UTM
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03: Constructors and Destructors

Programming Technique II

(SCSJ1023)

Adapted from Tony Gaddis and Barret Krupnow (2016), Starting out with C++: From Control Structures through Objects

Constructors

Constructors

- Member function that is automatically called when an object is created.
- Purpose is to construct an object.
- Constructor function name is class name.
- Has no return type.

Example 1: Constructors

Contents of `Rectangle.h` (Version 3)

```
1  // Specification file for the Rectangle class
2  // This version has a constructor.
3  #ifndef RECTANGLE_H
4  #define RECTANGLE_H
5
6  class Rectangle
7  {
8     private:
9        double width;
10       double length;
11    public:
12       Rectangle();              // Constructor
13       void setWidth(double);
14       void setLength(double);
15
16       double getWidth() const
17          { return width; }
18
19       double getLength() const
20          { return length; }
21
22       double getArea() const
23          { return width * length; }
24 };
25 #endif
```

Constructor in class definition

Example 1: Constructors (cont')

Contents of `Rectangle.cpp` (Version 3)

```
1  // Implementation file for the Rectangle class.
2  // This version has a constructor.
3  #include "Rectangle.h"    // Needed for the Rectangle class
4  #include <iostream>       // Needed for cout
5  #include <cstdlib>        // Needed for the exit function
6  using namespace std;
7
8  //*************************************************************
9  // The constructor initializes width and length to 0.0.      *
10 //*************************************************************
11
12 Rectangle::Rectangle()
13 {
14    width = 0.0;
15    length = 0.0;
16 }
```

Constructor definition

Example 1: Constructors (cont')

Contents of `Rectangle.ccp` Version3

```
17
18  //*************************************************************
19  // setWidth sets the value of the member variable width.    *
20  //*************************************************************
21
22  void Rectangle::setWidth(double w)
23  {
24     if (w >= 0)
25        width = w;
26     else
27     {
28        cout << "Invalid width\n";
29        exit(EXIT_FAILURE);
30     }
31  }
32
33  //*************************************************************
34  // setLength sets the value of the member variable length.  *
35  //*************************************************************
36
37  void Rectangle::setLength(double len)
38  {
39     if (len >= 0)
40        length = len;
41     else
42     {
43        cout << "Invalid length\n";
44        exit(EXIT_FAILURE);
45     }
46  }
```

Example 1: Constructors (cont')

Contents of `Rectangle.ccp` Version3

Program 13-6

```
1  // This program uses the Rectangle class's constructor.
2  #include <iostream>
3  #include "Rectangle.h"  // Needed for Rectangle class
4  using namespace std;
5
6  int main()
7  {
8     Rectangle box;     // Define an instance of the Rectangle class
9
10    // Display the rectangle's data.
11    cout << "Here is the rectangle's data:\n";
12    cout << "Width: " << box.getWidth() << endl;
13    cout << "Length: " << box.getLength() << endl;
14    cout << "Area: " << box.getArea() << endl;
15    return 0;
16 }
```

Program 13-6 *(continued)*

Program Output

```
Here is the rectangle's data:
Width: 0
Length: 0
Area: 0
```

Default Constructors

- A default constructor is a constructor that takes no arguments.
- If you write a class with no constructor at all, C++ will write a default constructor for you, one that does nothing.
- A simple instantiation of a class (with no arguments) calls the default constructor:

```
Rectangle r;
```

Passing Arguments to Constructors

Passing Arguments to Constructors

- To create a constructor that takes arguments:
  - indicate parameters in prototype:

```
Rectangle(double, double);
```

  - use parameters in the definition:

```
Rectangle::Rectangle(double w, double len)
{
    width = w;
    length = len;
}
```

Passing Arguments to Constructors (cont')

- You can pass arguments to the constructor when you create an object:

```
Rectangle r(10, 5);
```

More About Default Constructors

- If all of a constructor's parameters have default arguments, then it is a **default constructor**. For example:

```
Rectangle::Rectangle(double w=0.0,
 double len=0.0){
    width = w;
    length = len;
}
```

- Creating an object and passing no arguments will cause this constructor to execute.

```
Rectangle r;
```

Classes with No Default Constructor

- When all of a **class's constructors require arguments**, then the class has **NO default constructor**.

- When this is the case, you must pass the required arguments to the constructor when creating an object.

Destructors

Destructors

- Member function automatically called when an object is **destroyed**
- Destructor name is **~classname**, *e.g.*, **`~Rectangle`**
- Has no return type; takes **no arguments**.
- **Only one destructor** per class, *i.e.*, it cannot be overloaded.
- If constructor allocates dynamic memory, destructor should release it.

