COMP 250

Lecture 8

stack

Sept. 25, 2017

What is a List (abstract) ?

```
get(i)        //  Returns the i-th element (but doesn't remove it)
set(i,e)      //  Replaces the i-th element with e
add(i,e)      //  Inserts element e into the i-th position
remove(i)     //  Removes the i-th element from list
remove(e)     //  Removes first occurrence of element e
              //   from the list (if it is there)
clear()       //  Empties the list.
isEmpty()     //  Returns true if empty, false if not empty.
size()        //  Returns number of elements in the list
:
```

This operations are defined without specifying the implementation details of the data structure (arraylist, linked list).

Abstract data type (ADT)

“ADT” defines a data type by the values and operations from the user’s perspective only.

It ignores the details of the implementation.

An ADT is more abstract than a data structure.

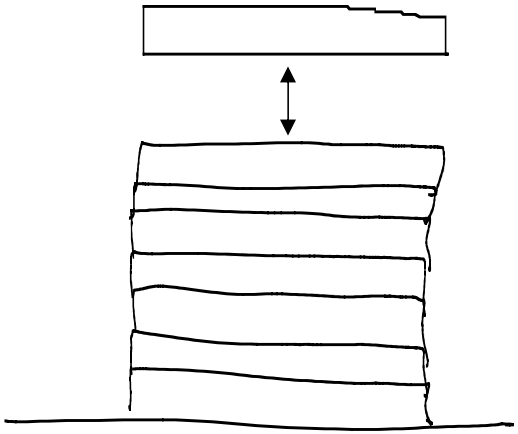
Stack ADT

push(element)

pop( )

isEmpty( )

peek( )



A stack is a list. However, it typically does not have operations to access the list element *i* directly.

How to implement a stack?

	push(e)	pop ()
array list		
singly linked list		
doubly linked list		

How to implement a stack?

	push(e)	pop ()
array list	addLast(e)	removeLast()
singly linked list		
doubly linked list		

How to implement a stack?

	push(e)	pop ()
array list	addLast(e)	removeLast()
singly linked list	addFirst(e)	removeFirst ()
doubly linked list		

How to implement a stack?

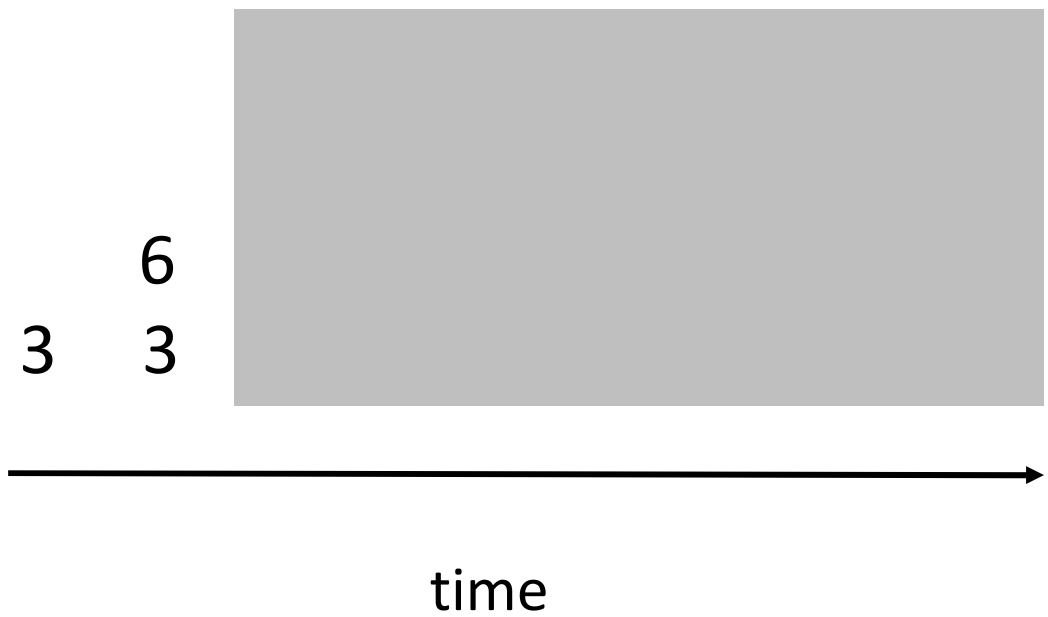
	push(e)	pop ()
array list	addLast(e)	removeLast()
singly linked list	addFirst(e)	removeFirst ()
doubly linked list	either row above	

