C++ is Fun – Part Four

at Turbine/Warner Bros.!

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Brief Overview

- We will do some lab examples using simple classes with private data and access functions like get() and set().
- Opening and reading Excel files and using/installing external libraries/API's
- Introduction to typedef, struct, and enum
- Some first gameplay classes

Typdef, struct, and enum

3 Ways to declare struct student:

1.
```
struct student {
char id_num[5];
char name[10];
char gender;
int age;
} studno_1, studno_2;
```

Here, struct is a **keyword** that tells the compiler that a *structure template* is being declared and student is a tag that identifies its data structure. Tag is not a variable; it is a label for the structure's template. Note that there is a semicolon after the closing curly brace

2.
```
struct {  // no tag
char id_num[5];
char name[10];
char gender;
int age;
} studno_1, studno_2;
```

3.
```
struct student{
char id_num[5];
char name[10];
char gender;
int age;
};
```

In the program declare as:
struct student studno_1, studno_2;

In (2) there is no structure tag, this means we cannot declare structure variables of this type elsewhere in the program instead we have to use the structure variables studno_1 and studno_2 directly.

- The **structure pointer operator** (→), consisting of a minus (−) sign and a greater than (>) sign with no intervening spaces, accesses a structure member via a **pointer to the structure**.

```
// The packet length
#define PCKT_LEN 8192

// Can create separate header file (.h) for all headers' structure
// The IP header's structure
struct ipheader {
 unsigned char      iph_ihl:5, iph_ver:4;
 unsigned char      iph_tos;
 unsigned short int iph_len;
 unsigned short int iph_ident;
 unsigned char      iph_flag;
 unsigned short int iph_offset;
 unsigned char      iph_ttl;
 unsigned char      iph_protocol;
 unsigned short int iph_chksum;
 unsigned int       iph_sourceip;
 unsigned int       iph_destip;
};

// UDP header's structure
struct udpheader {
 unsigned short int udph_srcport;
 unsigned short int udph_destport;
 unsigned short int udph_len;
 unsigned short int udph_chksum;
};
// total udp header length: 8 bytes
```

Initialize struct

Use the (->) structure pointer operator

```
// Our own headers' structures
struct ipheader *ip = (struct ipheader *) buffer;
struct udpheader *udp = (struct udpheader *) (buffer + sizeof(struct ipheader));
```

```
// Fabricate the IP header or we can use the
// standard header structures but assign our own values.
ip->iph_ihl = 5;
ip->iph_ver = 4;
ip->iph_tos = 16; // Low delay
ip->iph_len = sizeof(struct ipheader) + sizeof(struct udph
ip->iph_ident = htons(54321);
ip->iph_ttl = 64; // hops
ip->iph_protocol = 17; // UDP
// Source IP address, can use spoofed address here!!!
ip->iph_sourceip = inet_addr(argv[1]);
// The destination IP address
ip->iph_destip = inet_addr(argv[3]);

// Fabricate the UDP header. Source port number, redundant
udp->udph_srcport = htons(atoi(argv[2]));
// Destination port number
udp->udph_destport = htons(atoi(argv[4]));
udp->udph_len = htons(sizeof(struct udpheader));
```

In class example! Typing is good for character(s)

```
//accessing structure element
#include <iostream.h>
#include <stdlib.h>
struct Card
{
  char *face; //pointer to char type
  char *suit; //pointer to char type
};
int main()
{
  //declare the struct type variables
  struct Card p;
  struct Card *SPtr;
  p.face = "Ace";
  p.suit = "Spades";
  SPtr = &p;
  cout<<"Accessing structure element:\n";
  cout<<"\n\'SPtr->suit\' = "<<SPtr->suit<<endl;
  cout<<"\'SPtr->face\' = "<<SPtr->face<<endl;

  // cout<<"\n\'SPtr->suit\' = "<<p->suit<<endl; // ERROR
  // cout<<"\'SPtr->face\' = "<<p->face<<endl;   // ERROR

  // structtest.cpp:23: error: base operand of '->' has non-pointer type 'Card'
  // structtest.cpp:24: error: base operand of '->' has non-pointer type 'Card'
}

// Running the program:
// ./structtest
// Accessing structure element:

// 'SPtr->suit' = Spades
// 'SPtr->face' = Ace
```

```
typedef type-declaration the_synonym;
```

You cannot use the `typedef` specifier inside a function definition.
When declaring a local-scope identifier by the same name as a `typedef`, or when declaring a member of a structure or `union` in the same scope or in an inner scope, the type specifier must be specified.
For example:

```
typedef float TestType;

int main()
{
}

//function scope...
int MyFunct(int)
{
  //same name with typedef, it is OK
  int TestType;
}
```

Names for structure types are often defined with `typedef` to create **shorter** and **simpler** type name. For example, the following statements:

```
typedef  struct Card Card;
typedef unsigned short USHORT;
```

Defines the new type name `Card` as a synonym for type `struct Card` and `USHORT` as a synonym for type `unsigned short`. Programmers usually use `typedef` to define a structure type so a structure tag is not required. For example, the following definition:

```
typedef struct{
      char  *face;
      char  *suit;
} Card;
```

Creates the structure type `Card` without the need for a separate `typedef` statement. Then `Card` can now be used to declare variables of type `struct Card`. For example, the following declaration:

```
Card  deck[50];
```

Declares an array of `50 Card` structures. `typedef` simply creates a **new type name** which may be used as an alias for an existing type name.

```c
//typedef specifier
#include <stdio.h>

typedef struct mystructtag
{
   int    x;
   double y;
   char* z;
} mystruct;

int main()
{
   mystruct Test1, *Test2;
   Test1.x = 111;
   Test1.y = 1.111;
   printf("Test1.x = %d\nTest1.y = %f\n", Test1.x, Test1.y);

   Test1.z = "This is a string";
   Test2 = &Test1;
   printf("Test1->z = %s\n", Test2->z);
   return 0;
}
```

```
$ ./structexample
Test1.x = 111
Test1.y = 1.111000
Test1->z = This is a string
```

In class typedef example! Typing is good for character(s)

```
//accessing structure element
#include <iostream.h>
#include <stdlib.h>
typedef struct Card
{
  char *face; //pointer to char type
  char *suit; //pointer to char type
};
int main()
{
  //declare the struct type variables
  Card p;
  Card *SPtr;
  p.face = "Ace";
  p.suit = "Spades";
  SPtr = &p;
  cout<<"Accessing structure element:\n";
  cout<<"\n\'SPtr->suit\' = "<<SPtr->suit<<endl;
  cout<<"\'SPtr->face\' = "<<SPtr->face<<endl;

  // cout<<"\n\'SPtr->suit\' = "<<p->suit<<endl; // ERROR
  // cout<<"\'SPtr->face\' = "<<p->face<<endl;   // ERROR

  // structtest.cpp:23: error: base operand of '->' has non-pointer type 'Card'
  // structtest.cpp:24: error: base operand of '->' has non-pointer type 'Card'

}

// Running the program:
// ./structtest
// Accessing structure element:

// 'SPtr->suit' = Spades
// 'SPtr->face' = Ace
```

Arrays of Structures

For example, to store and manipulate the information contained in 100 student records, we use the following statement:

```
struct student{
      char id[5];
      char name[80];
      char gender; int age;
      }stud[100];
```

Or something like the following statements:

```
struct student{
      char id[5];
      char name[80];
      char gender;
      };
struct student stud[100];
```

These statements declare 100 variables of type `student` (a structure). As in arrays, we can use a subscript to reference a particular student structure or record.
For example, to print the name of the seventh student, we could write the following statement:

```
cout<<stud[6].name;
```

