Πανεπιστήμιο Πατρών

Τμήμα Μηχανικών Ηλεκτρονικών Υπολογιστών και Πληροφορικής

ΟΝΤΟΚΕΝΤΡΙΚΟΣ ΠΡΟΓΡΑΜΜΑΤΙΣΜΟΣ ΙΙ (C++)

Κλάσεις και Αφαίρεση Δεδομένων

Κλάσεις Μέρος ΙΙ

Εισαγωγή

- Κλάσεις
- Αφαίρεση Δεδομένων
- Αντικειμενοστραφής προγραμματισμός
- Κληρονομικότητα και πολυμορφισμός

7.2 const (Σταθερά) Αντικείμενα και Μέθοδοι

- Η αρχή της ελάχιστης πρόσβασης
  - Επιτρέπουμε πρόσβαση για τροποποιήσεις μόνο στα απαραίτητα αντικείμενα
- **`const`**
  - Ορίζει αντικείμενο που δε τροποποιείται
  - Δίνει Compiler error
  - Παράδειγμα

```
const Time noon( 12, 0, 0 );
```

    - Δηλώνει **`const`** αντικείμενο **`noon`** της **`Time`**
    - Αρχικοποιεί σε 12

7.2 const (Σταθερά) Αντικείμενα και Μέθοδοι

- `const` μέθοδοι
  - Οι μέθοδοι αντικειμένων `const` πρέπει να είναι και αυτές `const`
    - Δε μπορεί να τροποποιούν αντικείμενα
  - Ορίζουμε ως `const` σε
    - Πρωτότυπο
      - Μετά τη λίστα παραμέτρων
    - Δηλώσεις
      - Πριν την αρχή του αριστερού αγκίστρου

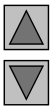
Outline

time5.h (1 of 2)

```
1  // Fig. 7.1: time5.h
2  // Definition of class Time.
3  // Member functions defined in time5.cpp.
4  #ifndef TIME5_H
5  #define TIME5_H
6
7  class Time {
8
9  public:
10    Time( int = 0, int = 0, int = 0 );  // default constructor
11
12    // set functions
13    void setTime( int, int, int );  // set time
14    void setHour( int );            // set hour
15    void setMinute( int );          // set minute
16    void setSecond( int );          // set second
17
18    // get functions (normally declared const)
19    int getHour() const;            // return hour
20    int getMinute() const;          // return minute
21    int getSecond() const;          // return second
22
23    // print functions (normally declared const)
24    void printUniversal() const;    // print universal time
25    void printStandard();           // print standard time
```

Declare **`const`** get functions.

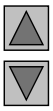
Declare **`const`** function **`printUniversal`**.



Outline

time5.h (2 of 2)

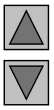
```
26
27 private:
28    int hour;    // 0 - 23 (24-hour clock format)
29    int minute;  // 0 - 59
30    int second;  // 0 - 59
31
32 }; // end class Time
33
34 #endif
```

Outline

time5.cpp (1 of 4)

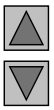
```
1  // Fig. 7.2: time5.cpp
2  // Member-function definitions for class Time.
3  #include <iostream>
4
5  using std::cout;
6
7  #include <iomanip>
8
9  using std::setfill;
10 using std::setw;
11
12 // include definition of class Time from time5.h
13 #include "time5.h"
14
15 // constructor function to initialize private data;
16 // calls member function setTime to set variables;
17 // default values are 0 (see class definition)
18 Time::Time( int hour, int minute, int second )
19 {
20    setTime( hour, minute, second );
21
22 } // end Time constructor
23
```



Outline

time5.cpp (2 of 4)

```
24 // set hour, minute and second values
25 void Time::setTime( int hour, int minute, int second )
26 {
27    setHour( hour );
28    setMinute( minute );
29    setSecond( second );
30
31 } // end function setTime
32
33 // set hour value
34 void Time::setHour( int h )
35 {
36    hour = ( h >= 0 && h < 24 ) ? h : 0;
37
38 } // end function setHour
39
40 // set minute value
41 void Time::setMinute( int m )
42 {
43    minute = ( m >= 0 && m < 60 ) ? m : 0;
44
45 } // end function setMinute
46
```

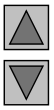



Outline

time5.cpp (3 of 4)

```
47 // set second value
48 void Time::setSecond( int s )
49 {
50    second = ( s >= 0 && s < 60 ) ? s : 0;
51
52 } // end function setSecond
53
54 // return hour value
55 int Time::getHour() const
56 {
57    return hour;
58
59 } // end function getHour
60
61 // return minute value
62 int Time::getMinute() const
63 {
64    return minute;
65
66 } // end function getMinute
67
```

`const` functions do not modify objects.

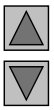


Outline

time5.cpp (4 of 4)

```
68 // return second value
69 int Time::getSecond() const
70 {
71    return second;
72
73 } // end function getSecond
74
75 // print Time in universal format
76 void Time::printUniversal() const
77 {
78    cout << setfill( '0' ) << setw( 2 ) << hour << ":"
79         << setw( 2 ) << minute << ":"
80         << setw( 2 ) << second;
81
82 } // end function printUniversal
83
84 // print Time in standard format
85 void Time::printStandard() // note lack of const declaration
86 {
87    cout << ( ( hour == 0 || hour == 12 ) ? 12 : hour % 12 )
88         << ":" << setfill( '0' ) << setw( 2 ) << minute
89         << ":" << setw( 2 ) << second
90         << ( hour < 12 ? " AM" : " PM" );
91
92 } // end function printStandard
```

`const` functions do not modify objects.



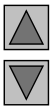
Outline

fig07_03.cpp (1 of 2)

```
1  // Fig. 7.3: fig07_03.cpp
2  // Attempting to access a const object with
3  // non-const member functions.
4
5  // include Time class definition from time5.h
6  #include "time5.h"
7
8  int main()
9  {
10    Time wakeUp( 6, 45, 0 );       // non-constant object
11    const Time noon( 12, 0, 0 );   // constant object
12
```

Declare **`noon`** a **`const`** object.

Note that non-**`const`** constructor can initialize **`const`** object.



