COMP2012H

Order of
Construction & Destruction

“Has” relationship

- When an object A has an object B as a data member, we say that “A has-a B”.

```
class B { … };

class A
{
   B my_b;
public:
   …      // some public members or functions
};
```

- It is easy to see which objects have other objects. All you need to do is to look at the class definition.

Example: Order of Constructions

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

class Clock {
public:
  Clock() { cout << "Constructor Clock" << endl; }
  ~Clock() { cout << "Destructor Clock" << endl; }
};

class Postoffice {
  Clock clock;
public:
  Postoffice() { cout << "Constructor Postoffice" << endl; }
  ~Postoffice() { cout << "Destructor Postoffice" << endl; }
};

int main()
{
  cout << "Beginning of main" << endl;
  Postoffice x;
  cout << "End of main" << endl;
  return 0;
}
```

Here's the output:

```
Beginning of main
Constructor Clock
Constructor Postoffice
End of main
Destructor Postoffice
Destructor Clock
```

Order of Constructions: Remarks

- When an object is constructed, all its data members are constructed first.

- The order of destruction is the exact opposite of the order of construction: the `Clock` constructor is called before the `Postoffice` constructor; but the `Clock` destructor is called after the `Postoffice` destructor.

- As always, construction of data member objects is done by calling the appropriate constructors.
  - If you do not do this explicitly, then the compiler will assume the default constructors should be used. Make sure they exist! That is,

    ```
    Postoffice::Postoffice() {}
    ```

    is equivalent to

    ```
    Postoffice::Postoffice() : clock() {}
    ```
  - Or, you may control construction of data member objects by calling their appropriate constructors using the member initialization list syntax.

Order of Constructions with Owned Objects

```
class Clock {
public:
    Clock() { cout << "Constructor Clock" << endl; }
    ~Clock() { cout << "Destructor Clock" << endl; }
};

class Postoffice {
    Clock* clock;
public:
    Postoffice() {
      clock = new Clock;
      cout << "Constructor Postoffice" << endl;
    }
    ~Postoffice() {
      cout << "Destructor Postoffice" << endl;
    }
};
```

Here is the output:

```
Beginning of main
Constructor Clock
Constructor Postoffice
End of main
Destructor Postoffice
```

Order of Construction with Owned Objects: Remarks

What happened…?

- Now the `Postoffice` owns the `Clock` (since it creates it dynamically)
- The `Clock` object is constructed in the `Postoffice` constructor, but it is never destructed, since we have not explicitly called `delete`.
- Remember that objects on the heap are never destructed automatically, so we have just created a memory leak!
- The lesson: When object A owns object B, A must be responsible for B's destruction.

Order of Constructions with Owned Objects: Fix

```
class Clock {
public:
   Clock() { cout << "Constructor Clock" << endl; }
   ~Clock() { cout << "Destructor Clock" << endl; }
};

class Postoffice {
   Clock* clock;
public:
   Postoffice() {
     clock = new Clock;
     cout << "Constructor Postoffice" << endl;
   }
   ~Postoffice() {
     cout << "Destructor Postoffice" << endl;
     delete clock;
   }
};
```

Here is the new output:

```
Beginning of main
Constructor Clock
Constructor Postoffice
End of main
Destructor Postoffice
Destructor Clock
```

Order of Constructions w/ Multiple Objects

```
class Clock {
  int HHMM;
public:
  Clock() : HHMM(0) { cout << "Constructor Clock" << endl; }
  Clock(int hhmm) : HHMM(hhmm) {
    cout<<"Constructor Clock at "<< HHMM << endl;
  }
  ~Clock() { cout << "Destructor Clock at " << HHMM << endl; }
};

class Room {
public:
  Room() { cout << "Constructor Room" << endl; }
  ~Room() { cout << "Destructor Room" << endl; }
};

class Postoffice {
  Clock clock;
  Room room;
public:
  Postoffice() { cout << "Constructor Postoffice" << endl; }
  ~Postoffice() { cout << "Destructor Postoffice" << endl; }
};
```

Here is the output:

```
Beginning of main
Constructor Clock
Constructor Room
Constructor Postoffice
End of main
Destructor Postoffice
Destructor Room
Destructor Clock at 0
```

- Note that the 2 data members, Clock and Room, are constructed first, in the order in which they appear in the Postoffice class.

Order of Construction w/ Nested Objects

- Let's move the clock to the room.

```
class Clock {
public:
  Clock() { cout << "Constructor Clock" << endl; }
  ~Clock() { cout << "Destructor Clock" << endl; }
};

class Room {
  Clock clock;
public:
  Room() { cout << "Constructor Room" << endl; }
  ~Room() { cout << "Destructor Room" << endl; }
};

class Postoffice {
  Room room;
public:
  Postoffice() {cout << "Constructor Postoffice" << endl; }
  ~Postoffice() {cout << "Destructor Postoffice" << endl; }
};
```

Here is the output:

```
Beginning of main
Constructor Clock
Constructor Room
Constructor Postoffice
End of main
Destructor Postoffice
Destructor Room
Destructor Clock
```

Order of Constructions with Temporary Objects

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

class Clock {
  int HHMM;
public:
  Clock() : HHMM(0) { cout << "Constructor Clock" << endl; }
  Clock(int hhmm) : HHMM(hhmm) {
    cout << "Constructor Clock at" << HHMM << endl;
  }
  ~Clock() { cout << "Destructor Clock" << endl; }
};

class Postoffice {
  Clock clock;
public:
  Postoffice() {
    clock = Clock(1800);              // creates and destroys a temporary object
    cout << "Constructor Postoffice" << endl;
  }
  ~Postoffice() { cout << "Destructor Postoffice" << endl; }
};
```

Here's the output:

```
Beginning of main
Constructor Clock
Constructor Clock at 1800
Destructor Clock
Constructor Postoffice
End of main
Destructor Postoffice
Destructor Clock
```

- Here a temporary clock object is created by `Clock(1800)`.
- Like a ghost, it is created and destroyed behind the scenes.

Summary

- When an object is constructed, its data members are constructed first.
- When the object is destructed, the data members are destructed after the destructor for the object has been executed.
- When object A owns other objects (via pointers), remember to explicitly destruct them in A's destructor.
- By default, the default constructor is used for the data members.