`enum` - Enumeration Constants

- This is another user-defined type consisting of a set of named constants called enumerators.
- Using a keyword `enum`, it is a set of **integer constants** represented by identifiers.
- The syntax is shown below:

```
//for definition of enumerated type
enum [tag]
{
      enum-list
}
[declarator];
```

- And

```
//for declaration of variable of type tag
enum tag declarator;
```

- These enumeration constants are, in effect, **symbolic constants** whose values can be set automatically. The values in an `enum` start with `0`, unless specified otherwise, and are incremented by `1`. For example, the following enumeration:

```
      enum days {Mon, Tue, Wed, Thu, Fri, Sat, Sun};
```

- Creates a new data type, `enum days`, in which the identifiers are set automatically to the integers `0` to `6`. To number the `days` 1 to 7, use the following enumeration:

```
      enum days {Mon = 1, Tue, Wed, Thu, Fri, Sat, Sun};
```

```
int rollDice(); // rolls dice, calculates and displays sum

int main()
{
   // enumeration with constants that represent the game status
   enum Status { CONTINUE, WON, LOST }; // all caps in constants

   int myPoint; // point if no win or loss on first roll
   Status gameStatus; // can contain CONTINUE, WON or LOST

   // randomize random number generator using current time
   srand( time( 0 ) );

   int sumOfDice = rollDice(); // first roll of the dice
```

(...)

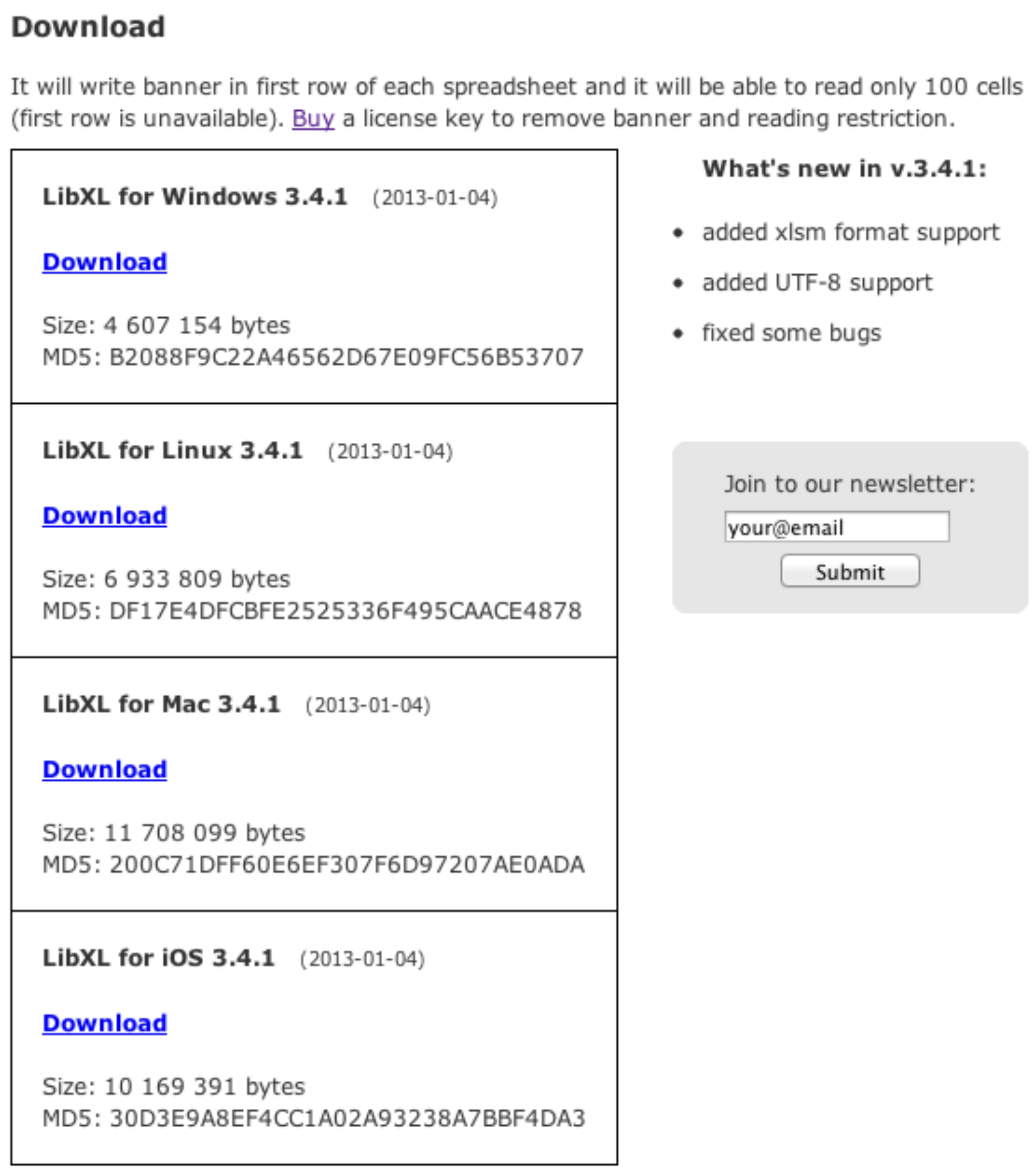
```
switch ( sumOfDice )
{
   case 7: // win with 7 on first roll
   case 11: // win with 11 on first roll
      gameStatus = WON;
      break;
   case 2: // lose with 2 on first roll
   case 3: // lose with 3 on first roll
   case 12: // lose with 12 on first roll
      gameStatus = LOST;
      break;
   default: // did not win or lose, so remember point
      gameStatus = CONTINUE; // game is not over
      myPoint = sumOfDice; // remember the point
      cout << "Point is " << myPoint << endl;
      break; // optional at end of switch
```

How to download an API off the internet and use it! ☺

- API's or "Application Programming Interfaces" are tools programmers use to add functionality to their programs and essentially these contain 1) header files (.h) and 2) library files (.dll or .lib)
- Examples include: physics engines, GUI libraries, game engines, Excel file reading engines, etc. … you name it.

Using the Excel Library "libxl"

http://www.libxl.com/download.html



Download

It will write banner in first row of each spreadsheet and it will be able to read only 100 cells (first row is unavailable). Buy a license key to remove banner and reading restriction.

LibXL for Windows 3.4.1 (2013-01-04)

Download

Size: 4 607 154 bytes
MD5: B2088F9C22A46562D67E09FC56B53707

LibXL for Linux 3.4.1 (2013-01-04)

Download

Size: 6 933 809 bytes
MD5: DF17E4DFCBFE2525336F495CAACE4878

LibXL for Mac 3.4.1 (2013-01-04)

Download

Size: 11 708 099 bytes
MD5: 200C71DFF60E6EF307F6D97207AE0ADA

LibXL for iOS 3.4.1 (2013-01-04)

Download

Size: 10 169 391 bytes
MD5: 30D3E9A8EF4CC1A02A93238A7BBF4DA3

What's new in v.3.4.1:

- added xlsm format support
- added UTF-8 support
- fixed some bugs

Join to our newsletter:

Using the Excel Library "libxl"

LibXL is a library for direct reading and writing Excel files.