Outline

```
13                          // OBJECT      MEMBER FUNCTION
14    wakeUp.setHour( 18 );  // non-const   non-const
15
16    noon.setHour( 12 );    // const       non-const
17
18    wakeUp.getHour();      // non-const   const
19
20    noon.getMinute();      // const       con
21    noon.printUniversal(); // const       con
22
23    noon.printStandard();  // const       non
24
25    return 0;
26
27 } // end main
```

Attempting to invoke non-**const** member function on **const** object results in compiler error.

Attempting to invoke non-**const** member function on **const** object results in compiler error even if function does not modify object.

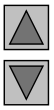
```
d:\cpphtp4_examples\ch07\fig07_01\fig07_01.cpp(16
   'setHour' : cannot convert 'this' pointer from
   to 'class Time &'
        Conversion loses qualifiers
d:\cpphtp4_examples\ch07\fig07_01\fig07_01.cpp(23) : error C2662:
   'printStandard' : cannot convert 'this' pointer from 'const class
   Time' to 'class Time &'
        Conversion loses qualifiers
```

fig07_03.cpp (2 of 2)

fig07_03.cpp output (1 of 1)

7.2 const (Σταθερά) Αντικείμενα και Μέθοδοι

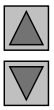
- Αρχικοποίηση αντικειμένου
  - Αρχικοποίηση με member initializer syntax
    - Μπορεί να χρησιμοποιηθεί
      - Με όλα τα μέλη δεδομένων
    - (Πρέπει να χρησιμοποιηθεί)
      - **Για τα μέλη const**
      - Για όλες τις αναφορές μεταβλητών
  - **C++11:**
    - **Μπορεί πλέον να αρχικοποιηθεί κανονικά** μέσα στην κλάση



Outline

fig07_04.cpp (1 of 3)

```
1  // Fig. 7.4: fig07_04.cpp
2  // Using a member initializer to initialize a
3  // constant of a built-in data type.
4  #include <iostream>
5
6  using std::cout;
7  using std::endl;
8
9  class Increment {
10
11 public:
12    Increment( int c = 0, int i = 1 );  // default constructor
13
14    void addIncrement()
15    {
16       count += increment;
17
18    } // end function addIncrement
19
20    void print() const;     // prints count and increment
21
```

Outline

fig07_04.cpp (2 of 3)

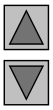
```
22 private:
23    int count;
24    const int increment;    // const data member
25
26 }; // end class Increment
27
28 // constructor
29 Increment::Increment
30    : count( c ),
31      increment( i )
32 {
33    // empty body
34
35 } // end Increment constructor
36
37 // print count and increment va
38 void Increment::print() const
39 {
40    cout << "count = " << count
41         << ", increment = " << increment << endl;
42
43 } // end function print
44
```

Member initializer list separated by colon.

Member initializer syntax can be

Member initializer syntax must be used for **const** data member **increment**.

Member initializer consists of data member name (**increment**) followed by parentheses containing initial value (**c**).



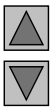
Outline

fig07_04.cpp (3 of 3)

fig07_04.cpp output (1 of 1)

```
45 int main()
46 {
47    Increment value( 10, 5 );
48
49    cout << "Before incrementing: ";
50    value.print();
51
52    for ( int j = 0; j < 3; j++ ) {
53       value.addIncrement();
54       cout << "After increment " << j + 1 << ": ";
55       value.print();
56    }
57
58    return 0;
59
60 } // end main
```

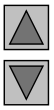
```
Before incrementing: count = 10, increment = 5
After increment 1: count = 15, increment = 5
After increment 2: count = 20, increment = 5
After increment 3: count = 25, increment = 5
```

Outline

fig07_05.cpp (1 of 3)

```
1  // Fig. 7.5: fig07_05.cpp
2  // Attempting to initialize a constant of
3  // a built-in data type with an assignment.
4  #include <iostream>
5
6  using std::cout;
7  using std::endl;
8
9  class Increment {
10
11 public:
12    Increment( int c = 0, int i = 1 );  // default constructor
13
14    void addIncrement()
15    {
16       count += increment;
17
18    } // end function addIncrement
19
20    void print() const;     // prints count and increment
21
```



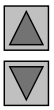
Outline

fig07_05.cpp (2 of 3)

```
22 private:
23    int count;
24    const int increment;    // const data member
25
26 }; // end class Increment
27
28 // constructor
29 Increment::Increment( int c, int i
30 {              // Constant member '
31    count = c;       // allowed beca
32    increment = i; // ERROR: Cannot modify a const object
33
34 } // end Increment constructor
35
36 // print count and increment values
37 void Increment::print() const
38 {
39    cout << "count = " << count
40         << ", increment = " << increment << endl;
41
42 } // end function print
43
```

Declare increment as **const** data member

Attempting to modify **const** data member **increment** results in error.



Outline

fig07_05.cpp (3 of 3)

fig07_05.cpp output (1 of 1)

```
44 int main()
45 {
46    Increment value( 10, 5 );
47
48    cout << "Before incrementing: ";
49    value.print();
50
51    for ( int j = 0; j < 3; j++ ) {
52       value.addIncrement();
53       cout << "After increment " << j + 1 << ": ";
54       value.print();
55    }
56
57    return 0;
58
59 } // end main
```

```
D:\cpphtp4_examples\ch07\Fig07_03\Fig07_03.cpp(30) : error C2758:
   'increment' : must be initialized in constructor base/me
   initializer list
        D:\cpphtp4_examples\ch07\Fig07_03\Fig07_03.cpp(24)
            see declaration of 'increment'
D:\cpphtp4_examples\ch07\Fig07_03\Fig07_03.cpp(32) : error C2166:
   l-value specifies const object
```

Not using member initializer syntax to initialize **const** data member **increment** results in error.

Attempting to modify **const** data member **increment** results in error.

