RECURSION ON LINKED LISTS C++ RULE OF THREE

Problem Solving with Computers-II

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

int main(){
    cout<<"Hola Facebook\n";
    return 0;
}
```

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

Review: Accessing structs using pointers

```
Node n {20, nullptr};
Node m {10, nullptr};
Node *p = &m;
```

Review: Dynamic memory (new and delete)

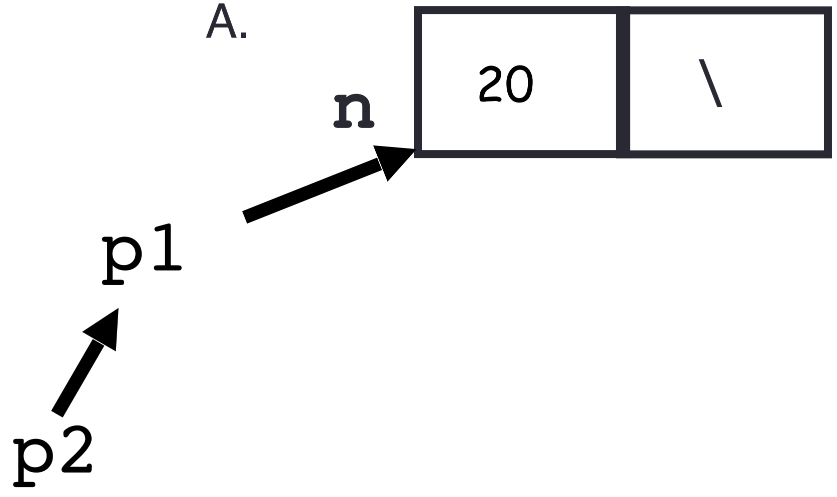
```
Node* p1 = new Node {10, nullptr};
p1->next = new Node {30, nullptr};
```

Review: Pointer assignment

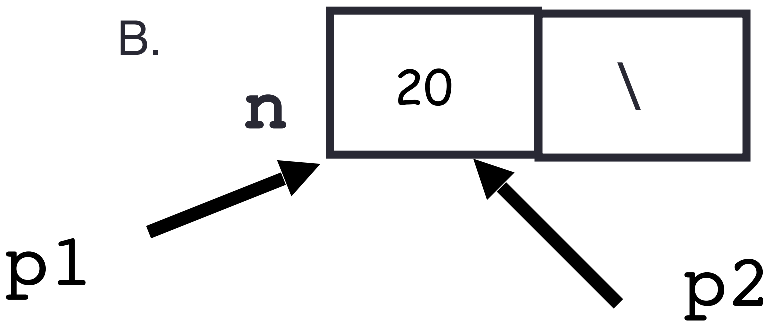
```
Node* p1, *p2;
Node n {20, nullptr};
p1 = &n;
p2 = p1;
```

Q: Which of the following pointer diagrams best represents the outcome of the above code?

A.



B.



C. Neither, the code is incorrect

Today’s learning goals:

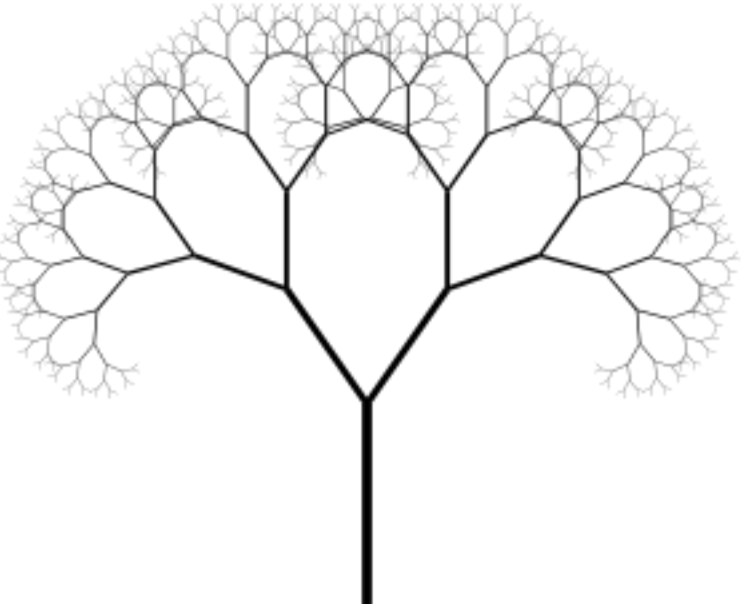
Recursion and its application to linked list operations

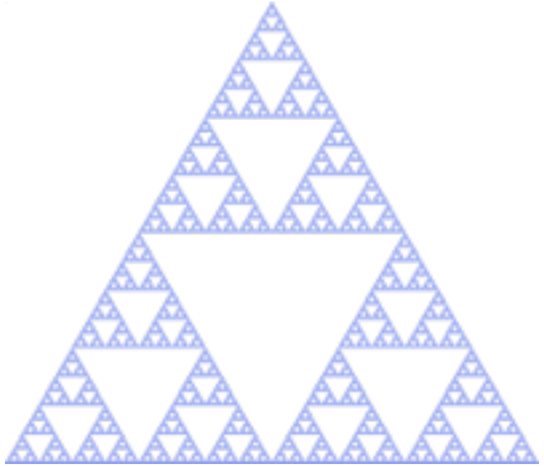
Dynamic memory and common errors

We want to understand the what, why, and how of the C++ Big Three:

- Destructor
- Copy constructor
- Copy assignment operator

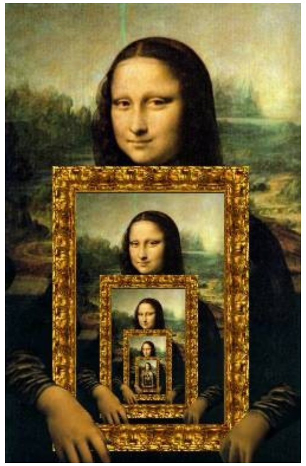
Recursion



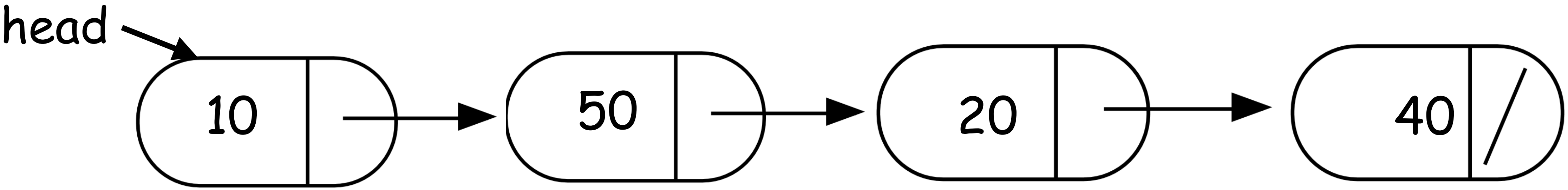


Sierpinski triangle

Zooming into a Koch's snowflake



Using recursion to implement operators involving a linked list



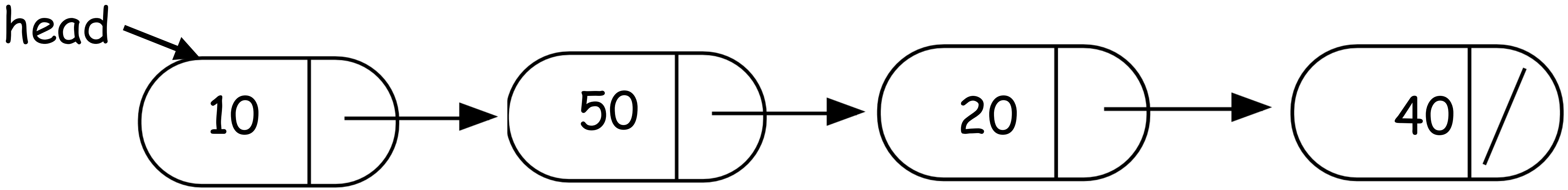
```
int IntList::sum(){