Package contents:

bin	32-bit dynamic library
bin64	64-bit dynamic library
doc	C++ documentation
examples	C, C++, C#, Delphi and Fortran examples (MinGW, Visual Studio, Qt, Code::Blocks)
include_c	headers for C
include_cpp	headers for C++
lib	32-bit import library for Microsoft Visual C++
lib64	64-bit import library for Microsoft Visual C++
net	.NET wrapper (assembly)
changelog.txt	change log
libxl.url	link to home page
license.txt	end-user license agreement
readme.txt	this file

Using the Excel Library “libxl”

Using library:

1. Microsoft Visual C++

- add include directory in your project, for example: c:\libxl\include_cpp

  Project -> Properties -> C/C++ -> General -> Additional Include Directories

- add library directory in your project, for example: c:\libxl\lib

  Project -> Properties -> Linker -> General -> Additional Library Directories

- add libxl.lib in project dependencies:

  Project -> Properties -> Linker -> Input -> Additional Dependencies

- copy bin\libxl.dll to directory of your project

Using the Excel Library "libxl"

```
#include <iostream>
#include <conio.h>
#include "libxl.h"

using namespace libxl;

int main()
{
   Book* book = xlCreateBook();
   if(book)

if(book->load(L"..\\generate\\example.xls"))
      {
         Sheet* sheet = book->getSheet(0);
         if(sheet)
         {
            const wchar_t* s = sheet->readStr(2, 1);
            if(s) std::wcout << s << std::endl << std::endl;

            std::cout << sheet->readNum(4, 1) << std::endl;
            std::cout << sheet->readNum(5, 1) << std::endl;
            const wchar_t* f = sheet->readFormula(6, 1);
```

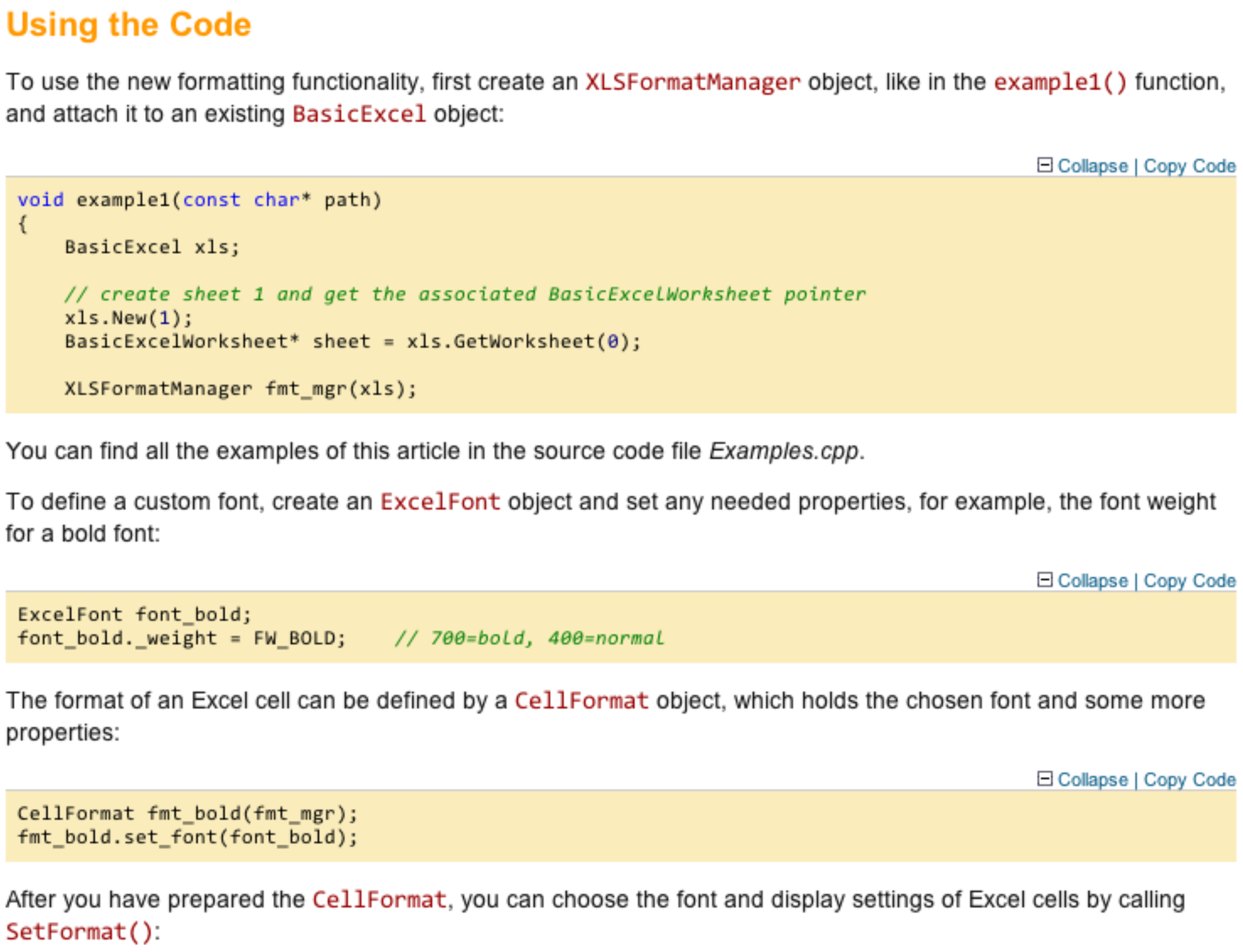
Using the Excel Library “libxl”

```
const wchar_t* f = sheet->readFormula(6, 1);
            if(f) std::wcout << f << std::endl << std::endl;

            int year, month, day;
            book->dateUnpack(sheet->readNum(8, 1), &year, &month, &day);
            std::cout << year << "-" << month << "-" << day << std::endl;
         }
      }
      else
      {
         std::cout << "At first run generate !" << std::endl;
      }

      book->release();
   }

   std::cout << "\nPress any key to exit...";
   _getch();

   return 0;
}
```

LibXL is pay software, ExcelFormat is another FREE option

It will write banner in first row of each spreadsheet and it will be able to read only 100 cells (first row is unavailable). Buy a license key to remove banner and reading restriction. –your friends at LibXL

http://www.codeproject.com/Articles/42504/ExcelFormat-Library



Using the Code

To use the new formatting functionality, first create an `XLSFormatManager` object, like in the `example1()` function, and attach it to an existing `BasicExcel` object:

⊟ Collapse | Copy Code

```
void example1(const char* path)
{
    BasicExcel xls;

    // create sheet 1 and get the associated BasicExcelWorksheet pointer
    xls.New(1);
    BasicExcelWorksheet* sheet = xls.GetWorksheet(0);

    XLSFormatManager fmt_mgr(xls);
```

You can find all the examples of this article in the source code file *Examples.cpp*.

