CSC 211: Computer Programming
Copy Constructors and Operator Overloading

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Administrative notes

More on constructors …

- So far …
  - ✓ default constructors, overloaded constructors
- C++ also defines **copy constructors**
  - ✓ used to create an object as a copy of an existing object
  - ✓ if you don't define your own, C++ will synthesize one copy constructor for you

```
Point2D obj1;               // default constructor
Point2D obj2(4.5, 3.2);     // overloaded constructor
Point2D obj3(obj2);         // copy constructor
Point2D obj4 = obj3;        // copy constructor
```


When are copy constructors invoked?

```
Point2D myfunc(Point2D obj) {
    Point2D newobj;
    // ...
    return newobj;
}

int main () {
    // copy constructor is invoked when an object is initialized from
    // another object of the same type
    Point2D obj2(4.5, 3.2);     // overloaded constructor
    Point2D obj3(obj2);         // copy constructor
    Point2D obj4 = obj3;        // copy constructor

    // copy constructor is invoked when a non-reference object is
    // passed to a function (to initialize parameter)
    myfunc(obj4);               // copy constructor

    // copy constructor is invoked when a non-reference object is
    // returned from a function
    Point2D obj5 = myfunc(obj2);
}
```

Shallow vs deep copies

- Synthesized copy constructors perform **shallow copies**
  - a shallow copy is a byte-to-byte copy of all data members (works fine most of the cases, except when pointers are used)

```
Point2D::Point2D(const Point2D& obj) {
    x = obj.x;
    y = obj.y;
    // ...
}
```

- Sometimes a **deep copy** is necessary (can handle more complex objects)
  - must define your own copy constructor


```
class Array {
    public:
        Array(int cap);
        ~Array();
    private:
        int size;
        int capacity;
        int *ptr;
};

Array::Array(int cap) {
    size = 0;
    capacity = cap;
    ptr = new int[cap];
}

Array::~Array() {
    delete [] ptr;
}

int main () {
    Array obj1(10);
    Array obj2(obj1);
    Array obj3 = obj2;
}
```



```
Array::Array(int cap) {
    size = 0;
    capacity = cap;
    ptr = new int[cap];
}

Array::Array(Array& obj) {
    size = obj.size;
    capacity = obj.capacity;
    ptr = new int[capacity];
    for (int i = 0 ; i < size ; i++) {
        ptr[i] = obj.ptr[i];
    }
}

Array::~Array() {
    delete [] ptr;
}

int main () {
    Array obj1(10);
    Array obj2(obj1);
    Array obj3 = obj2;
}
```



```
class Array {
    public:
        Array(int cap);
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Array::~Array() {
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}

int main () {
    Array obj1(10);
    Array obj2(obj1);
    Array obj3 = obj2;
}
```

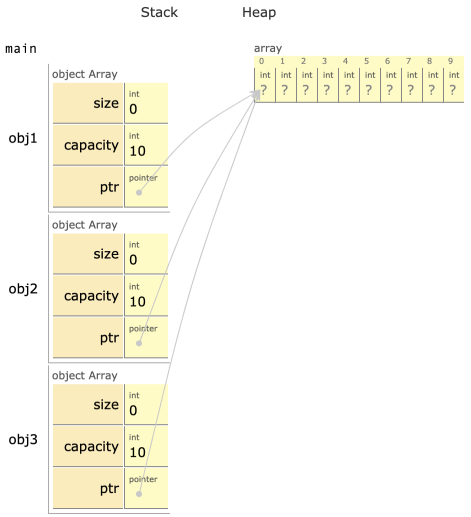

shallow copies

```
Array::Array(int cap) {
    size = 0;
    capacity = cap;
    ptr = new int[cap];
}

Array::Array(Array& obj) {
    size = obj.size;
    capacity = obj.capacity;
    ptr = new int[capacity];
    for (int i = 0 ; i < size ; i++) {
        ptr[i] = obj.ptr[i];
    }
}

Array::~Array() {
    delete [] ptr;
}

int main () {
    Array obj1(10);
    Array obj2(obj1);
    Array obj3 = obj2;
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```
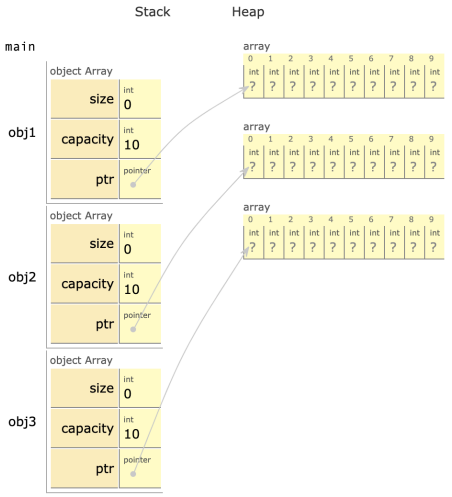



deep copies

The **assignment** operator =

- Assignment is not construction
- The assignment operator '=' assigns an object to an existing object (already constructed)

