THE RULE OF THREE (CONT.) LINKED LISTS WITH CLASSES

Problem Solving with Computers-II

Last lecture:

- Modified the Complex class member variables to be pointers
- Wrote user-defined versions of the
  - Constructor
  - Destructor
  - Copy-constructor

Rule of Three

Assume:

* **User-defined destructor**
* **User-defined copy constructor**
* **Default copy assignment**

```
class Complex
{
private:
    double *real;
    double *imag;
public:
    Complex(double re = 0, double im = 0);
    Complex(const Complex& other);
    ~Complex();
    double getMagnitude() const;
    double getReal() const;
    double getImaginary() const;
    void print() const;
    void conjugate();
    void setReal(double r);
    void setImag(double r);
    Complex operator+(const Complex& y);
};
```

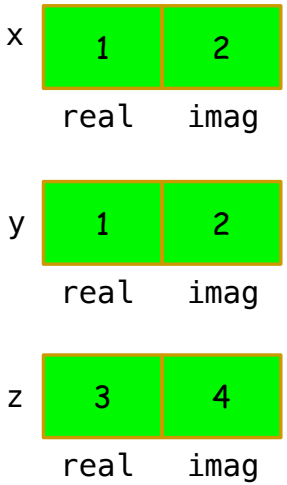
```
void bar(){
    Complex x(1, 2);
    Complex y(x);
    Complex z(3, 4);
    x = z;
}
```

return;

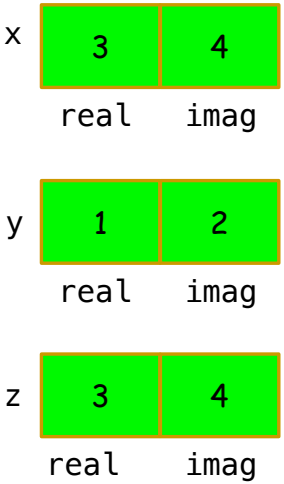
Assume execution has reached the last line of bar()
Which diagram correctly depicts the objects x, y, z (and their values)

Complex x(1,2);
Complex &z = x;

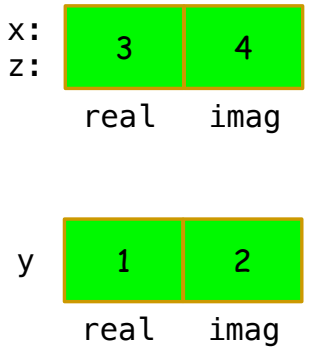
A



B



C



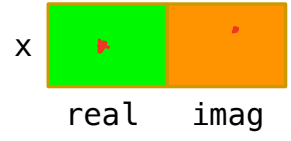
D: None of the above

```
void bar(){
    Complex x(1, 2);
    Complex y(x);
    Complex z(3, 4);
    x = z;
}
```

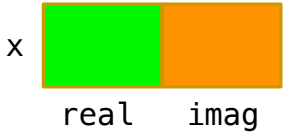
Pointers with the same value have the same color

Which pointers have the same value?

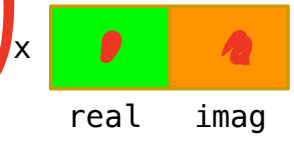
A



B



C



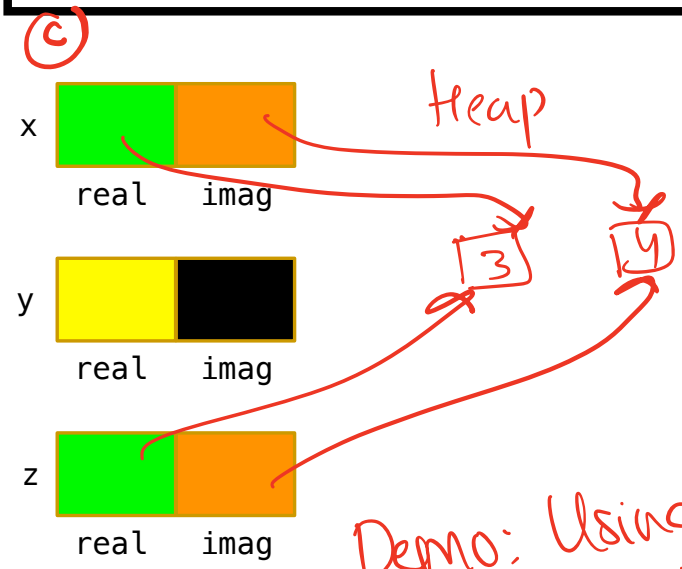
```
void bar(){
    Complex x(1, 2);
    Complex y(x);
    Complex z(3, 4);
    x = z;
}
```

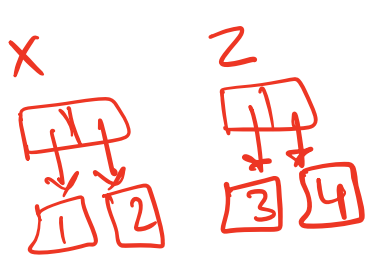
Will calling bar() result in a seg fault?