7.3 Σύνθεση/ Composition: Αντικείμενα ως μέλη κλάσης

- Σύνθεση/ Composition
  - Μία κλάση έχει αντικείμενα άλλης κλάσης ως μέλη
- Κατασκευή αντικειμένων
  - Τα μέλη αντικείμενα δημιουργούνται με τη σειρά που δηλώνονται
    - Δεν ακολουθείται η σειρά του constructor
    - Δημιουργούνται πριν από τα αντικείμενα της κλάσης που τα χρησιμοποιεί

Outline

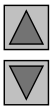
date1.h (1 of 1)

```
1  // Fig. 7.6: date1.h
2  // Date class definition.
3  // Member functions defined in date1.cpp
4  #ifndef DATE1_H
5  #define DATE1_H
6
7  class Date {
8
9  public:
10    Date( int = 1, int = 1, int
11    void print() const;  // pri
12    ~Date();  // provided to confirm destruction order
13
14 private:
15    int month;  // 1-12 (January-December)
16    int day;    // 1-31 based on month
17    int year;   // any year
18
19    // utility function to test proper day for month and year
20    int checkDay( int ) const;
21
22 }; // end class Date
23
24 #endif
```

ctor

mat

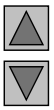
Note no constructor with parameter of type **Date**. Recall compiler provides default copy constructor.



Outline

date1.cpp (1 of 3)

```
1  // Fig. 7.7: date1.cpp
2  // Member-function definitions for class Date.
3  #include <iostream>
4
5  using std::cout;
6  using std::endl;
7
8  // include Date class definition from date1.h
9  #include "date1.h"
10
11 // constructor confirms proper value for month; calls
12 // utility function checkDay to confirm proper value for day
13 Date::Date( int mn, int dy, int yr )
14 {
15    if ( mn > 0 && mn <= 12 )  // validate the month
16       month = mn;
17
18    else {                     // invalid month set to 1
19       month = 1;
20       cout << "Month " << mn << " invalid. Set to month 1.\n";
21    }
22
23    year = yr;                 // should validate yr
24    day = checkDay( dy );      // validate the day
25
```

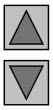
Outline

date1.cpp (2 of 3)

```
26    // output Date object to show when its constructor is called
27    cout << "Date object constructor for date ";
28    print();
29    cout << endl;
30
31 } // end Date constructor
32
33 // print Date object in form mont
34 void Date::print() const
35 {
36    cout << month << '/' << day << '/' << year;
37
38 } // end function print
39
40 // output Date object to show when it
41 Date::~Date()
42 {
43    cout << "Date object destructor for date ";
44    print();
45    cout << endl;
46
47 } // end destructor ~Date
48
```

No arguments; each member function contains implicit handle to object on which it operates.

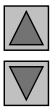
Output to show timing of destructors.



Outline

date1.cpp (3 of 3)

```
49 // utility function to confirm proper day value based on
50 // month and year; handles leap years, too
51 int Date::checkDay( int testDay ) const
52 {
53    static const int daysPerMonth[ 13 ] =
54       { 0, 31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31 };
55
56    // determine whether testDay is valid for specified month
57    if ( testDay > 0 && testDay <= daysPerMonth[ month ] )
58       return testDay;
59
60    // February 29 check for leap year
61    if ( month == 2 && testDay == 29 &&
62       ( year % 400 == 0 ||
63          ( year % 4 == 0 && year % 100 != 0 ) ) )
64       return testDay;
65
66    cout << "Day " << testDay << " invalid. Set to day 1.\n";
67
68    return 1;  // leave object in consistent state if bad value
69
70 } // end function checkDay
```

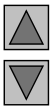



Outline

employee1.h (1 of 2)

```
1  // Fig. 7.8: employee1.h
2  // Employee class definition.
3  // Member functions defined in employee1.cpp.
4  #ifndef EMPLOYEE1_H
5  #define EMPLOYEE1_H
6
7  // include Date class definition from date1.h
8  #include "date1.h"
9
10 class Employee {
11
12 public:
13    Employee(
14       const char *, const char *, const Date &, const Date & );
15
16    void print() const;
17    ~Employee();  // provided to confirm destruction order
18
19 private:
20    char firstName[ 25 ];
21    char lastName[ 25 ];
22    const Date birthDate;  // composition: member object
23    const Date hireDate;   // composition: member object
24
25 }; // end class Employee
```

Using composition; **`Employee`** object contains **`Date`** objects as data members.



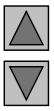
Outline

```
26
27 #endif
```

employee1.h (2 of 2)

employee1.cpp (1 of 3)

```
1  // Fig. 7.9: employee1.cpp
2  // Member-function definitions for class Employee.
3  #include <iostream>
4
5  using std::cout;
6  using std::endl;
7
8  #include <cstring>      // strcpy and strlen prototypes
9
10 #include "employee1.h"  // Employee class definition
11 #include "date1.h"      // Date class definition
12
```

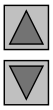
Outline

employee1.cpp (2 of 3)

```
13 // constructor uses member initializer list to pass initializer
14 // values to constructors of member objects birthDate and
15 // hireDate [Note: This invokes the so-called "default copy
16 // constructor" which the C++ compiler provides implicitly.]
17 Employee::Employee( const char *first, const char *last,
18    const Date &dateOfBirth, const Date &dateOfHire )
19    : birthDate( dateOfBirth ),  // initialize birthDate
20      hireDate( dateOfHire )     // initialize hireDate
21 {
22    // copy first into firstName and be sure
23    int length = strlen( first );
24    length = ( length < 25 ? length : 24 );
25    strncpy( firstName, first, length );
26    firstName[ length ] = '\0';
27
28    // copy last into lastName and be sure that it fits
29    length = strlen( last );
30    length = ( length < 25 ? length : 24 );
31    strncpy( lastName, last, length );
32    lastName[ length ] = '\0';
33
34    // output Employee object to show when constructor is called
35    cout << "Employee object constructor: "
36         << firstName << ' ' << lastName << endl;
37
```

Member initializer syntax to initialize **`Date`** data members **`birthDate`** and **`hireDate`**; compiler uses default copy constructor.

Output to show timing of constructors.