To define a custom font, create an `ExcelFont` object and set any needed properties, for example, the font weight for a bold font:

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```
ExcelFont font_bold;
font_bold._weight = FW_BOLD;    // 700=bold, 400=normal
```

The format of an Excel cell can be defined by a `CellFormat` object, which holds the chosen font and some more properties:

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```
CellFormat fmt_bold(fmt_mgr);
fmt_bold.set_font(font_bold);
```

After you have prepared the `CellFormat`, you can choose the font and display settings of Excel cells by calling `SetFormat()`:

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```
// Create a table containing a header row in bold and four rows below.
int col, row = 0;

for(col=0; col<10; ++col) {
    BasicExcelCell* cell = sheet->Cell(row, col);

    cell->Set("TITLE");
    cell->SetFormat(fmt_bold);
}

while(++row < 4) {
    for(int col=0; col<10; ++col)
        sheet->Cell(row, col)->Set("text");
}

++row;
```

Text color is specified by setting color indices in `ExcelFont`, for example:

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```
ExcelFont font_red_bold;
font_red_bold._weight = FW_BOLD;
font_red_bold._color_index = EGA_RED;

CellFormat fmt_red_bold(fmt_mgr, font_red_bold);
fmt_red_bold.set_color1(COLOR1_PAT_SOLID);           // solid background
fmt_red_bold.set_color2(MAKE_COLOR2(EGA_BLUE,0));    // blue background


CellFormat fmt_green(fmt_mgr, ExcelFont().set_color_index(EGA_GREEN));

for(col=0; col<10; ++col) {
    BasicExcelCell* cell = sheet->Cell(row, col);

    cell->Set("xxx");
    cell->SetFormat(fmt_red_bold);

    cell = sheet->Cell(row, ++col);
    cell->Set("yyy");
    cell->SetFormat(fmt_green);
}
```

ExcelFormat.h contains constants to define basic palette colors in the enumeration `EXCEL_COLORS`, you can use in calls to `ExcelFont()::set_color_index()`. The macro `MAKE_COLOR2` accepts two color indices to specify the pattern line and pattern background colors. As a shortcut to calling `CellFormat::set_color1()` and `CellFormat::set_color2()`, you can also use `CellFormat::set_background()` to define cells with solid background colors or colorize patterns.

After creating and formatting the Excel cells in memory, all you have to do is to save the new Excel sheet as a file:

⊟ Collapse | Copy Code

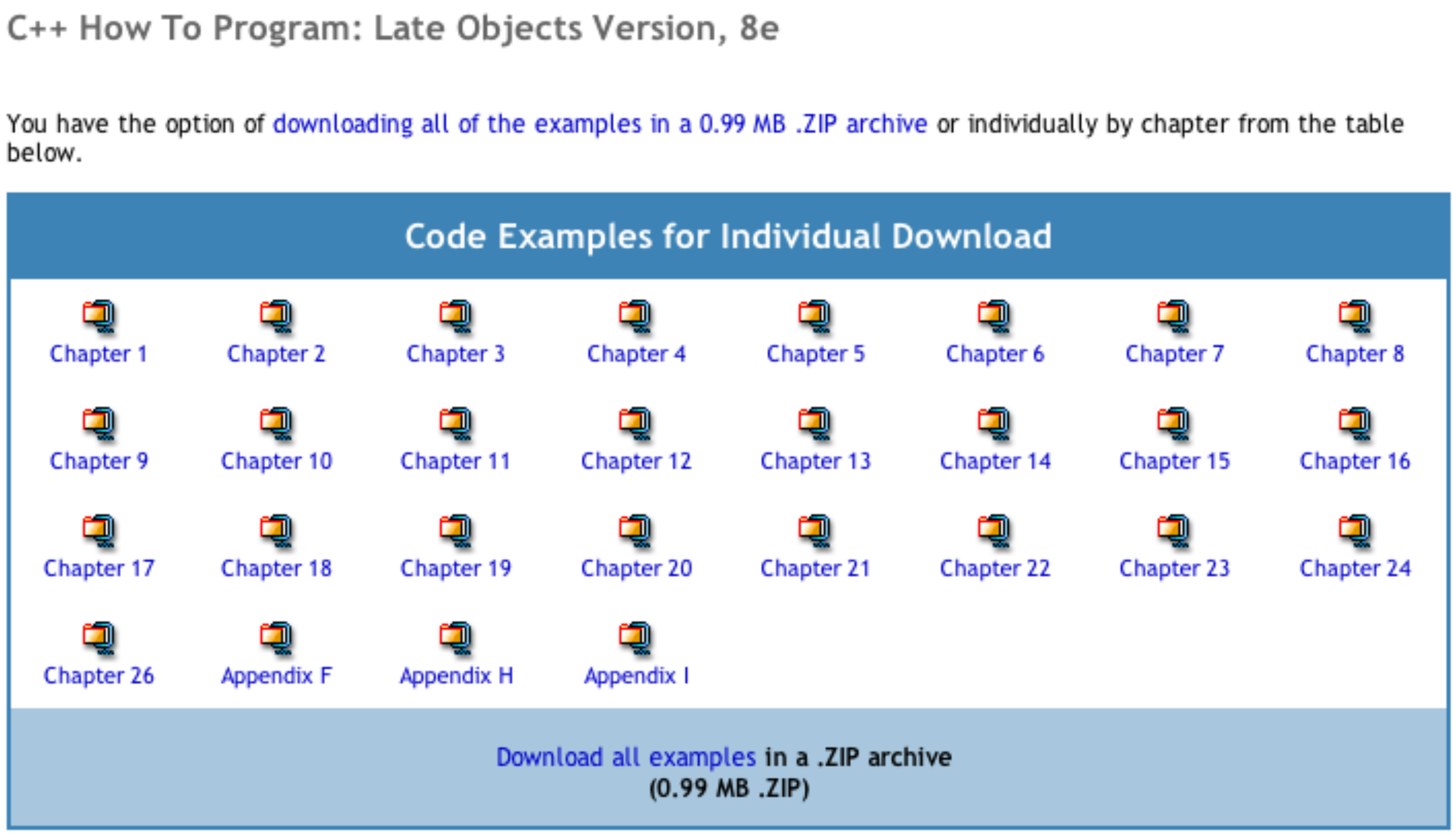
```
    xls.SaveAs(path);
}
```

What these Excel interfaces are actually doing….

```
struct CODE
{
enum {      FORMULA=0x0006,          //Token array and the result of a formula cell.
            YEOF=0x000A,             //End of a record block with leading BOF record.
            CALCCOUNT=0x000C,        //Maximum number of times the forumlas should be iteratively calculated
            CALCMODE=0x000D,         //Calculate formulas manually, automatically, or automatically except for multiple table operations
            PRECISION=0x000E,        //Whether formulas use the real cell values for calculation or the values displayed on the screen.
            REFMODE=0x000F,          //Method used to show cell addresses in formulas.
            DELTA=0x0010,                    //Maximum change of the result to exit an iteration.
            ITERATION=0x0011,        //Whether iterations are allowed while calculating recursive formulas.
            PROTECT=0x0012,          //Whether worksheet or a workbook is protected against modification.
            PASSWORD=0x0013,         //16-bit hash value, calculated from the worksheet or workbook protection password.
            HEADER=0x0014,                   //Page header string for the current worksheet.
            FOOTER=0x0015,                   //Page footer string for the current worksheet.
            EXTERNSHEET=0x0017,  //List with indexes to SUPBOOK records
            NAME=0x0018,                     //Name and token array of an internal defined name.
…
```

You can download the class example programs from here:

http://media.pearsoncmg.com/ph/esm/deitel/cpp_htp_8/code_examples/code_examples.html



C++ How To Program: Late Objects Version, 8e

You have the option of downloading all of the examples in a 0.99 MB .ZIP archive or individually by chapter from the table below.