Example 1: stack of int

push(3)
push(6)

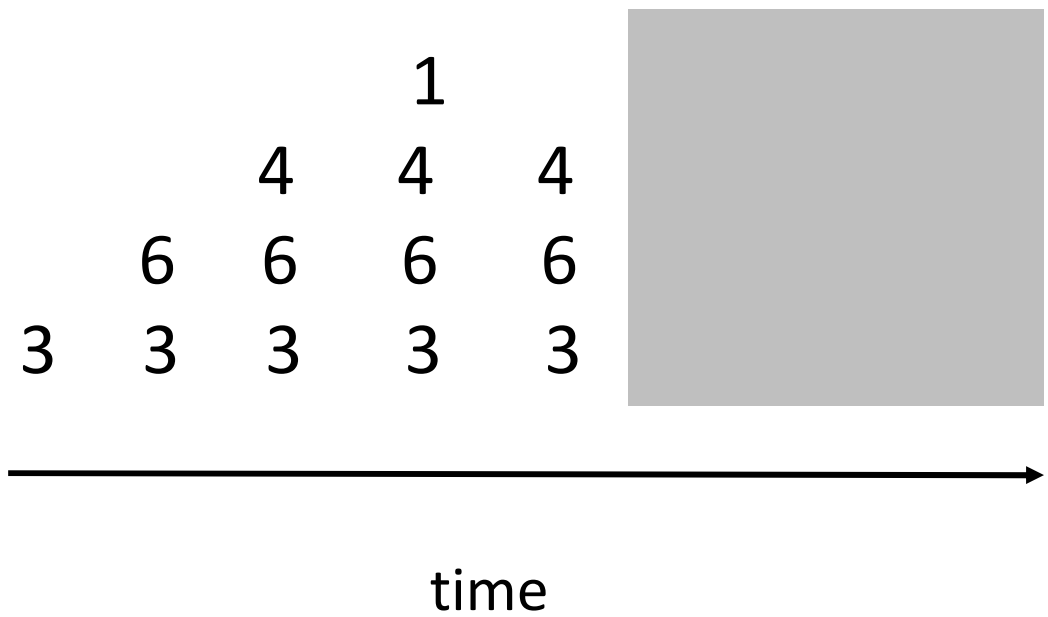
Example 1: stack of int

push(3)
push(6)
push(4)
push(1)
pop()



Example 1: stack of int

push(3)
push(6)
push(4)
push(1)
pop()
push(5)
pop()
pop()



Example 1: stack of int

push(3)
push(6)
push(4)
push(1)
pop()
push(5)
pop()
pop()

			1		5		
		4	4	4	4	4	
	6	6	6	6	6	6	6
3	3	3	3	3	3	3	3

time

Example 2 - balancing parentheses

e.g. (([ ])) [ ] { [ ] }

To ensure proper nesting, we traverse the list and use a stack.

How?