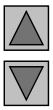


Outline

employee1.cpp (3 of 3)

```
38 } // end Employee constructor
39
40 // print Employee object
41 void Employee::print() const
42 {
43    cout << lastName << ", " << firstName << "\nHired: ";
44    hireDate.print();
45    cout << "  Birth date: ";
46    birthDate.print();
47    cout << endl;
48
49 } // end function print
50
51 // output Employee object to show when it
52 Employee::~Employee()
53 {
54    cout << "Employee object destructor: "
55         << lastName << ", " << firstName << endl;
56
57 } // end destructor ~Employee
```

Output to show timing of destructors.

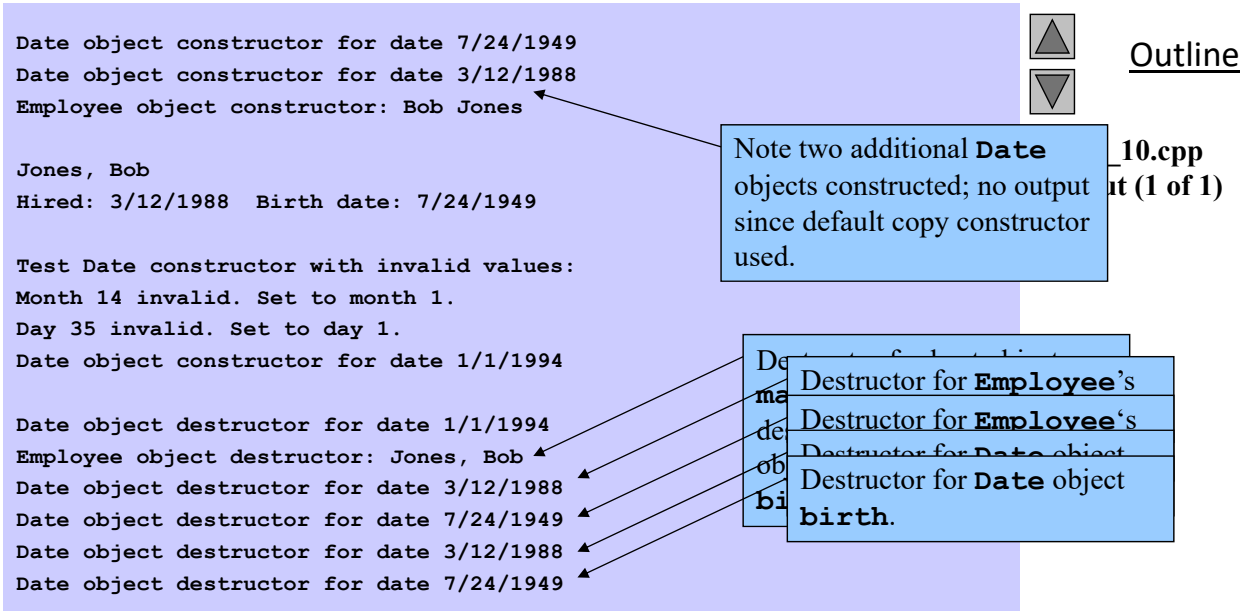


Outline

fig07_10.cpp (1 of 1)

```
1  // Fig. 7.10: fig07_10.cpp
2  // Demonstrating composition--an object with member objects.
3  #include <iostream>
4
5  using std::cout;
6  using std::endl;
7
8  #include "employee1.h"  // Employee class definition
9
10 int main()
11 {
12    Date birth( 7, 24, 1949 );
13    Date hire( 3, 12, 1988 );
14    Employee manager( "Bob", "Jones", birth, hire );
15
16    cout << '\n';
17    manager.print();
18
19    cout << "\nTest Date constructor with invalid values:\n";
20    Date lastDayOff( 14, 35, 1994 );  // invalid month and day
21    cout << endl;
22
23    return 0;
24
25 } // end main
```

Create **Date** objects to pass to **Employee** constructor.



7.4 friend Συναρτήσεις και friend Κλάσεις

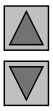
- **`friend`** συναρτήσεις
  - Ορίζονται εκτός εμβέλειας της κλάσης
  - Έχουν πρόσβαση σε non-public members
- Δήλωση **`friend`**s
  - Συνάρτηση
    - Προηγείται το keyword **`friend`**
  - Όλες οι συναρτήσεις της κλάσης **`classTwo`** ως **`friend`**s της κλάσης **`classOne`**
    - Βάζουμε τη δήλωση της μορφής

```
friend class classTwo;
```

στον ορισμό της **`classOne`**

7.4 friend Συναρτήσεις και friend Κλάσεις

- Ιδιότητες
  - Μπορεί να δοθεί όχι να ανακληθεί
    - κλάση **B** **friend** της κλάσης **A**
      - Η κλάση **A** πρέπει να δηλώσει την κλάση **B** ως **friend**
  - Όχι συμμετρική
    - κλάση **B** **friend** της κλάσης **A**
    - κλάση **A** όχι απαραίτητα **friend** της κλάσης **B**
  - Όχι μεταβατική
    - κλάση **A** **friend** της **B**
    - κλάση **B** **friend** της **C**
    - κλάση **A** όχι απαραίτητα **friend** της **C**

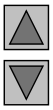


Outline

fig07_11.cpp (1 of 3)

```
1  // Fig. 7.11: fig07_11.cpp
2  // Friends can access private members of a class.
3  #include <iostream>
4
5  using std::cout;
6  using std::endl;
7
8  // Count class definition
9  class Count {
10    friend void setX( Count &, int ); // friend declaration
11
12 public:
13
14    // constructor
15    Count()
16       : x( 0 )  // initialize x to 0
17    {
18       // empty body
19
20    } // end Count constructor
21
```

Precede function prototype with keyword **friend**.



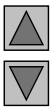
Outline

fig07_11.cpp (2 of 3)

```
22    // output x
23    void print() const
24    {
25       cout << x << endl;
26
27    } // end function print
28
29 private:
30    int x;  // data member
31
32 }; // end class Count
33
34 // function setX can
35 // because setX is
36 void setX( Count &c,
37 {
38    c.x = val;  // lega
39
40 } // end function setX
41
```

Pass **Count** object since C-style standalone function.

Since **setX friend** of **Count**, can access and modify **private** data member **x**.