Code Examples for Individual Download							
Chapter 1	Chapter 2	Chapter 3	Chapter 4	Chapter 5	Chapter 6	Chapter 7	Chapter 8
Chapter 9	Chapter 10	Chapter 11	Chapter 12	Chapter 13	Chapter 14	Chapter 15	Chapter 16
Chapter 17	Chapter 18	Chapter 19	Chapter 20	Chapter 21	Chapter 22	Chapter 23	Chapter 24
Chapter 26	Appendix F	Appendix H	Appendix I				

Download all examples in a .ZIP archive
(0.99 MB .ZIP)

A simple class GradeBook

```cpp

// GradeBook class definition
class GradeBook
{
public:
   // function that displays a welcome message to the GradeBook user
   void displayMessage()
   {
      cout << "Welcome to the Grade Book!" << endl;
   } // end function displayMessage
}; // end class GradeBook

// function main begins program execution
int main()
{
   GradeBook myGradeBook; // create a GradeBook object named myGradeBook
   myGradeBook.displayMessage(); // call object's displayMessage function
} // end main
```

```
Welcome to the Grade Book!
```

Let’s compile & run the program!

```
// Define class GradeBook with a member function displayMessage;
// Create a GradeBook object and call its displayMessage function.
#include <iostream>
using namespace std;

// GradeBook class definition
class GradeBook
{
public:
  // function that displays a welcome message to the GradeBook user
  void displayMessage()
  {
    cout << "Welcome to the Grade Book!" << endl;
  } // end function displayMessage
}; // end class GradeBook

// function main begins program execution
int main()
{
  GradeBook myGradeBook; // create a GradeBook object named
myGradeBook
  myGradeBook.displayMessage(); // call object's displayMessage function

} // end main
```

This is the copy-paste-able source code

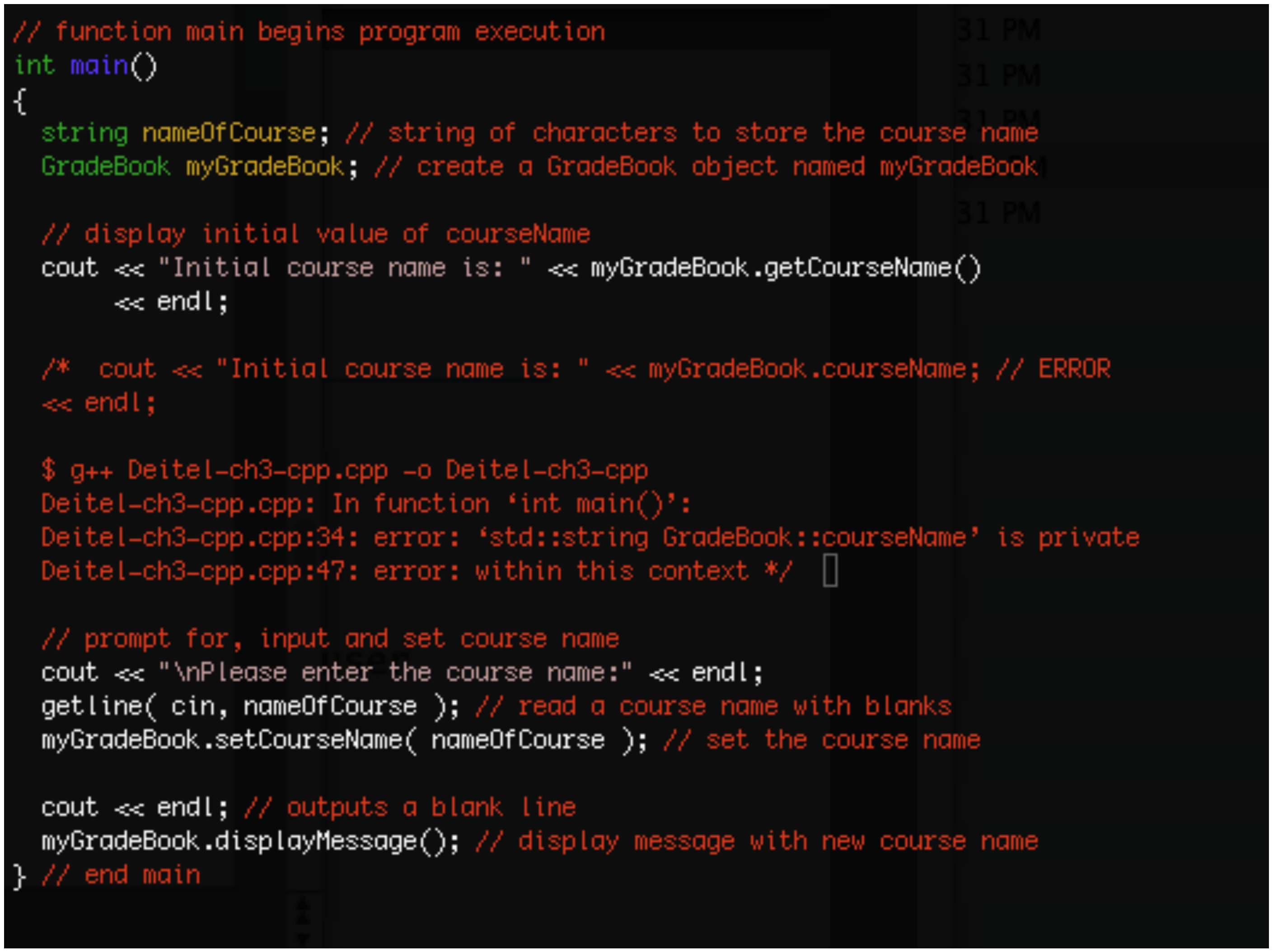
Add set() and get() functions to the class

```
// Define class GradeBook that contains a courseName data member
// and member functions to set and get its value;
// Create and manipulate a GradeBook object with these functions.
#include <iostream>
#include <string> // program uses C++ standard string class
using namespace std;

// GradeBook class definition
class GradeBook
{
public:
   // function that sets the course name
   void setCourseName( string name )
   {
      courseName = name; // store the course name in the object
   } // end function setCourseName

   // function that gets the course name
   string getCourseName()
   {
      return courseName; // return the object's courseName
   } // end function getCourseName

   // function that displays a welcome message
   void displayMessage()
   {
      // this statement calls getCourseName to get the
      // name of the course this GradeBook represents
      cout << "Welcome to the grade book for\n" << getCourseName() << "!"
         << endl;
   } // end function displayMessage
```

```cpp
private:
   string courseName; // course name for this GradeBook
}; // end class GradeBook

// function main begins program execution
int main()
{
   string nameOfCourse; // string of characters to store the course name
   GradeBook myGradeBook; // create a GradeBook object named myGradeBook

   // display initial value of courseName
   cout << "Initial course name is: " << myGradeBook.getCourseName()
      << endl;

   // prompt for, input and set course name
   cout << "\nPlease enter the course name:" << endl;
   getline( cin, nameOfCourse ); // read a course name with blanks
   myGradeBook.setCourseName( nameOfCourse ); // set the course name

   cout << endl; // outputs a blank line
   myGradeBook.displayMessage(); // display message with new course name
} // end main
```

```
Initial course name is:

Please enter the course name:
CS101 Introduction to C++ Programming

Welcome to the grade book for
CS101 Introduction to C++ Programming!
```