Example 2: Destructors

Contents of `InventoryItem.h` (Version 1)

```
1  // Specification file for the InventoryItem class.
2  #ifndef INVENTORYITEM_H
3  #define INVENTORYITEM_H
4  #include <cstring>   // Needed for strlen and strcpy
5
6  // InventoryItem class declaration.
7  class InventoryItem
8  {
9  private:
10    char *description;  // The item description
11    double cost;        // The item cost
12    int units;          // Number of units on hand
```

Example 2: Destructors

```
13  public:
14     // Constructor
15     InventoryItem(char *desc, double c, int u)
16        { // Allocate just enough memory for the description.
17          description = new char [strlen(desc) + 1];
18
19          // Copy the description to the allocated memory.
20          strcpy(description, desc);
21
22          // Assign values to cost and units.
23          cost = c;
24          units = u;}
25
26     // Destructor
27     ~InventoryItem()
28        { delete [] description; }
29
30     const char *getDescription() const
31        { return description; }
32
33     double getCost() const
34        { return cost; }
35
36     int getUnits() const
37        { return units; }
38  };
39  #endif
```

Example 2: Destructors

Contents of `InventoryItem.h` Version1 (cont')

```
1  // This program demonstrates a class with a destructor.
2  #include <iostream>
3  #include <iomanip>
4  #include "InventoryItem.h"
5  using namespace std;
6
7  int main()
8  {
9     // Define an InventoryItem object with the following data:
10    // Description: Wrench  Cost: 8.75   Units on hand: 20
11    InventoryItem stock("Wrench", 8.75, 20);
12
13    // Set numeric output formatting.
14    cout << setprecision(2) << fixed << showpoint;
15
```

Example 2: Destructors

Contents of `InventoryItem.h` Version1 (cont')

```
16      // Display the object's data.
17      cout << "Item Description: " << stock.getDescription() << endl;
18      cout << "Cost: $" << stock.getCost() << endl;
19      cout << "Units on hand: " << stock.getUnits() << endl;
20      return 0;
21  }
```

Program Output

```
Item Description: Wrench
Cost: $8.75
Units on hand: 20
```

Constructors, Destructors, and Dynamically Allocated Objects

- When an object is dynamically allocated with the new operator, its constructor executes:

```
Rectangle *r = new Rectangle(10, 20);
```

- When the object is destroyed, its destructor executes:

```
delete r;
```

Overloading Constructors

Overloading Constructors

- A class can have more than one constructor.

- Overloaded constructors in a class must have different parameter lists:

```
Rectangle();
Rectangle(double);
Rectangle(double, double);
```

Program 1

From Contents of `InventoryItem.h` Version2

```
16      // Constructor #1
17      InventoryItem()
18         { // Allocate the default amount of memory for description.
19           description = new char [DEFAULT_SIZE];
20
21           // Store a null terminator in the first character.
22           *description = '\0';
23
24           // Initialize cost and units.
25           cost = 0.0;
26           units = 0; }
```

Program 1

From Contents of `InventoryItem.h` Version2

```
28      // Constructor #2
29      InventoryItem(char *desc)
30         { // Allocate just enough memory for the description.
31           description = new char [strlen(desc) + 1];
32
33           // Copy the description to the allocated memory.
34           strcpy(description, desc);
35
36           // Initialize cost and units.
37           cost = 0.0;
38           units = 0; }
```

Program 1

From Contents of `InventoryItem.h` Version2

```
40      // Constructor #3
41      InventoryItem(char *desc, double c, int u)
42         { // Allocate just enough memory for the description.
43           description = new char [strlen(desc) + 1];
44
45           // Copy the description to the allocated memory.
46           strcpy(description, desc);
47
48           // Assign values to cost and units.
49           cost = c;
50           units = u; }
```

Only One Default Constructor and One Destructor

- **Do not provide more than one default** constructor for a class: one that takes no arguments and one that has default arguments for all parameters.

```
Square();
Square(int = 0);  // will not compile
```

- Since a destructor takes no arguments, there can only be one destructor for a class.

Member Function Overloading

- Non-constructor member functions can also be overloaded:

```
void setCost(double);
void setCost(char *);
```

- Must have unique parameter lists as for constructors.

Example 3: Member Function Overloading

```
#include <iostream>
using namespace std;
class Rectangle
{       private:    int height, width;
        public:
            Rectangle(int);
            Rectangle(int, int);
            int getSide()
            {return height;}
            int getArea(int);
            int getArea(int, int);
};
```

Example 3: Member Function Overloading (cont')

```
Rectangle::Rectangle(int x)
{    height=x;     width=x;}
Rectangle::Rectangle(int x, int y)
{     height=x;       width=y;}
int Rectangle::getArea(int x)
{     return(x*x);}
int Rectangle::getArea(int x, int y)
{     return (x*y);}
int main(){
    Rectangle c(5,6);
    Rectangle d(6);
    cout<<d.getArea(d.getSide())<<endl;
    cout<<c.getArea(5,6);
    return 0;
}
```

Constructor overloading

Function overloading

Using Private Member Functions

- A `private` member function can only be called by another member function.
- It is used for internal processing by the class, not for use outside of the class.
- See the `createDescription` function in **`InventoryItem.h`** (Version 3).