Outline

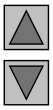
fig07_11.cpp (3 of 3)

```
42 int main()
43 {
44    Count counter;        // create Count object
45
46    cout << "counter.x after instantiati
47    counter.print();
48
49    setX( counter, 8 );  // set x with a friend
50
51    cout << "counter.x after call to setX friend function: ";
52    counter.print();
53
54    return 0;
55
56 } // end main
```

Use **friend** function to access and modify **private** data member **x**.

fig07_11.cpp output (1 of 1)

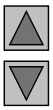
```
counter.x after instantiation: 0
counter.x after call to setX friend function: 8
```



Outline

fig07_12.cpp (1 of 3)

```
1  // Fig. 7.12: fig07_12.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  // Count class definition
10 // (note that there is no friendship declaration)
11 class Count {
12
13 public:
14
15    // constructor
16    Count()
17       : x( 0 )  // initialize x to 0
18    {
19       // empty body
20
21    } // end Count constructor
22
```

Outline

fig07_12.cpp (2 of 3)

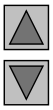
```
23    // output x
24    void print() const
25    {
26       cout << x << endl;
27
28    } // end function print
29
30 private:
31    int x;  // data member
32
33 }; // end class Count
34
35 // function tries to modify
36 // but cannot because functi
37 void cannotSetX( Count &c, i
38 {
39    c.x = val;  // ERROR: can                    Count
40
41 } // end function cannotSetX
42
```

Attempting to modify **private** data member from non-**friend** function results in error.

```
43 int main()
44 {
45    Count counter;            // create Count object
46
47    cannotSetX( counter, 3 ); // cannotSetX is not a friend
48
49    return 0;
50
51 } // end main
```

```
D:\cpphtp4_examples\ch07\Fig07_12\Fig07_12.cpp(39) : error C2248:
   'x' : cannot access private member declared in class 'Count'
        D:\cpphtp4_examples\ch07\Fig07_12\Fig07_12.cpp(31) :
           see declaration of 'x'
```

Attempting to modify **`private`** data member from non-**`friend`** function results in error.



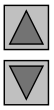
Outline

fig07_12.cpp (3 of 3)

fig07_12.cpp output (1 of 1)

7.5 Χρήση του `this`

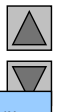
- **`this`**
  - Επιτρέπει στο αντικείμενο να έχει πρόσβαση στη δική του διεύθυνση
  - Ο τύπος του δείκτη **`this`** εξαρτάται από:
    - Τύπο του αντικειμένου
    - Αν η συνάρτηση είναι **`const`**
    - Για τις non-**`const`** συναρτήσεις **`Employee`**
      - **`this`** έχει τύπο **`Employee * const`**
        - Constant δείκτη σε non-const **`Employee`** αντικείμενο
    - Για τις **`const`** συναρτήσεις **`Employee`**
      - **`this`** έχει τύπο **`const Employee * const`**
        - Constant δείκτη σε constant **`Employee`** αντικείμενο



Outline

fig07_13.cpp (1 of 3)

```
1  // Fig. 7.13: fig07_13.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
10 public:
11    Test( int = 0 );    // default constructor
12    void print() const;
13
14 private:
15    int x;
16
17 }; // end class Test
18
19 // constructor
20 Test::Test( int value )
21    : x( value )  // initialize x to value
22 {
23    // empty body
24
25 } // end Test constructor
```

Outline

07_13.cpp of 3)

```
26
27 // print x using implicit and explicit this pointers;
28 // parentheses around *this required
29 void Test::print() const
30 {
31    // implicitly use this pointer to access mem
32    cout << "        x = " << x;
33
34    // explicitly use this pointer to access member x
35    cout << "\n  this->x = " << this->x;
36
37    // explicitly use dereferenced this pointer and
38    // the dot operator to access member x
39    cout << "\n(*this).x = " << ( *this ).x << endl;
40
41 } // end function print
42
43 int main()
44 {
45    Test testObject( 12 );
46
47    testObject.print();
48
49    return 0;
50
```

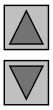
Implicitly use **this** pointer; only specify name of data member (**x**)

Explicitly use **this** pointer with arrow operator.

Explicitly use **this** pointer; dereference **this** pointer first, then use dot operator.

```
51 } // end main
```

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



Outline

fig07_13.cpp (3 of 3)

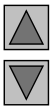
fig07_13.cpp output (1 of 1)

7.5 Χρήση του `this`

- Σειριακή κλήση συναρτήσεων
  - Πολλαπλές συναρτήσεις καλούνται με μία δήλωση
  - Η συνάρτηση επιστρέφει δείκτη αναφοράς στο ίδιο το αντικείμενο

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

  - Οι συναρτήσεις που δεν επιστρέφουν αναφορές πρέπει να κληθούν τελευταίες

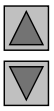


Outline

time6.h (1 of 2)

```
1  // Fig. 7.14: time6.h
2  // Cascading member function calls.
3
4  // Time class definition.
5  // Member functions defined in time6.cpp.
6  #ifndef TIME6_H
7  #define TIME6_H
8
9  class Time {
10
11 public:
12    Time( int = 0, int = 0, int = 0 );
13
14    // set functions
15    Time &setTime( int, int, int ); // se
16    Time &setHour( int );     // set hour
17    Time &setMinute( int );   // set minute
18    Time &setSecond( int );   // set second
19
20    // get functions (normally declared const)
21    int getHour() const;      // return hour
22    int getMinute() const;    // return minute
23    int getSecond() const;    // return second
24
```

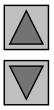
Set functions return reference to **Time** object to enable cascaded member function calls.