```
Point2D obj1;                // default constructor
Point2D obj2(4.5, 3.2);      // overloaded constructor
Point2D obj3(obj2);          // copy constructor
Point2D obj4 = obj3;         // copy constructor
obj1 = obj4;                 // assignment operator
```

- If you don't define your own, C++ will synthesize one assignment operator for you (performs **shallow copy**)

The `this` pointer

- Pointer accessible only within member functions of a class
  - ✓ it points to the object for which the member function is called
  - ✓ **static member functions** do not have this pointer

```
void Date::set_year(int y) {
    // statements below are equivalent
    year = y;
    this->year = y;
    (*this).year = y;
}
```


Overloading Operators

How to overload the '=' operator?

```
Point2D& Point2D::operator=(const Point2D &obj) {
    // always check against self-assignment
    // especially when performing deep copies
    if (this != &obj) {
        this->x = obj.x;
        this->y = obj.y;
    }
    // always return *this, necessary for
    // cascade assignments (a = b = c)
    return *this;
}
```

Modify the self object reference and return it

can perform either shallow or deep copies

How many copy constructor calls?

```
Point2D myfunc(const Point2D& obj) {
    Point2D newobj;
    newobj = obj;
    // ...
    return newobj;
}

int main () {
    Point2D obj2(4.3, 1.1);
    Point2D obj3(obj2);
    Point2D obj4 = myfunc(obj3);
    Point2D obj5;
    obj5 = obj4 = obj2;
}
```


Static Data Members

- We can define static class members using static keyword
- When we declare a member of a class as static it means no matter how many objects of the class are created, there is only one copy of the static member
- A static member is shared by all objects of the class

Static Data Members

- All static data is initialized to zero when the first object is created, if no other initialization is present
- We can't initialized static members in the class definition
  - Need to be initialized outside the class

Static Data Members

```cpp
#include <iostream>

using namespace std;

class Box {
   public:
      static int objectCount;

      // Constructor definition
      Box(double l = 2.0, double w = 2.0, double h = 2.0) {
         cout <<"Constructor called." << endl;
         length = l;
         width = w;
         height = h;

         // Increase every time object is created
         objectCount++;
      }
      double Volume() {
         return length * width * height;
      }

   private:
      double length;     // Length of a box
      double width;      // width of a box
      double height;     // Height of a box
};
```


Static Data Members

```cpp
// Initialize static member of class Box
int Box::objectCount = 0;

int main() {
   Box Box1(3.3, 1.2, 1.5);    // Construct box1
   Box Box2(8.5, 6.0, 2.0);    // Construct box2

   // Print total number of objects.
   cout << "Total objects: " << Box::objectCount << endl;

   return 0;
}
```

```
Desktop — -zsh — 80×5
~/Desktop — -zsh
michaelconti@Michaels-MacBook-Pro-2 Desktop % ./temp
Constructor called.
Constructor called.
Total objects: 2
michaelconti@Michaels-MacBook-Pro-2 Desktop %
```


Static Member Functions

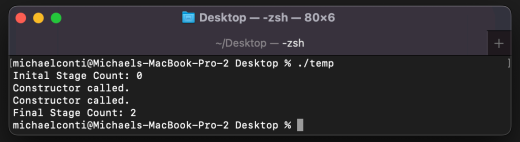
- By declaring a function member as static, you make it independent of any particular object of the class
- A static member function can be called even if no objects of the class exist
- Static functions are accessed using only the class name and the scope resolution operator ::

Static Member Functions

- A static member function can only access:
  - static data member
  - other static member functions
  - any other functions from outside the class
- You could use a static member function to determine whether some objects of the class have been created or not

Static Member Functions

```
static int Box::getCount() {
     return objectCount;
  }

int main() {
   // Print total number of objects before creating object.
   cout << "Initial Stage Count: " << Box::getCount() << endl;

   Box Box1(3.3, 1.2, 1.5);    // Construct box1
   Box Box2(8.5, 6.0, 2.0);    // Construct box2

   // Print total number of objects after creating object.
   cout << "Final Stage Count: " << Box::getCount() << endl;

   return 0;
}
```



Lets try it

- Overload the ++ (post increment) operator for the Date class we build in a previous lecture to increment the year for any object of type Date
  - Hint:

```
void operator++(int);
Date someDay(12, 30, 1993);
someDay++;
```

- Write a (shallow) copy constructor for objects of type Date
- Include a static member that counts the number of date objects