      //return the sum of the sequence
  }
```

Helper functions

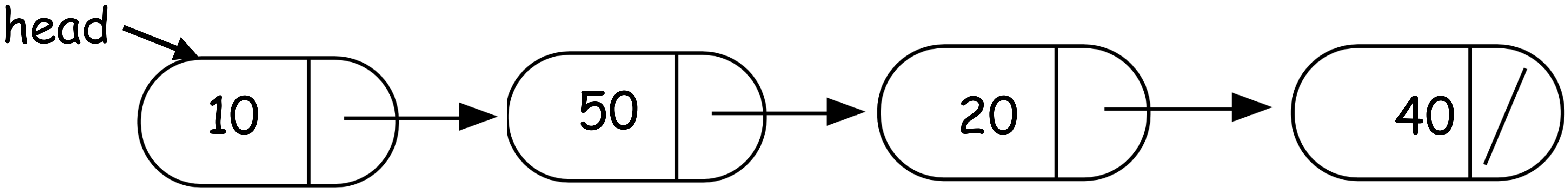
- Sometimes your functions takes an input that is not easy to recurse on
- In that case define a new function with appropriate parameters: This is your helper function
- Call the helper function to perform the recursion
- Usually the helper function is private

For example

```
 Int IntList::sum(){

    return sum(head);
     //helper function that performs the recursion.