Outline

time6.h (2 of 2)

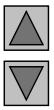
```
25    // print functions (normally declared const)
26    void printUniversal() const;  // print universal time
27    void printStandard() const;   // print standard time
28
29 private:
30    int hour;     // 0 - 23 (24-hour clock format)
31    int minute;   // 0 - 59
32    int second;   // 0 - 59
33
34 }; // end class Time
35
36 #endif
```



Outline

time6.cpp (1 of 5)

```
1  // Fig. 7.15: time6.cpp
2  // Member-function definitions for Time class.
3  #include <iostream>
4
5  using std::cout;
6
7  #include <iomanip>
8
9  using std::setfill;
10 using std::setw;
11
12 #include "time6.h"  // Time class definition
13
14 // constructor function to initialize private data;
15 // calls member function setTime to set variables;
16 // default values are 0 (see class definition)
17 Time::Time( int hr, int min, int sec )
18 {
19    setTime( hr, min, sec );
20
21 } // end Time constructor
22
```

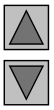
Outline

time6.cpp (2 of 5)

```
23 // set values of hour, minute, and second
24 Time &Time::setTime( int h, int m, int s )
25 {
26    setHour( h );
27    setMinute( m );
28    setSecond( s );
29
30    return *this;   // enables cascading
31
32 } // end function setTime
33
34 // set hour value
35 Time &Time::setHour( int h )
36 {
37    hour = ( h >= 0 && h < 24 ) ? h
38
39    return *this;   // enables cascading
40
41 } // end function setHour
42
```

Return ***this** as reference to enable cascaded member function calls.

Return ***this** as reference to enable cascaded member function calls.



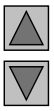
Outline

time6.cpp (3 of 5)

```
43 // set minute value
44 Time &Time::setMinute( int m )
45 {
46    minute = ( m >= 0 && m < 60 )
47
48    return *this;  // enables cascading
49
50 } // end function setMinute
51
52 // set second value
53 Time &Time::setSecond( int s )
54 {
55    second = ( s >= 0 && s < 60 )
56
57    return *this;  // enables cascading
58
59 } // end function setSecond
60
61 // get hour value
62 int Time::getHour() const
63 {
64    return hour;
65
66 } // end function getHour
67
```

Return ***this** as reference to enable cascaded member function calls.

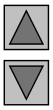
Return ***this** as reference to enable cascaded member function calls.



Outline

time6.cpp (4 of 5)

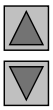
```
68 // get minute value
69 int Time::getMinute() const
70 {
71    return minute;
72
73 } // end function getMinute
74
75 // get second value
76 int Time::getSecond() const
77 {
78    return second;
79
80 } // end function getSecond
81
82 // print Time in universal format
83 void Time::printUniversal() const
84 {
85    cout << setfill( '0' ) << setw( 2 ) << hour << ":"
86         << setw( 2 ) << minute << ":"
87         << setw( 2 ) << second;
88
89 } // end function printUniversal
90
```



Outline

time6.cpp (5 of 5)

```
91 // print Time in standard format
92 void Time::printStandard() const
93 {
94    cout << ( ( hour == 0 || hour == 12 ) ? 12 : hour % 12 )
95         << ":" << setfill( '0' ) << setw( 2 ) << minute
96         << ":" << setw( 2 ) << second
97         << ( hour < 12 ? " AM" : " PM" );
98
99 } // end function printStandard
```

Outline

fig07_16.cpp (1 of 2)

```
1  // Fig. 7.16: fig07_16.cpp
2  // Cascading member function calls with the this pointer.
3  #include <iostream>
4
5  using std::cout;
6  using std::endl;
7
8  #include "time6.h"  // Time class definition
9
10 int main()
11 {
12    Time t;
13
14    // cascaded function calls
15    t.setHour( 18 ).setMinute( 30 ).setSecond( 22 );
16
17    // output time in universal and standard formats
18    cout << "Universal time: ";
19    t.printUniversal();
20
21    cout << "\nStandard time: ";
22    t.printStandard();
23
24    cout << "\n\nNew standard time: ";
25
```

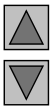
Cascade member function calls; recall dot operator associates from left to right.

```
26    // cascaded function calls
27    t.setTime( 20, 20, 20 ).printStandard();
28
29    cout << endl;
30
31    return 0;
32
33 } // end main
```

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

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

Function call to **printStandard** must appear last; **printStandard** does not return reference to **t**.



Outline

7_16.cpp
f 2)

7_16.cpp
ut (1 of 1)

7.6 Διαχείριση Δυναμικής Μνήμης με χρήση new και delete

- Διαχείριση δυναμικής μνήμης
  - Ελέγχει τη διανομή μνήμης
  - Με χρήση των τελεστών **new** και **delete**
    - include standard header **<new>**

7.6 Διαχείριση Δυναμικής Μνήμης με χρήση new και delete

- Έστω
  ```
  Time *timePtr;
  timePtr = new Time;
  ```
- **Τελεστής new**
  - Δημιουργεί αντικείμενα κατάλληλου μεγέθους για τον τύπο **Time**
    - Δίνει λάθος αν δεν υπάρχει χώρος στη μνήμη
  - Επιστρέφει δείκτη στον συγκεκριμένο τύπο
- **Stack vs Heap**
- Με αρχικοποίηση
  ```
  double *ptr = new double( 3.14159 );
  Time *timePtr = new Time( 12, 0, 0 );
  ```
- Δήλωση πίνακα
  ```
  int *gradesArray = new int[ 10 ];
  ```


7.6 Διαχείριση Δυναμικής Μνήμης με χρήση new και delete

- Έστω
  ```
  delete timePtr;
  ```
  Απελευθερώνει τη μνήμη και καταστρέφει τα αντικείμενα
- Τελεστής **delete**
  - Καλεί το destructor
  - Η μνήμη μπορεί να χρησιμοποιηθεί με άλλα αντικείμενα
- Deallocating arrays
  ```
  delete [] gradesArray;
  ```
  - Απελευθερώνει το array στο οποίο δείχνει το **gradesArray**
  - Αν είναι δείκτης σε array αντικειμένων
    - Καλείται πρώτα ο destructor για κάθε αντικείμενο του array
    - Μετά απελευθερώνει τη μνήμη

7.7 `static` κλάσεις

- μεταβλητή κλάσης **`static`**
  - Δεδομένα διαθέσιμα σε όλη την κλάση
    - Ιδιότητα της κλάσης, όχι συγκεκριμένου αντικειμένου της κλάσης
  - Αποδοτικό όταν απλά ένα αντίγραφο της κλάσης είναι αρκετό
    - Μόνο η μεταβλητή **`static`** πρέπει να ενημερώνεται
  - Μπορεί να μοιάζει με global, αλλά έχει εμβέλεια στην κλάση
  - Αρχικοποιείται μια μόνο φορά
  - Υπάρχει ακόμη και χωρίς αντικείμενο