Example 2 - balancing parentheses

e.g. (([ ])) [ ] { [ ] }

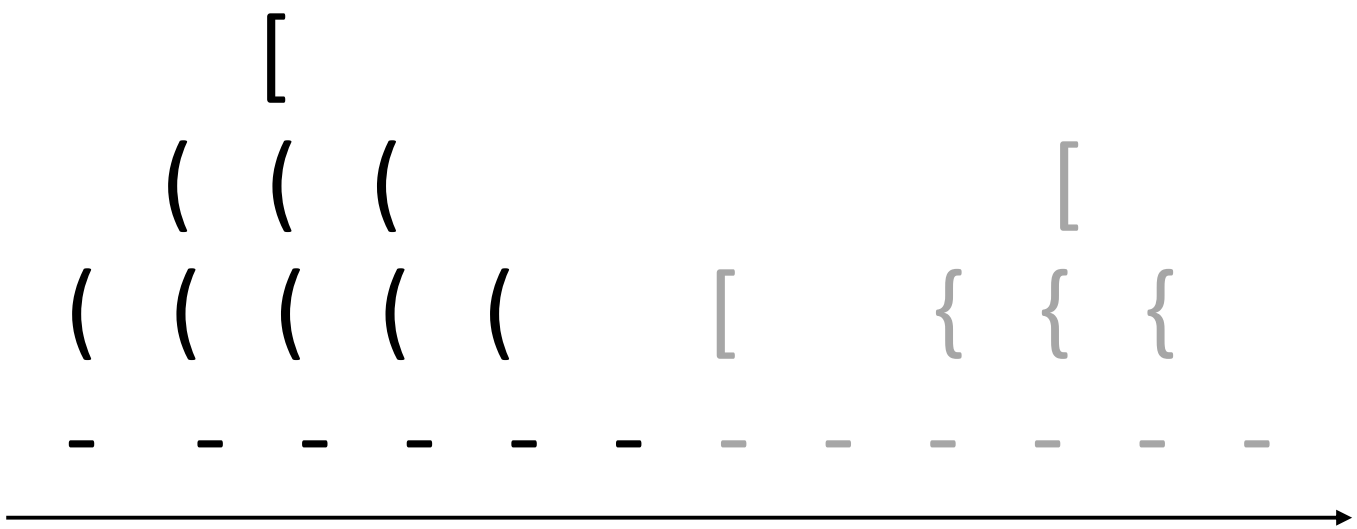
To ensure proper nesting, we traverse the list and use a stack.

We push left parentheses on the stack.

When we reach a right parenthesis, we compare it to top of the stack.

Example 2 - balancing parentheses

e.g. (([ ])) [ ] { [ ] }

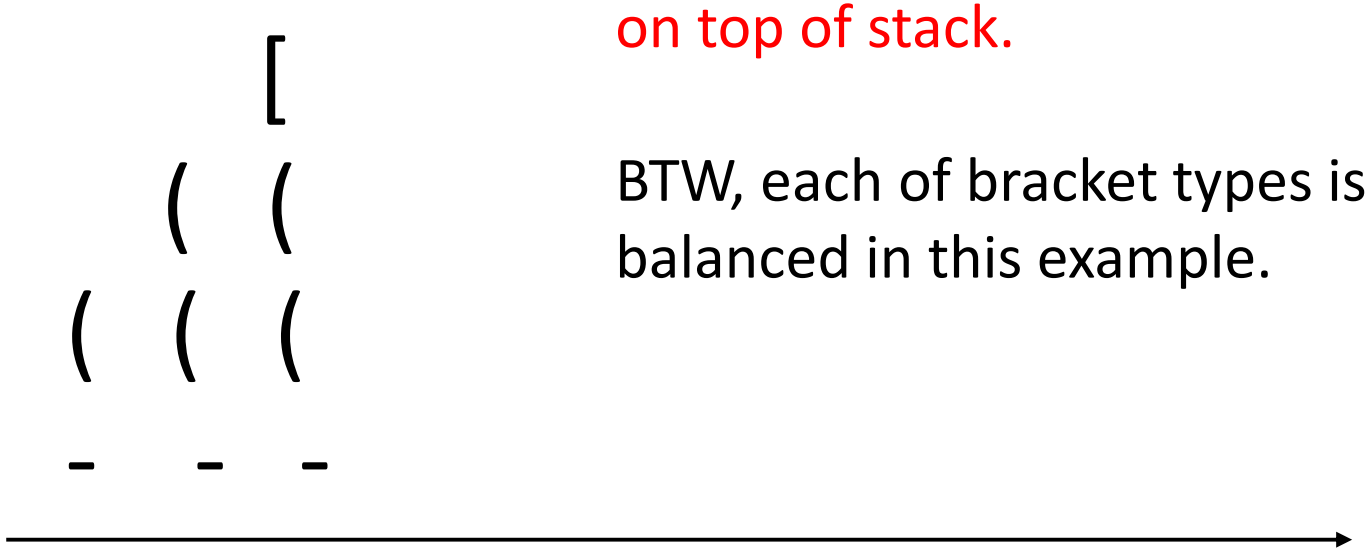


Example 2 - balancing parentheses

e.g. (([ ))] { [ ] }

Does not match left bracket on top of stack.