Dear class, let's try, and fail, to access a private member of a class (without a get() function)



```
// function main begins program execution
int main()
{
  string nameOfCourse; // string of characters to store the course name
  GradeBook myGradeBook; // create a GradeBook object named myGradeBook

  // display initial value of courseName
  cout << "Initial course name is: " << myGradeBook.getCourseName()
       << endl;

  /*  cout << "Initial course name is: " << myGradeBook.courseName; // ERROR
  << endl;

  $ g++ Deitel-ch3-cpp.cpp -o Deitel-ch3-cpp
  Deitel-ch3-cpp.cpp: In function 'int main()':
  Deitel-ch3-cpp.cpp:34: error: 'std::string GradeBook::courseName' is private
  Deitel-ch3-cpp.cpp:47: error: within this context */

  // prompt for, input and set course name
  cout << "\nPlease enter the course name:" << endl;
  getline( cin, nameOfCourse ); // read a course name with blanks
  myGradeBook.setCourseName( nameOfCourse ); // set the course name

  cout << endl; // outputs a blank line
  myGradeBook.displayMessage(); // display message with new course name
} // end main
```

```
// Define class GradeBook that contains a courseName data member
// and member functions to set and get its value;
// Create and manipulate a GradeBook object.
#include <iostream>
#include <string> // program uses C++ standard string class
using namespace std;

// GradeBook class definition
class GradeBook
{
public:
  // function that sets the course name
  void setCourseName( string name )
  {
    courseName = name; // store the course name in the object
  } // end function setCourseName

  // function that gets the course name
  string getCourseName()
  {
    return courseName; // return the object's courseName
  } // end function getCourseName

  // function that displays a welcome message
  void displayMessage()
  {
    // this statement calls getCourseName to get the
    // name of the course this GradeBook represents
    cout << "Welcome to the grade book for\n" << getCourseName() << "!"
      << endl;
  } // end function displayMessage
private:
  string courseName; // course name for this GradeBook
}; // end class GradeBook
// function main begins program execution
int main(){
  string nameOfCourse; // string of characters to store the course name
  GradeBook myGradeBook; // create a GradeBook object named myGradeBook

  // display initial value of courseName
  cout << "Initial course name is: " << myGradeBook.getCourseName()
    << endl;

  // prompt for, input and set course name
  cout << "\nPlease enter the course name:" << endl;
  getline( cin, nameOfCourse ); // read a course name with blanks
  myGradeBook.setCourseName( nameOfCourse ); // set the course name

  cout << endl; // outputs a blank line
  myGradeBook.displayMessage(); // display message with new course name
} // end main
```

This is the copy-paste-able source code for the class program with get() and set() parameters

However, with a friend function we can access the private members

```
 1  // Fig. 10.13: fig10_13.cpp
 2  // Friends can access private members of a class.
 3  #include <iostream>
 4  using namespace std;
 5
 6  // Count class definition
 7  class Count
 8  {
 9     friend void setX( Count &, int ); // friend declaration
10  public:
11     // constructor
12     Count()
13        : x( 0 ) // initialize x to 0
14     {
15        // empty body
16     } // end constructor Count
17
18     // output x
19     void print() const
20     {
21        cout << x << endl;
22     } // end function print
23  private:
24     int x; // data member
25  }; // end class Count
26
27  // function setX can modify private data of Count
28  // because setX is declared as a friend of Count (line 9)
29  void setX( Count &c, int val )
30  {
31     c.x = val; // allowed because setX is a friend of Count
32  } // end function setX
```

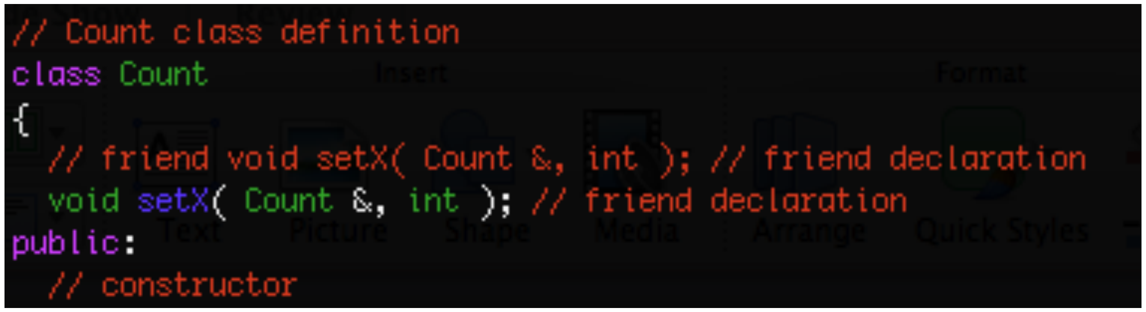
```
34  int main()
35  {
36     Count counter; // create Count object
37
38     cout << "counter.x after instantiation: ";
39     counter.print();
40
41     setX( counter, 8 ); // set x using a friend function
42     cout << "counter.x after call to setX friend function: ";
43     counter.print();
44  } // end main
```

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

```
#include <iostream>
using namespace std;

// Count class definition
class Count
{
   // friend void setX( Count &, int ); // friend declaration
  void setX( Count &, int ); // friend declaration
public:
   // constructor
   Count()
      : x( 0 ) // initialize x to 0
   {
      // empty body
   } // end constructor Count

   // output x
   void print() const
   {
      cout << x << endl;
   } // end function print
private:
   int x; // data member
}; // end class Count

// function setX can modify private data of Count
// because setX is declared as a friend of Count (line 9)
void setX( Count &c, int val )
{
   c.x = val; // allowed because setX is a friend of Count
} // end function setX

int main(){
   Count counter; // create Count object
   cout << "counter.x after instantiation: ";
   counter.print();

   setX( counter, 8 ); // set x using a friend function
   cout << "counter.x after call to setX friend function: ";
   counter.print();
} // end main
```

This is the copy-paste-able source code for using friends to access private parts

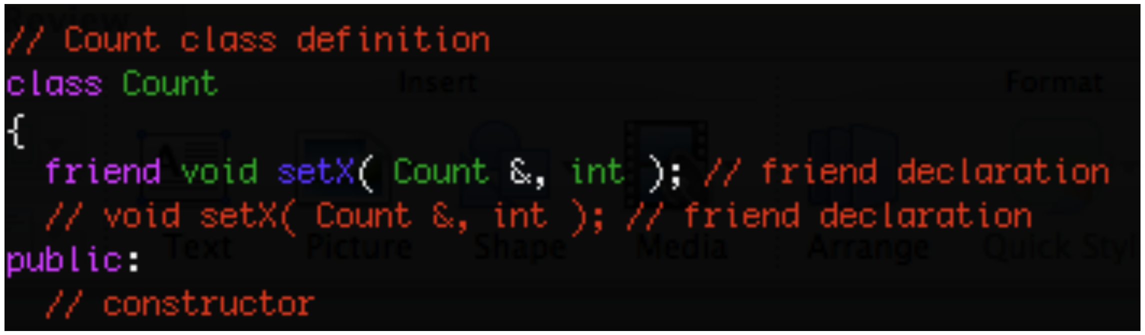
Without *friend* – compiler error



```
// Count class definition
class Count
{
  // friend void setX( Count &, int ); // friend declaration
  void setX( Count &, int ); // friend declaration
public:
  // constructor
```

```
$ g++ friend.cpp -o friendcpp
friend.cpp: In function 'void setX(Count&, int)':
friend.cpp:25: error: 'int Count::x' is private
friend.cpp:32: error: within this context
```

With *friend*



```
// Count class definition
class Count
{
  friend void setX( Count &, int ); // friend declaration
  // void setX( Count &, int ); // friend declaration
public:
  // constructor
```

```
$ g++ friend.cpp -o friendcpp
Russells-MacBook-Pro:TurbineWarnerBros
russell$ ./friendcpp
counter.x after instantiation: 0
counter.x after call to setX friend function: 8
```

Protected base-class data can be accessed from derived classes

`protected` base-class data can be accessed from derived class.

Notes on Using* `protected` *Data

In this example, we declared base-class data members as `protected`, so derived classes can modify the data directly. Inheriting `protected` data members slightly improves performance, because we can directly access the members without incurring the overhead of calls to *set* or *get* member functions.

