DYNAMIC MEMORY
THE BIG FOUR

Problem Solving with Computers-II

Read the syllabus. Know what's required. Know how to get help.

Learning Goals (Last Week)

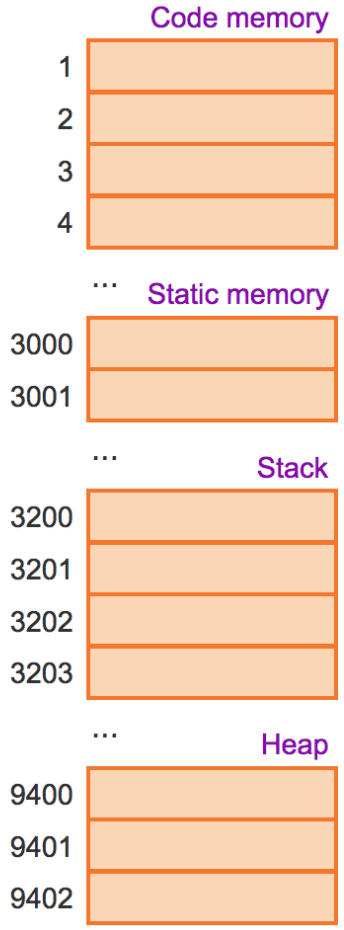
- Review basics of classes
  - Defining classes and declaring objects
  - Access specifiers: private, public
  - Different ways of initializing objects and when to use each:
    - Default constructor
    - Parametrized constructor
    - Parameterized constructor with default values
    - Initializer lists

Learning Goals (today)

- Develop a mental model of how programs are represented in memory.
- Identify situations when data needs to be created on the heap vs. stack
- Identify the big four and when you need to implement these vs. use the default versions provided by C++

C++ Program's Memory Regions

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

// Program is stored in code memory

int myGlobal = 33;     // In static memory

void MyFct() {
   int myLocal;        // On stack
   myLocal = 999;
   cout << " " << myLocal;
}

int main() {
   int myInt;             // On stack
   int* myPtr = nullptr; // On stack
   myInt = 555;

   myPtr = new int;       // In heap
   *myPtr = 222;
   cout << *myPtr << " " << myInt;
   delete myPtr; // Deallocated from heap

   MyFct(); // Stack grows, then shrinks

   return 0;
}
```



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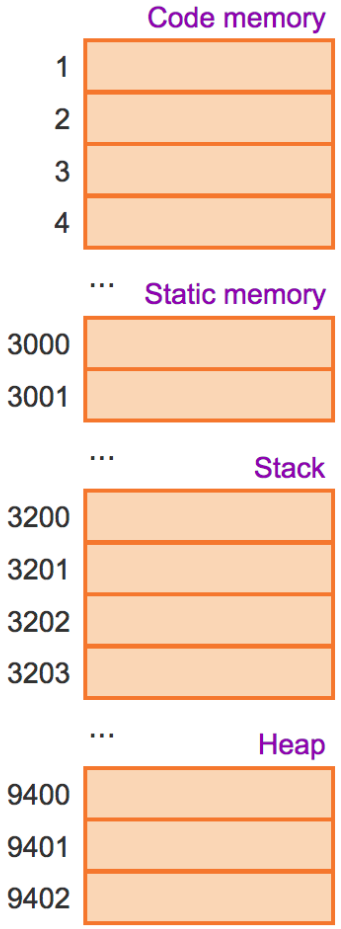

- Stack: Segment of memory managed automatically using a Last in First Out (LIFO) principle.
- Heap: Segment of memory managed by the programmer
  - Data created on the heap stays there
  - FOREVER or
  - until the programmer explicitly deletes it

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Heap vs. stack

```
1 #include <iostream>
2 using namespace std;
3
4 int* createAnIntArray(int len){
5
6     int arr[len];
7     return arr;
8
9 }
```

Does the above function correctly return an array of integers?

A. Yes

B. No

The Big Four

1. Constructor
2. Destructor
3. Copy Constructor
4. Copy Assignment

Constructor and Destructor

Every class has the following special methods:

- Constructor: Called right AFTER new objects are created in memory
- Destructor: Called right BEFORE an object is deleted from memory

The compiler automatically generates default versions, but you can override them

```
void foo(){
    Complex p;
    Complex* q = new Complex;
    Complex w{10, 5};
}
```

How many times is the constructor called above?

A. Never
B. Once
C. Two times
D. Three times

```
void foo(){
     Complex p;
     Complex *q = new Complex;
}
```

The destructor of which of the objects is called after foo() returns?

A. p
B. q
C. *q
D. None of the above

Copy constructor

- Creates a new object and initializes it using an existing object

In which of the following cases is the copy constructor called?

A.
```
Complex p1;
Complex p2{1, 2};
```

B.
```
Complex p1{1, 2};
Complex p2{p1};
```

C.
```
Complex *p1 = new Complex{1, 2};
Complex p2 = *p1;
```

D. B&C

E. A, B & C

Copy assignment

- Default behavior: Copies the member variables of one object into another

```
Complex p1{1, 2}; // Parametrized constructor
Complex p2;
p2 = p1; // Copy assignment function is called
```

```
double foo(Complex p){
    return p.evaluate(10);
}
int main(){
     Complex q{1, 2};
     foo(q);
     }
```

Which of the following special methods is called as a result of calling foo?

A. Parameterized constructor
B. Copy constructor
C. Copy Assignment
D. Destructor

Constant pointers and pointers to constants

```
const char* p1;
char* const p2;
const char* const p3;
```

Operator Overloading

We would like to be able to compare two objects of the class using the following operators

==

!=

and possibly others

```
bool operator==(const Complex & c1, const Complex &c2){
    return c1.real==c2.real && c1.imag == c2.imag;

}
```

Summary

- Classes have member variables and member functions (method). An object is a variable where the data type is a class.
- You should know how to declare a new class type, how to implement its member functions, how to use the class type.
- Frequently, the member functions of an class type place information in the member variables, or use information that's already in the member variables.
- New functionality may be added using non-member functions, friend functions, and operator overloading (next lectures)

Next time

- Linked Lists and the rule of three