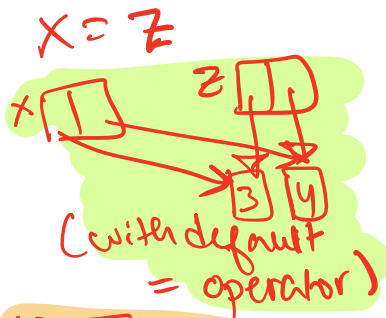
A. Yes

B. No

C. I don't know!







This is what we really want

Assume:

* **User-defined** destructor
* **User-defined** copy constructor
* Default copy assignment

Demo: Using vgdb in vscode

RULE OF THREE

If a class defines one (or more) of the following it should probably explicitly define all three:

1. Destructor
2. Copy constructor
3. Copy assignment

We answered the following questions for the Complex class:

1. What is the behavior of these defaults?
2. What is the desired behavior ?
3. How should we over-ride these methods?

Questions to ask about any data structure:

- **What operations does the data structure support?**
  A linked list supports the following operations:
  1. push_front (add a value to the head)
  2. append/push_back (add a value to the tail)
  3. delete (a value)
  4. search (for a value)
  5. min
  6. max
  7. print all values
- **How do you implement each operation?**
- **How fast is each operation?**

Linked List Abstract Data Type (ADT)

```
class LinkedList {
public:
    LinkedList();
    ~LinkedList();
    // other public methods


private:
    struct Node {
        int info;
        Node* next;
    };
    Node* head;
    Node* tail;
};
```

Memory Errors

- Memory Leak: Program does not free memory allocated on the heap.

- Segmentation Fault: Code tries to access an invalid memory location

(See example code from lecture)

```
void test_append_0(){
      LinkedList ll;
      ll.append(10);
       ll.print();
}
```

Assume:

* **Default destructor**
* **Default copy constructor**
* **Default copy assignment**

What is the result of running the above code?

A. Compiler error

B. Memory leak

C. Segmentation fault (Maybe or incorrect output)

D. None of the above

Behavior of default copy constructor

```
void test_copy_constructor(){
   LinkedList l1;
   l1.append(1);
   l1.append(2);
   LinkedList l2(l1);
   // calls the copy c'tor
   l1.print();
   l2.print();
}
```

Assume:
destructor: user-defined
copy constructor: default

What is the output?
A. Compiler error
B. Memory leak
C. Segmentation fault double free
D. All of the above
E. None of the above

Behavior of default copy assignment

l1 : 1 -> 2- > 5 -> null

```
void default_assignment_1(LinkedList& l1){
   LinkedList l2;
   l2 = l1;
}
```

* What is the behavior of the default assignment operator?

Assume:

* **User-defined destructor**
* **Default copy constructor**
* **Default copy assignment**

Behavior of default copy assignment

```
void test_default_assignment_2(){
    LinkedList l1, l2;
    l1.append(1);
    l1.append(2)
    l2 = l1;
    l2.print()
}
```

No memory leak in this case because l2 was an empty list before the assignment

What is the result of running the above code?
A. Prints 1 , 2
B. Segmentation fault
C. Memory leak
D. A &B
E. A, B and C

Assume:

* **User-defined destructor**
* **Default copy constructor**
* **Default copy assignment**

Behavior of default copy assignment

```
void test_default_assignment_3(){
   LinkedList l1;
   l1.append(1);
   l1.append(2)
   LinkedList l2(l1);
   l2.append(10);
   l2.append(20);
   l2 = l1;
   l2.print()
}
```

What is the result of running the above code?
A. Prints 1 , 2
B. Segmentation fault
C. Memory leak
D. A &B
E. A, B and C

Assume:

* **User-defined destructor**
* **User-defined copy constructor**
* **Default copy assignment**

Overloading Operators

Overload relational operators for LinkedLists

==

!=

and possibly others

```
void test_equal(const LinkedList & lst1, const LinkedList &lst2){
    if (lst1 == lst2)
        cout<<“Lists are equal”<<endl;
    else
        cout<<“Lists are not equal”<<endl;

}
```

Overloading Arithmetic Operators

Define your own addition operator for linked lists:

```
LinkedList l1, l2;

//append nodes to l1 and l2;

LinkedList l3 = l1 + l2 ;
```

Overloading input/output stream

Wouldn’t it be convenient if we could do this:

```
LinkedList list;
cout<<list; //prints all the elements of list
```

Next time

- Binary Search Trees