
9     ...
10
11
12
13    // static member function
14    static int getCount();  // return # objects instantiated
15
16 private:
17    ...
18
19
20    // static data member
21    static int count;  // number of objects instantiated
22 };
23
24 #endif
```

`static` member function and variable declared.



Outline

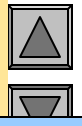
1. Load header file

1.1 Initialize `static` data members

```
25 // Fig. 7.9: employ1.cpp
26 // Member function definitions for class Employee
27
28
29 #include "employ1.h"
30
31
32
33
34 // Initialize the static data member
35 int Employee::count = 0;
36
37
38
39 // Define the static member function that
40 // returns the number of employee objects instantiated.
41 int Employee::getCount() { return count; }
42
43
44
45 // Constructor
46 Employee::Employee( ... )
47 {
48    ...
49    count++;  // increment static count of employees
50 }
51
52
53
54
55
56
```

`static` data member **`count`** and function **`getCount( )`** initialized at file scope (required).

`static` data member **`count`** changed when a constructor is called.



Outline

1. Static data members
2. Function calls
3. Print data

```
57 // Fig. 7.9: fig07_09.cpp
58 // Driver to test the employee class
59 #include <iostream>
60
61 usi
62 usi
63
64 #inc
65
66 int main()
67 {
68    cout << "Number of employees before ins
69         << Employee::getCount() << endl;
70
71    Employee e1 Employee( … );
72    Employee e2 Employee( … );
73
74    cout << "Number of employees after instantiation is "
75         << e1.getCount();
76
77    return 0;
78 }
```

count incremented because of constructor calls.

If no **Employee** objects exist **getCount** must be accessed using the class name and (**::**).

```
Number of employees before instantiation is 0
```

e2.getCount() or **Employee::getCount()** would also work.

```
Number of employees after instantiation is 2
```

```
Employee constructor for e1 is called.
Employee constructor for e2 is called.
```