BTW, each of bracket types is balanced in this example.



// We refer to brackets as “tokens”. This is the more general term using in
// string parsing.

Algorithm: decide is parentheses are matched.
If yes, return true, else return false.

```
while (there are more tokens) {
   token  =  get next token
   if token is a left parenthesis
        push(token)
   else {                                  //  token is a right parenthesis
              if stack is empty
                 return false
              else {
                  pop left parenthesis from stack
                  if  popped left parenthesis doesn’t match the right parenthesis
                        return false
               }
          }
}
return  stack.empty   //   true if stack is empty,  false if not.
```

Example 3: HTML tags

 I am bold. < i > I am italic. < /i >

I am bold. *I am italic.*

HTML Elements

An HTML *element* starts with a start tag.
An HTML *element* ends with an end tag.

HTML documents consist of nested HTML *elements*.

```
<html>
<body>
<b>  I am bold </b>
<i>  I am italic </i>
</body>
</html>
```

These tags can be thought of as brackets.

Suppose you want:

I am bold. ***I am bold and italic.*** *I am italic.*

What if you were to write the following ?

 I am bold. I am bold and italic. I am italic.

Suppose you want:

I am bold. ***I am bold and italic.*** *I am italic.*

What if you were to write the following ?

 I am bold. I am bold and italic. I am italic.

This is *officially* incorrect, because elements are not nested.

< i >

____   Error: mismatch between

Most web browsers will interpret it correctly, however.

I am bold. ***I am bold and italic.*** *I am italic.*

The correct way to write it is:

 I am bold. I am bold and italic.   I am italic.

		< i >				
___	< b >	< b >	< b >	___	< i >	___

What problems can arise if you write it incorrectly?

Suppose you are editing a html document that contains the following:

… Hello. I am bold.

<i> I am bold and italic. I am italic. **< /i >**

Bla bla bla ……

Q: What happens if you delete the middle line ?

What problems can arise if you do not write it correctly?

Suppose you are editing a html document that contains the following:

… Hello. I am bold.

<i> I am bold and italic. I am italic. < /i >

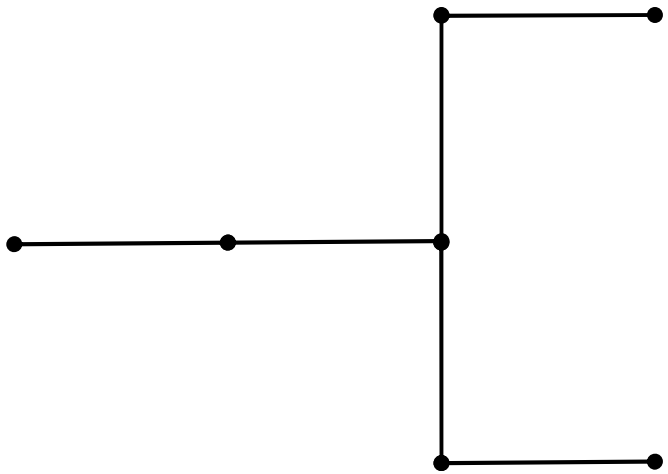
Bla bla bla ……

Q: What happens if you delete the middle line ?