 }
```



```
int IntList::sum(Node* p){









 }
```



```
bool IntList::clear(Node* p){







 }
```

Dynamic Memory: common errors

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

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

Constructor and Destructor

Every class has the following special methods:

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

The compiler automatically generates default versions, but you can provide user-defined implementations

```
void foo(){
    Complex p(1, 2);
    Complex* q = new Complex(3, 4);
}
```

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

What is the output?

A. 1 + 2j

B. 3 + 4j

C. 1 + 2j
   3 + 4j

D. None of the above

```
void test_0(){
     IntList x;
     x.push_front(10);
      x.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

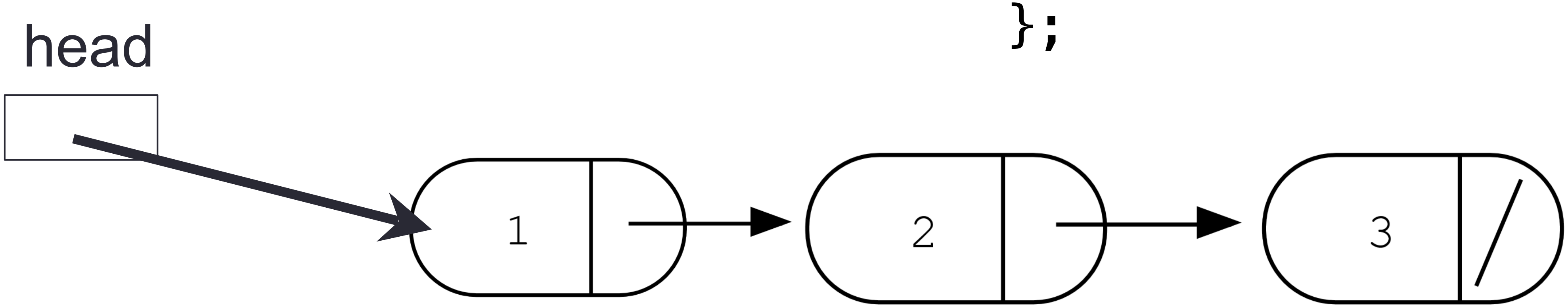
C. Segmentation fault

D. None of the above

Concept Question

```
IntList::~IntList(){
   delete head;
}
```

```
class Node {
    public:
       int data;
       Node *next;
};
```



Which of the following objects are deleted when the destructor of IntList is called?

(A): head pointer

(B): only the first node

(C): A and B

(D): All the nodes of the linked list

(E): A and D

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?

Copy constructor

- Parameterized constructor whose first argument is a class object
- **initializes a (new) object using an existing object**

Behavior of default copy constructor

```
void test_copy_constructor(){
   IntList x;
   x.push_front(10);
   x.push_front(20);
   IntList y(x);
   // calls the copy c'tor
   x.clear();
   y.print();
}
```

Assume:

destructor: user-defined

copy constructor: default

copy assignment: default

What is the output?

A. No output

B. 10 20

C. Segmentation fault

Copy assignment (operator=)

- For existing objects x, y, this statement calls the operator= function:

  x = y;

- Default behavior: Copies the member variables of rhs object (y) to lhs object (x)

```
Complex x(1, 2);
Complex y;
y = x;
cout << y;
```

Behavior of default copy assignment

x : 1 -> 2- > 5 -> null

```
void default_assignment_1(IntList& x){
   IntList y;
   y = x;
}
```

```
* 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(){
    IntList x, y;
    x.push_front(10);
    x.push_front(20)
   y = x;
   y.print()
}
```

What is the result of running the above code?

A. Prints 20, 10

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(){
   IntList x;
   x.push_front(10);
   x.push_front(20)
   IntList y(x);
   y.push_front(30);
   y.push_front(40);
   y = x;
   y.print()
}
```

What is the result of running the above code?

A. Prints 20, 10

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**

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

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