7.7 `static` κλάσεις

- Πρόσβαση σε μεταβλητές κλάσης **`static`**
  - Προσβάσιμα μέσω οποιουδήποτε αντικειμένου κλάσης
  - **`public static`** μεταβλητές
    - Μπορούν να προσπελαστούν και μέσω (`::`)

```
Employee::count
```

  - **`private static`** μεταβλητές
    - Όταν δεν υπάρχει αντικείμενο
      - Μπορεί να τα προσπελάσει κανείς μέσω συνάρτησης **`public static`**

7.7 `static` κλάσεις

- **`static`** συναρτήσεις
  - Δε μπορούν να προσπελάσουν non-**`static`** δεδομένα ή συναρτήσεις
  - Δεν υπάρχει **`this`** για τις **`static`** συναρτήσεις
    - **`static`** δεδομένα και συναρτήσεις υπάρχουν ανεξάρτητα από τα αντικείμενα

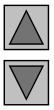
Outline

employee2.h (1 of 2)

```
1  // Fig. 7.17: employee2.h
2  // Employee class definition.
3  #ifndef EMPLOYEE2_H
4  #define EMPLOYEE2_H
5
6  class Employee {
7
8  public:
9     Employee( const char *, const char * );  // constructor
10    ~Employee();                             // destructor
11    const char *getFirstName() const;  // return first name
12    const char *getLastName() const;   // re
13
14    // static member function
15    static int getCount();  // return # obje
16
17 private:
18    char *firstName;
19    char *lastName;
20
21    // static data member
22    static int count;  // number of objects instantiated
23
24 }; // end class Employee
25
```

`static` member function can only access **`static`** data members and member functions.

`static` data member is class-wide data.



Outline

employee2.h (2 of 2)

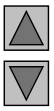
employee2.cpp (1 of 3)

```
26 #endif
```

```
1  // Fig. 7.18: employee2.cpp
2  // Member-function definitions for class Employee.
3  #include <iostream>
4
5  using std::cout;
6  using std::endl;
7
8  #include <new>          // C++ standard new operator
9  #include <cstring>      // strcpy and strlen prototypes
10
11 #include "employee2.h"  // Employee class
12
13 // define and initialize static data membe
14 int Employee::count = 0;
15
16 // define static member function that retu
17 // Employee objects instantiated
18 int Employee::getCount()
19 {
20    return count;
21
22 } // end static function getCount
```

Initialize **static** data member exactly once at file scope.

static member function accesses **static** data member **count**.



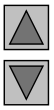
Outline

employee2.cpp

```
23
24 // constructor dynamically allocates space for
25 // first and last name and uses strcpy to copy
26 // first and last names into the object
27 Employee::Employee( const char *first, const char *l
28 {
29    firstName = new char[ strlen( first ) + 1 ];
30    strcpy( firstName, first );
31
32    lastName = new char[ strl
33    strcpy( lastName, last );
34
35    ++count; // increment static count of employees
36
37    cout << "Employee constructor for " << firstName
38         << ' ' << lastName << " called." << endl;
39
40 } // end Employee constructor
41
42 // destructor deallocates dynamically allocated memory
43 Employee::~Employee()
44 {
45    cout << "~Employee() called for " << firstName
46         << ' ' << lastName << endl;
47
```

new operator dynamically allocates space.

Use **static** data member to store total **count** of employees.



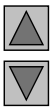
Outline

employee2.cpp (3 of 3)

```
48    delete [] firstName;  // recapture memory
49    delete [] lastName;   // recapture memory
50
51    --count; // decrement static count of employees
52
53 } // end destructor ~Empl
54
55 // return first name of e
56 const char *Employee::getFirstName() const
57 {
58    // const before return type prevents client from modifying
59    // private data; client should copy returned string before
60    // destructor deletes storage to prevent undefined pointer
61    return firstName;
62
63 } // end function getFirstName
64
65 // return last name of employee
66 const char *Employee::getLastName() const
67 {
68    // const before return type prevents client from modifying
69    // private data; client should copy returned string before
70    // destructor deletes storage to prevent undefined pointer
71    return lastName;
72
73 } // end function getLastName
```

allocates

Use **static** data member to store total **count** of employees.



Outline

fig07_19.cpp (1 of 2)

```
1  // Fig. 7.19: fig07_19.cpp
2  // Driver to test class Employee.
3  #include <iostream>
4
5  using std::cout;
6  using std::endl;
7
8  #include <new>          // C++ standard new operator
9
10 #include "employee2.h"  // Employee class definition
11
12 int main()
13 {
14    cout << "Number of employees before instantiation is "
15         << Employee::getCount() << endl;   // use class name
16
17    Employee *e1Ptr = new Employee( "
18    Employee *e2Ptr = new Employee( "
19
20    cout << "Number of employees afte
21         << e1Ptr->getCount();
22
```

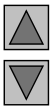
new operator dynamically allocates space.

static member function can be invoked on any object of class.

```
23    cout << "\n\nEmployee 1: "
24         << e1Ptr->getFirstName()
25         << " " << e1Ptr->getLastName()
26         << "\nEmployee 2: "
27         << e2Ptr->getFirstName()
28         << " " << e2Ptr->getLastName() << "\n\n";
29
30    delete e1Ptr;  // recapture memory
31    e1Ptr = 0;     // disconnect pointer from free-store space
32    delete e2Ptr;  // recapture memory
33    e2Ptr = 0;     // disconnect pointer fr
34
35    cout << "Number of employees af
36         << Employee::getCount() <<
37
38    return 0;
39
40 } // end main
```

Operato
memory

`static` member function invoked using binary scope resolution operator (no existing class objects).