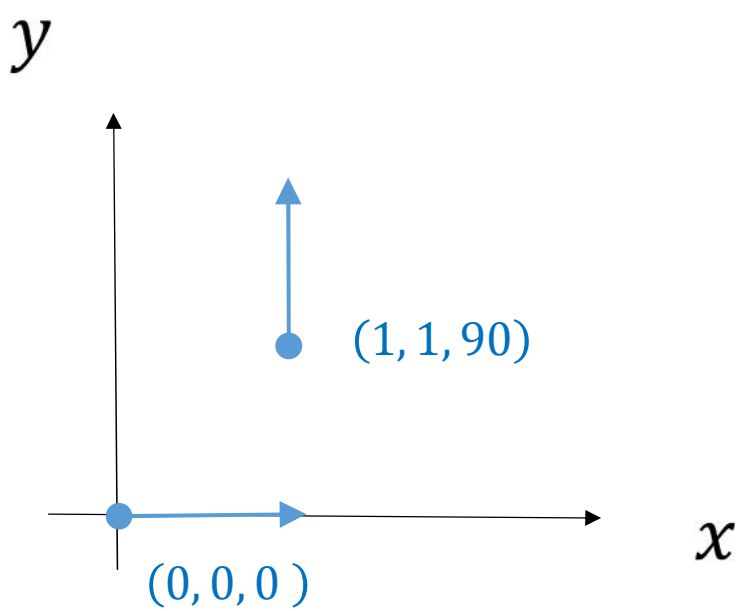
A: … Hello. **I am bold. Bla bla bla ……**

Example 4: Stacks in Graphics

Define a ‘programming language’ for drawing simple figures like this:



Define a pen position and direction (x, y, θ) where θ is clockwise degrees from x axis.



The initial state of the pen is (0, 0, 0).

Let instructions be symbols :

D - draw unit length line in direction (changes (x, y))

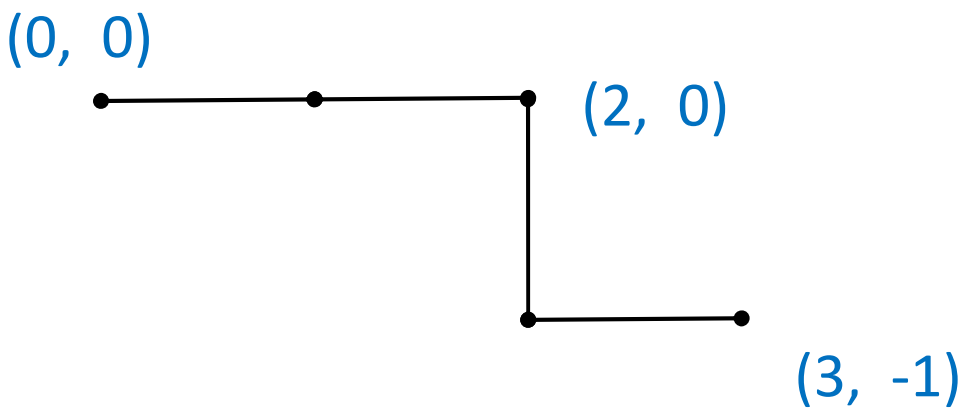
R - turn right 90 degrees clockwise (changes θ)

L - turn left 90 degrees counterclockwise (changes θ)

[- push state (x, y, θ)

] - pop state, and go to that state

The initial state of the pen is (0, 0, 0).

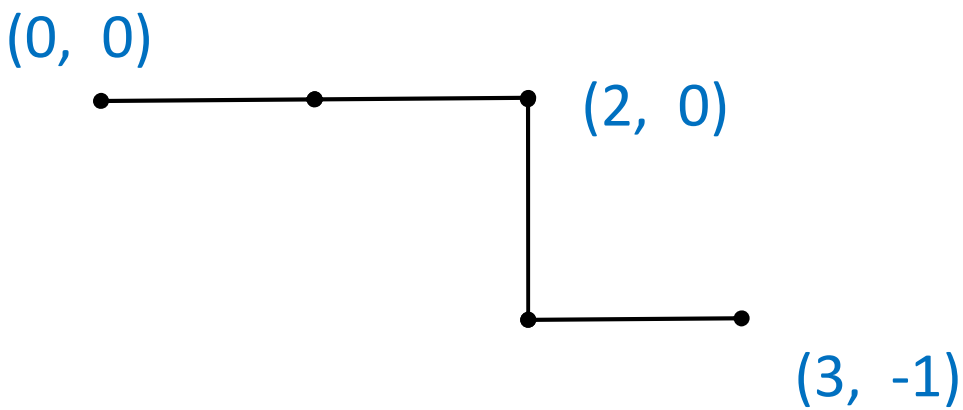


D D R D L D

D - draw
R - turn right
L - turn left
[- push state
] - pop state

The final pen state is (3, -1, 0).