From Contents of InventoryItem.h Version2

```
class InventoryItem
{
private:
   char *description;  // The item description
   double cost;        // The item cost
   int units;          // Number of units on hand

void createDescription(int size, char *value)   {
    description = new char [size];
    strcpy(description, value); }
```

```
public:
   :
   :

 void setDescription(char *d)
  { strcpy(description, d); }
:
:
};
```

Copy Constructors

Copy Constructors

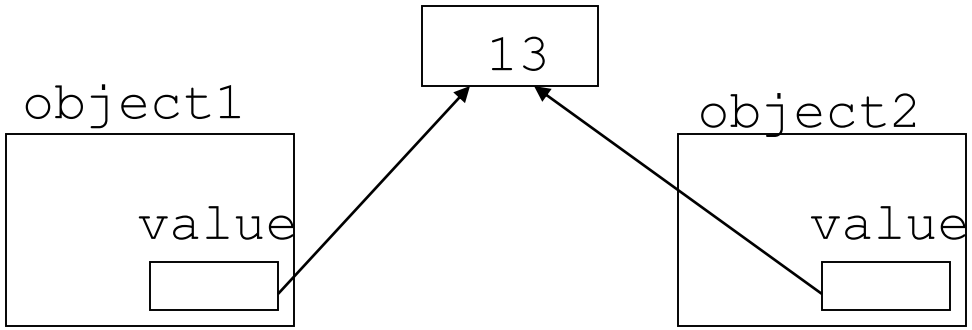
Problem: what if object contains a pointer?

```
class SomeClass
{ public:
      SomeClass(int val = 0)
          {value = new int; *value = val;}
      int getVal();
      void setVal(int);
    private:
      int *value;
}
```

Copy Constructors

- What we get using memberwise copy with objects containing dynamic memory:

```
SomeClass object1(5);
SomeClass object2 = object1;
object2.setVal(13);
cout << object1.getVal(); // also 13
```



Programmer-Defined Copy Constructor

- Allows us to solve problem with objects containing pointers:

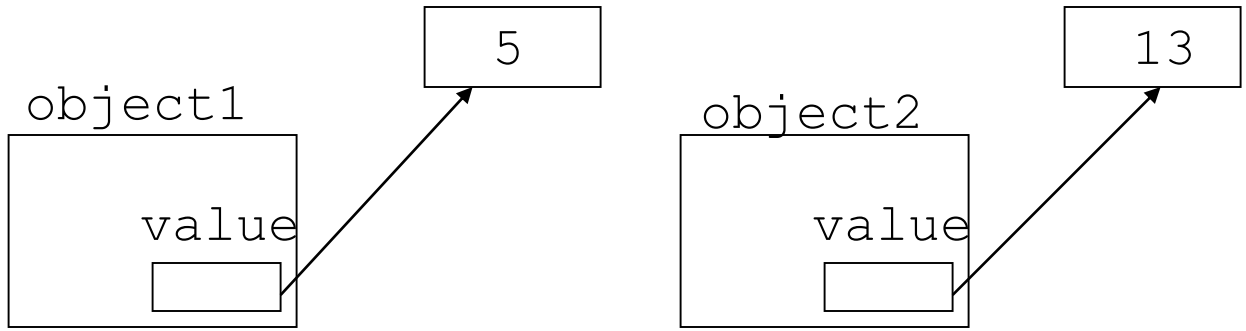
```
SomeClass::SomeClass(const SomeClass
&obj)
{
        value = new int;
        *value = *obj.value;
 }
```

- Copy constructor takes a reference parameter to an object of the class.

Programmer-Defined Copy Constructor

- Each object now points to separate dynamic memory:

```
SomeClass object1(5);
SomeClass object2 = object1;
object2.setVal(13);
cout << object1.getVal();
// still 5
```



Programmer-Defined Copy Constructor

- Since copy constructor has a reference to the object it is copying from,

```
SomeClass::SomeClass(SomeClass &obj)
```

it can modify that object.

- To prevent this from happening, make the object parameter `const`:

```
SomeClass::SomeClass(const SomeClass &obj)
```

Example 5: Copy Constructor

Contents of `PersonInfo.h` (Version 2)

```
1  #include <cstring>
2
3  class PersonInfo
4  {
5  private:
6     char *name;
7     int age;
8
9  public:
10    // Constructor
11    PersonInfo(char *n, int a)
12       { name = new char[strlen(n) + 1];
13         strcpy(name, n);
14         age = a; }
15
16    // Copy Constructor
17    PersonInfo(const PersonInfo &obj)
18       { name = new char[strlen(obj.name) + 1];
19         strcpy(name, obj.name);
20         age = obj.age; }
21
22    ~PersonInfo()
23       { delete [] name; }
24
25    const char *getName()
26       { return name; }
27
28    int getAge()
29       { return age; }
30 };
```