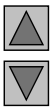
Outline

fig07_19.cpp (2 of 2)


```
Number of employees before instantiation is 0
Employee constructor for Susan Baker called.
Employee constructor for Robert Jones called.
Number of employees after instantiation is 2

Employee 1: Susan Baker
Employee 2: Robert Jones

~Employee() called for Susan Baker
~Employee() called for Robert Jones
Number of employees after deletion is 0
```



Outline

fig07_19.cpp output (1 of 1)

17.9 Class `unique_ptr` and Dynamic Memory Allocation

- A common programming practice is to *allocate* dynamic memory, assign the address of that memory to a pointer, use the pointer to manipulate the memory and *deallocate* the memory with `delete` when the memory is no longer needed.
- If an exception occurs after successful memory allocation but *before* the `delete` statement executes, a *memory leak* could occur.
- C++ 11 provides class template `unique_ptr` in header file `<memory>` to deal with this situation.

17.9 Class `unique_ptr` and Dynamic Memory Allocation (cont.)

- An object of class `unique_ptr` maintains a pointer to dynamically allocated memory.
- When an `unique_ptr` object destructor is called (for example, when an `unique_ptr` object goes out of scope), it performs a `delete` operation on its pointer data member.
- Class template `unique_ptr` provides overloaded operators `*` and `->` so that an `unique_ptr` object can be used just as a regular pointer variable is.
- Figure 17.9 demonstrates an `unique_ptr` object that points to a dynamically allocated object of class `Integer` (Figs. 17.7–17.8).

```
1  // Fig. 17.7: Integer.h
2  // Integer class definition.
3
4  class Integer
5  {
6  public:
7     Integer( int i = 0 ); // Integer default constructor
8     ~Integer(); // Integer destructor
9     void setInteger( int i ); // set Integer value
10    int getInteger() const; // return Integer value
11 private:
12    int value;
13 }; // end class Integer
```

Fig. 17.7 | `Integer` class definition.

```
1  // Fig. 17.8: Integer.cpp
2  // Integer member function definitions.
3  #include <iostream>
4  #include "Integer.h"
5  using namespace std;
6
7  // Integer default constructor
8  Integer::Integer( int i )
9     : value( i )
10 {
11    cout << "Constructor for Integer " << value << endl;
12 } // end Integer constructor
13
14 // Integer destructor
15 Integer::~Integer()
16 {
17    cout << "Destructor for Integer " << value << endl;
18 } // end Integer destructor
19
20 // set Integer value
21 void Integer::setInteger( int i )
22 {
23    value = i;
24 } // end function setInteger
```

Fig. 17.8 | Member function definitions of class `Integer`. (Part 1 of 2.)

```
25
26 // return Integer value
27 int Integer::getInteger() const
28 {
29    return value;
30 } // end function getInteger
```

Fig. 17.8 | Member function definitions of class `Integer`. (Part 2 of 2.)

```
1  // Fig. 17.9: fig17_09.cpp
2  // Demonstrating unique_ptr.
3  #include <iostream>
4  #include <memory>
5  using namespace std;
6
7  #include "Integer.h"
8
9  // use unique_ptr to manipulate Integer object
10 int main()
11 {
12    cout << "Creating a unique_ptr object that points to an Integer\n";
13
14    // "aim" unique_ptr at Integer object
15    unique_ptr< Integer > ptrToInteger( new Integer( 7 ) );
16
17    cout << "\nUsing the unique_ptr to manipulate the Integer\n";
18    ptrToInteger->setInteger( 99 ); // use unique_ptr to set Integer value
19
20    // use unique_ptr to get Integer value
21    cout << "Integer after setInteger: " << ( *ptrToInteger ).getInteger()
22       << "\n\nTerminating program" << endl;
23 } // end main
```

Fig. 17.9 | `unique_ptr` object manages dynamically allocated memory. (Part 1 of 2.)

```
Creating a unique_ptr object that points to an Integer
Constructor for Integer 7

Using the unique_ptr to manipulate the Integer
Integer after setInteger: 99

Terminating program
Destructor for Integer 99
```

Fig. 17.9 | `unique_ptr` object manages dynamically allocated memory. (Part 2 of 2.)

17.9 Class `unique_ptr` and Dynamic Memory Allocation (cont.)

- Because `ptrToInteger` is a local automatic variable in `main`, `ptrToInteger` is destroyed when `main` terminates.
- The `unique_ptr` destructor forces a `delete` of the `Integer` object pointed to by `ptrToInteger`, which in turn calls the `Integer` class destructor.
- The memory that `Integer` occupies is released, regardless of how control leaves the block (e.g., by a `return` statement or by an exception).
- Most importantly, using this technique can *prevent memory leaks*.

17.9 Class `unique_ptr` and Dynamic Memory Allocation (cont.)

`unique_ptr` Notes

- The class is called `unique_ptr` because only one `unique_ptr` at a time can own a dynamically allocated object.
- By using its overloaded assignment operator or copy constructor, an `unique_ptr` can *transfer ownership* of the dynamic memory it manages.

17.9 Class `unique_ptr` and Dynamic Memory Allocation (cont.)

- The *last* `unique_ptr` object that maintains the pointer to the dynamic memory will delete the memory.
- This makes `unique_ptr` an ideal mechanism for returning dynamically allocated memory to client code.
- When the `unique_ptr` goes out of scope in the client code, the `unique_ptr`'s destructor destroys the dynamically allocated object and deletes its memory.

17.9 Class unique_ptr and Dynamic Memory Allocation (cont.)

unique_ptr to a Built-In Array

- You can also use a `unique_ptr` to manage a dynamically allocated built-in array.
- For example, consider the statement

```
unique_ptr< string[] > ptr( new string[ 10 ] );
```

- which dynamically allocates an array of 10 strings managed by `ptr`.
- The type `string[]` indicates that the managed memory is a built-in array containing `string`s.

17.9 Class unique_ptr and Dynamic Memory Allocation (cont.)

- When a `unique_ptr` that manages an array goes out of scope it deletes the memory with `delete []` so that every element of the array receives a destructor call.
- A `unique_ptr` that manages an array provides an `overloaded []` operator for accessing the array's elements.
- For example, the statement

```
ptr[ 2 ] = "hello";
```

- assigns `"hello"` to the `string` at `ptr[2]` and the statement

```
cout << ptr[ 2 ] << endl;
```

- displays that `string`.