The initial state of the pen is (0, 0, 0).

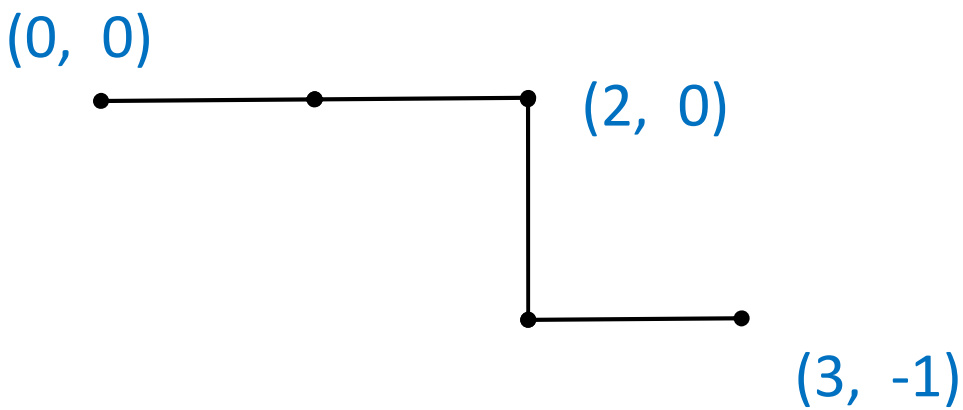


D - draw
R - turn right 90 deg
L - turn left 90 deg
[- push state
] - pop state

D D [R D L D]

Q: What will be the final pen state ?

The initial state of the pen is (0, 0, 0).



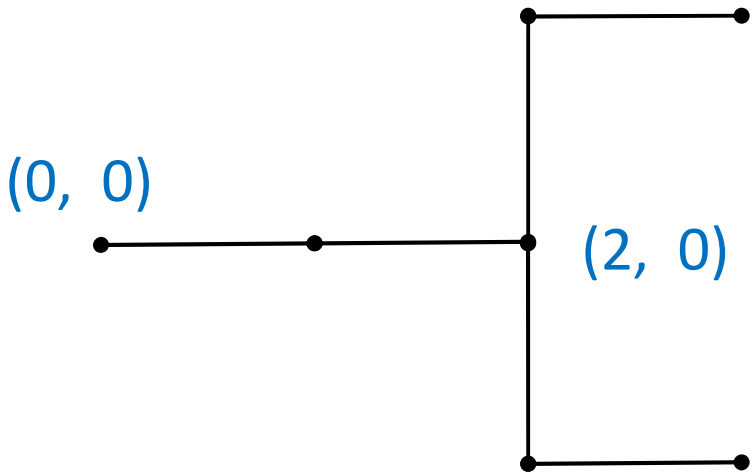
D - draw
R - turn right 90 deg
L - turn left 90 deg
[- push state
] - pop state

D D [R D L D]

Q: What will be the final pen state ?

A: (2, 0, 0)

The initial state of the pen is (0, 0, 0).