Member initializer list, separated by commas

```
 8  // constructor uses member initializer list to pass initializer
 9  // values to constructors of member objects
10  Employee::Employee( const string &first, const string &last,
11     const Date &dateOfBirth, const Date &dateOfHire )
12     : firstName( first ), // initialize firstName
13       lastName( last ), // initialize lastName
14       birthDate( dateOfBirth ), // initialize birthDate
15       hireDate( dateOfHire ) // initialize hireDate
16  {
17     // output Employee object to show when constructor is called
18     cout << "Employee object constructor: "
19        << firstName << ' ' << lastName << endl;
20  } // end Employee constructor
```

`Employee` Constructor's Member Initializer List

The colon (`:`) following the constructor's header (Fig. 10.11, line 12) begins the member initializer list. The member initializers specify the `Employee` constructor parameters being passed to the constructors of the `string` and `Date` data members. Parameters `first`, `last`,

`dateOfBirth` and `dateOfHire` are passed to the constructors for objects `firstName`'s (Fig. 10.11, line 12), `lastName` (Fig. 10.11, line 13), `birthDate` (Fig. 10.11, line 14) and `hireDate` (Fig. 10.11, line 15), respectively. Again, member initializers are separated by

Default and copy constructors

```
// default constructor for class Array (default size 10)
Array::Array( int arraySize )
{
   // validate arraySize
   if ( arraySize > 0 )
      size = arraySize;
   else
      throw invalid_argument( "Array size must be greater than 0" );

   ptr = new int[ size ]; // create space for pointer-based array

   for ( int i = 0; i < size; ++i )
      ptr[ i ] = 0; // set pointer-based array element
} // end Array default constructor
```

```
// copy constructor for class Array;
// must receive a reference to prevent infinite recursion
Array::Array( const Array &arrayToCopy )
   : size( arrayToCopy.size )
{
   ptr = new int[ size ]; // create space for pointer-based array

   for ( int i = 0; i < size; ++i )
      ptr[ i ] = arrayToCopy.ptr[ i ]; // copy into object
} // end Array copy constructor

// destructor for class Array
Array::~Array()
{
   delete [] ptr; // release pointer-based array space
} // end destructor
```

A copy constructor is a special constructor in the C++ programming language for creating a new object as a copy of an existing object. The first argument of such a constructor is a reference to an object of the same type as is being constructed (const or non-const), which might be followed by parameters of any type (all having default values).

Normally the compiler automatically creates a copy constructor for each class (known as a default copy constructor) but for special cases the programmer creates the copy constructor, known as a user-defined copy constructor. In such cases, the compiler does not create one. Hence, there is always one copy constructor that is either defined by the user or by the system.

Let’s do an example with a constructor and destructor, these are quite common

```cpp
// CreateAndDestroy class definition.
// Member functions defined in CreateAndDestroy.cpp.
#include <string>
using namespace std;

#ifndef CREATE_H
#define CREATE_H

class CreateAndDestroy
{
public:
   CreateAndDestroy( int, string ); // constructor
   ~CreateAndDestroy(); // destructor
private:
   int objectID; // ID number for object
   string message; // message describing object
}; // end class CreateAndDestroy

#endif
```

```cpp
// CreateAndDestroy class member-function definitions.
#include <iostream>
#include "CreateAndDestroy.h"// include CreateAndDestroy class definition
using namespace std;

// constructor
CreateAndDestroy::CreateAndDestroy( int ID, string messageString )
{
   objectID = ID; // set object's ID number
   message = messageString; // set object's descriptive message

   cout << "Object " << objectID << "   constructor runs   "
      << message << endl;
} // end CreateAndDestroy constructor

// destructor
CreateAndDestroy::~CreateAndDestroy()
{
   // output newline for certain objects; helps readability
   cout << ( objectID == 1 || objectID == 6 ? "\n" : "" );

   cout << "Object " << objectID << "   destructor runs    "
      << message << endl;
} // end ~CreateAndDestroy destructor
```

```cpp
// Demonstrating the order in which constructors and
// destructors are called.
#include <iostream>
#include "CreateAndDestroy.h" // include CreateAndDestroy class definition
using namespace std;

void create( void ); // prototype

CreateAndDestroy first( 1, "(global before main)" ); // global object

int main()
{
   cout << "\nMAIN FUNCTION: EXECUTION BEGINS" << endl;
   CreateAndDestroy second( 2, "(local automatic in main)" );
   static CreateAndDestroy third( 3, "(local static in main)" );

   create(); // call function to create objects

   cout << "\nMAIN FUNCTION: EXECUTION RESUMES" << endl;
   CreateAndDestroy fourth( 4, "(local automatic in main)" );
   cout << "\nMAIN FUNCTION: EXECUTION ENDS" << endl;
} // end main

// function to create objects
void create( void )
{
   cout << "\nCREATE FUNCTION: EXECUTION BEGINS" << endl;
   CreateAndDestroy fifth( 5, "(local automatic in create)" );
   static CreateAndDestroy sixth( 6, "(local static in create)" );
   CreateAndDestroy seventh( 7, "(local automatic in create)" );
   cout << "\nCREATE FUNCTION: EXECUTION ENDS" << endl;
} // end function create
```

```
Object 1   constructor runs   (global before main)

MAIN FUNCTION: EXECUTION BEGINS
Object 2   constructor runs   (local automatic in main)
Object 3   constructor runs   (local static in main)

CREATE FUNCTION: EXECUTION BEGINS
Object 5   constructor runs   (local automatic in create)
Object 6   constructor runs   (local static in create)
Object 7   constructor runs   (local automatic in create)

CREATE FUNCTION: EXECUTION ENDS
Object 7   destructor runs    (local automatic in create)
Object 5   destructor runs    (local automatic in create)

MAIN FUNCTION: EXECUTION RESUMES
Object 4   constructor runs   (local automatic in main)

MAIN FUNCTION: EXECUTION ENDS
Object 4   destructor runs    (local automatic in main)
Object 2   destructor runs    (local automatic in main)

Object 6   destructor runs    (local static in create)
Object 3   destructor runs    (local static in main)

Object 1   destructor runs    (global before main)
```

This is the copy-paste-able source code

```
// CreateAndDestroy class definition.
// Member functions defined in CreateAndDestroy.cpp.
#include <string>
using namespace std;

#ifndef CREATE_H
#define CREATE_H

class CreateAndDestroy
{
public:
   CreateAndDestroy( int, string ); // constructor
   ~CreateAndDestroy(); // destructor
private:
   int objectID; // ID number for object
   string message; // message describing object
}; // end class CreateAndDestroy

#endif
```

```
// CreateAndDestroy class member-function definitions.
#include <iostream>
#include "CreateAndDestroy.h" // include CreateAndDestroy class definition
using namespace std;

// constructor
CreateAndDestroy::CreateAndDestroy( int ID, string messageString )
{
   objectID = ID; // set object's ID number
   message = messageString; // set object's descriptive message

   cout << "Object " << objectID << "   constructor runs   "
      << message << endl;
} // end CreateAndDestroy constructor

// destructor
CreateAndDestroy::~CreateAndDestroy()
{
   // output newline for certain objects; helps readability
   cout << ( objectID == 1 || objectID == 6 ? "\n" : "" );

   cout << "Object " << objectID << "   destructor runs    "
      << message << endl;
} // end ~CreateAndDestroy destructor
```

```
// Demonstrating the order in which constructors and
// destructors are called.
#include <iostream>
#include "CreateAndDestroy.h" // include CreateAndDestroy class definition
using namespace std;

void create( void ); // prototype

CreateAndDestroy first( 1, "(global before main)" ); // global object

int main()
{
   cout << "\nMAIN FUNCTION: EXECUTION BEGINS" << endl;
   CreateAndDestroy second( 2, "(local automatic in main)" );
   static CreateAndDestroy third( 3, "(local static in main)" );

   create(); // call function to create objects

   cout << "\nMAIN FUNCTION: EXECUTION RESUMES" << endl;
   CreateAndDestroy fourth( 4, "(local automatic in main)" );
   cout << "\nMAIN FUNCTION: EXECUTION ENDS" << endl;
} // end main

// function to create objects
void create( void )
{
   cout << "\nCREATE FUNCTION: EXECUTION BEGINS" << endl;
   CreateAndDestroy fifth( 5, "(local automatic in create)" );
   static CreateAndDestroy sixth( 6, "(local static in create)" );
   CreateAndDestroy seventh( 7, "(local automatic in create)" );
   cout << "\nCREATE FUNCTION: EXECUTION ENDS" << endl;
} // end function create
```