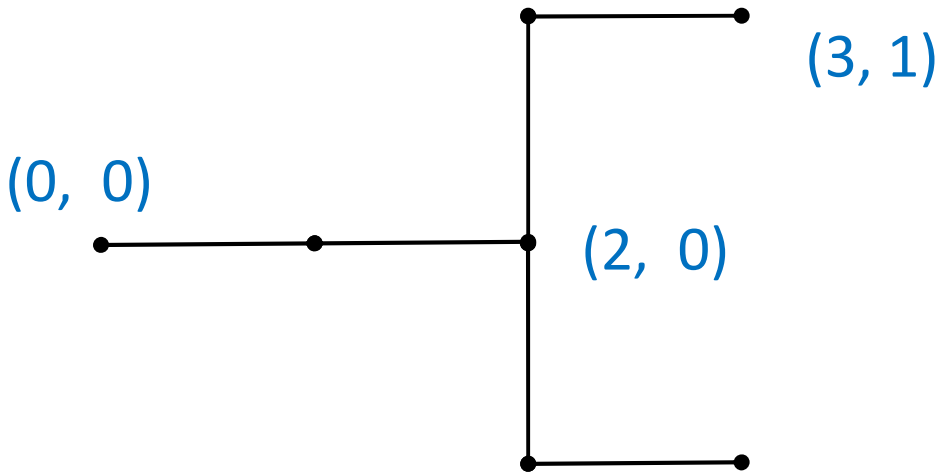
D - draw
R - turn right 90 deg
L - turn left 90 deg
[- push state
] - pop state

D D [R D L D] L D R D

_____ (2, 0, 0) _____

Q: What will be the final pen state ?

The initial state of the pen is (0, 0, 0).



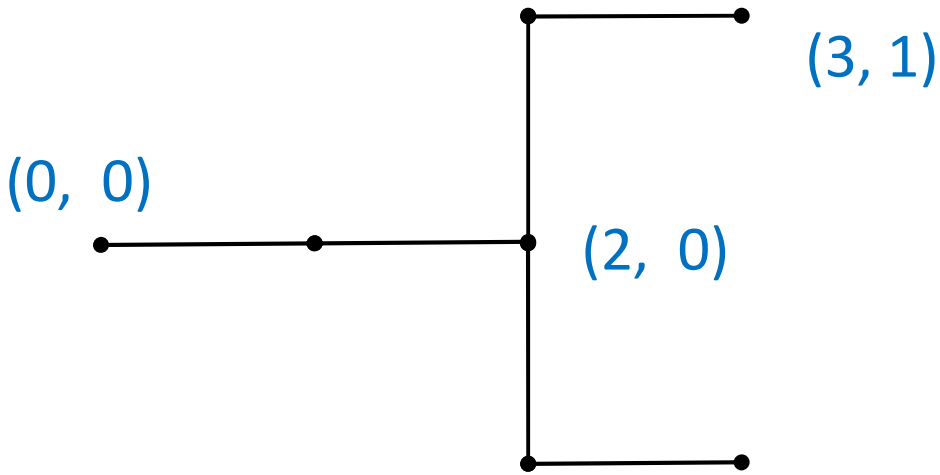
D - draw
R - turn right 90 deg
L - turn left 90 deg
[- push state
] - pop state

D D [R D L D] L D R D

_____ (2, 0, 0) _____

Q: What will be the final pen state ?
A: (3, 1, 0)

The initial state of the pen is (0, 0, 0).

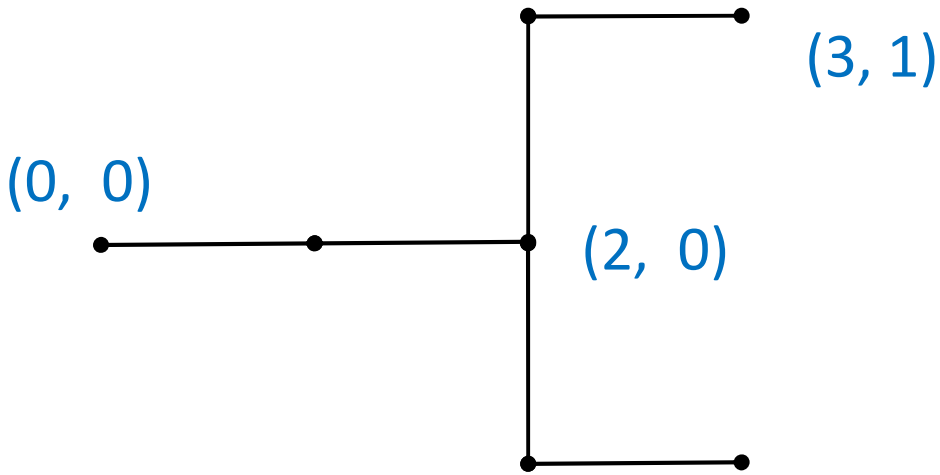


D - draw
R - turn right 90 deg
L - turn left 90 deg
[- push state
] - pop state

Q: What if we add brackets at beginning and ending ?