Definition for a complex number class with real and imaginary parts

```cpp
// Complex class definition.
#ifndef COMPLEX_H
#define COMPLEX_H

class Complex
{
public:
   Complex( double = 0.0, double = 0.0 ); // constructor
   Complex operator+( const Complex & ) const; // addition
   Complex operator-( const Complex & ) const; // subtraction
   void print() const; // output
private:
   double real; // real part
   double imaginary; // imaginary part
}; // end class Complex

#endif
```

```cpp
// Complex class member-function definitions.
#include <iostream>
#include "Complex.h" // Complex class definition
using namespace std;

// Constructor
Complex::Complex( double realPart, double imaginaryPart )
   : real( realPart ),
   imaginary( imaginaryPart )
{
   // empty body
} // end Complex constructor

// addition operator
Complex Complex::operator+( const Complex &operand2 ) const
{
   return Complex( real + operand2.real,
      imaginary + operand2.imaginary );
} // end function operator+

// subtraction operator
Complex Complex::operator-( const Complex &operand2 ) const
{
   return Complex( real - operand2.real,
      imaginary - operand2.imaginary );
} // end function operator-

```

To randomize without having to enter a seed each time, we may use a statement like

```
    srand( time( 0 ) );
```

This causes the computer to read its clock to obtain the value for the seed. Function **`time`** (with the argument `0` as written in the preceding statement) typically returns the current time as the number of seconds since January 1, 1970, at midnight Greenwich Mean Time (GMT). This value is converted to an `unsigned` integer and used as the seed to the random number generator. The function prototype for `time` is in `<ctime>`.

Generalized Scaling and Shifting of Random Numbers

Previously, we simulated the rolling of a six-sided die with the statement

```
    face = 1 + rand() % 6;
```

which always assigns an integer (at random) to variable `face` in the range 1 ≤`face` ≤6. The width of this range (i.e., the number of consecutive integers in the range) is 6 and the starting number in the range is 1. Referring to the preceding statement, we see that the width of the range is determined by the number used to scale `rand` with the modulus operator (i.e., 6), and the starting number of the range is equal to the number (i.e., 1) that is added to the expression `rand % 6`. We can generalize this result as

```
    number = shiftingValue + rand() % scalingFactor;
```

where ***shiftingValue*** is equal to the first number in the desired range of consecutive integers and ***scalingFactor*** is equal to the width of the desired range of consecutive integers.

A simple die-rolling program

```cpp
// Randomizing the die-rolling program.
#include <iostream>
#include <iomanip>
#include <cstdlib> // contains prototypes for functions srand and rand
using namespace std;

int main()
{
   unsigned seed; // stores the seed entered by the user

   cout << "Enter seed: ";
   cin >> seed;
   srand( seed ); // seed random number generator

   // loop 10 times
   for ( int counter = 1; counter <= 10; ++counter )
   {
      // pick random number from 1 to 6 and output it
      cout << setw( 10 ) << ( 1 + rand() % 6 );

      // if counter is divisible by 5, start a new line of output
      if ( counter % 5 == 0 )
         cout << endl;
   } // end for
} // end main
```

Source code for die-rolling program

```
// Randomizing die-rolling program.
#include <iostream>
#include <iomanip>
#include <cstdlib> // contains prototypes for functions srand and rand
using namespace std;

int main()
{
  unsigned seed; // stores the seed entered by the user

  cout << "Enter seed: ";
  cin >> seed;
  srand( seed ); // seed random number generator

  // loop 10 times
  for ( int counter = 1; counter <= 10; ++counter )
  {
    // pick random number from 1 to 6 and output it
    cout << setw( 10 ) << ( 1 + rand() % 6 );
    // setw is "set width" of output operations
    // if counter is divisible by 5, start a new line of output
    if ( counter % 5 == 0 )
      cout << endl;
  } // end for
} // end main
```

Here is a BankDatabase class

```
#include "Account.h" // Account class definition

class BankDatabase
{
public:
   BankDatabase(); // constructor initializes accounts

   // determine whether account number and PIN match those of an Account
   bool authenticateUser( int, int ); // returns true if Account authentic

   double getAvailableBalance( int ); // get an available balance
   double getTotalBalance( int ); // get an Account's total balance
   void credit( int, double ); // add amount to Account balance
   void debit( int, double ); // subtract amount from Account balance
private:
   vector< Account > accounts; // vector of the bank's Accounts

   // private utility function
   Account * getAccount( int ); // get pointer to Account object
}; // end class BankDatabase
```

Here is a Paddle class

```cpp
// Paddle.h
// Paddle class definition (represents a paddle in the game).
#ifndef PADDLE_H
#define PADDLE_H

#include <Ogre.h> // Ogre class definitions
using namespace Ogre;

class Paddle
{
public:
   // constructor
   Paddle( SceneManager *sceneManagerPtr, String paddleName,
      int positionX );
   ~Paddle(); // destructor
   void addToScene(); // add a Paddle to the scene
   void movePaddle( const Vector3 &direction ); // move a Paddle

private:
   SceneManager* sceneManagerPtr; // pointer to the SceneManager
   SceneNode *nodePtr; // pointer to a SceneNode
   String name; // name of the Paddle
   int x; // x-coordinate of the Paddle
}; // end of class Paddle

#endif // PADDLE_H
```

Fig. 27.10 | `Paddle` class definition (represents a paddle in the game).

Homework for Next Monday (pick two)

1) Write a class for a character in gameplay, with set() and get() methods. You should be able to get() or set() the player's health, location, direction of movement, velocity, and any gear he/she has with him. What character data should be public or protected or private? What data structure should be used for the player's direction or current location? What data structure should be used for his/her gear? Write how a driver class can interact with the character class, by updating, interacting with other characters, or interacting with the environment.

2) Design and implement a blackjack or twenty-one game using the randomization functions we have used for cards/suits. Allow playing against the computer as the "house." Reveal all the cards at the end of a hand.

3) Write a function mysort() that takes an array of integers or floating point values and returns them sorted from least to greatest. Bonus 1: Pass the array by reference and change the original array. Bonus 2: Include an option to sort the array from greatest to least.

4) Make a dice rolling program that rolls two dice of any number of sides. Bonus: Implement a standard dice game of your choice (http://en.wikipedia.org/wiki/List_of_dice_games).

5) Outline how to implement the game Pong using pseudocode and/or class diagrams (http://en.wikipedia.org/wiki/Class_diagram). Bonus: Implement one of these classes.

Homework for Next Monday (pick two)

6) Write a concatenate function that takes a variable number of arguments (may or may not be of different data types) and returns their concatenation as a string.

7) Overload the ‘+’ operator to concatenate not only strings but also integers and/or floating point numbers.

8) Write a .cpp file that uses a function prototype and default parameters for a function.