[D D [R D L D] L D R D]

The initial state of the pen is (0, 0, 0).



D - draw
R - turn right 90 deg
L - turn left 90 deg
[- push state
] - pop state

Q: What if we add brackets at beginning and ending ?

[D D [R D L D] L D R D]

A: The pen state will return to (0, 0, 0).

Example 5a : stack of tasks

As I work in my office, emails arrive, the phone rings, people drop by, …..

To make sure items all get finished, I must keep a stack.
(“What was I doing when ….? “)

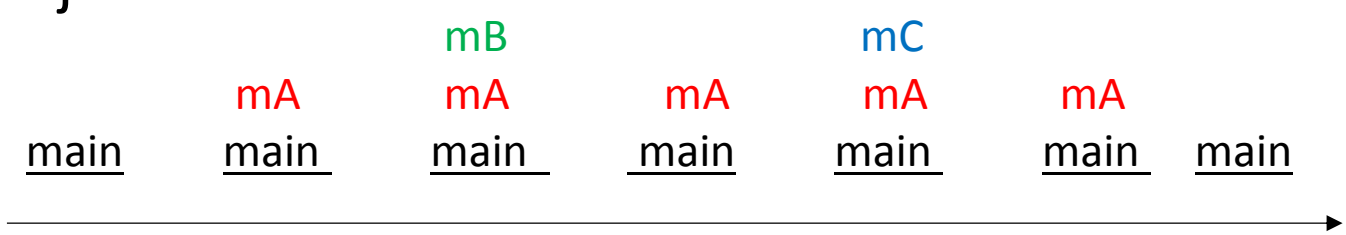
Example 5b : “Call Stack”

```
class   Demo {
    void   mA( ) {
                mB( );
                mC( );
            }
    void  mB( ) { … }
    void  mC( ) { … }

    void  main( ){
                mA(  );
        }
}
```

```
class   Demo {
   void   mA( ) {
              mB( );
              mC( );
           }
   void  mB( ) { … }
   void  mC( ) { … }

   void  main( ){
              mA(  );
        }
}
```



Eclipse debug mode

Debug -

File Edit Source Refactor Navigate Search Project Pydev Run Window Help

Debug

TestSLinkedList1.java | SLinkedList1.java

```
public static void main(String[] args){

    //  HERE IS A SIMPLE TEST.

    SLinkedList1<String> list = new SLinkedList1<

    list.addFirst("a");
    list.addLast("b");
    list.addLast("c");
    list.addLast("d");
    list.addLast("e");
```

TestSLinkedList1's main() method calls addLast() method of SLinkedList class.

Eclipse debug mode

call stack

breakpoint

Debug -

File Edit Source Refactor Navigate Search Project Pydev Run Window Help

Debug

TestSLinkedList1 [Java Application]

linkedlists.TestSLinkedList1 at localhost:52013

Thread [main] (Suspended (breakpoint at line 85 in SLinkedList1))

SLinkedList1<E>.addLast(E) line: 85

TestSLinkedList1.main(String[]) line: 14

C:\Program Files\Java\jre7\bin\javaw.exe (Sep 19, 2016, 4:14:02 PM)

TestSLinkedList1.java | SLinkedList1.java

```
78      /**
79       * add a new element to the end of the list
80       * @param element  the new element
81       */
82
83      public void addLast(E element){
84          SNode<E> newNode = new SNode<E>(element);
85          size++;
86          if (head == null){
87              head = newNode;
88              tail = newNode;
```

Quiz 1 is today

8 AM to 8 PM