

COMP 250

INTRODUCTION TO COMPUTER SCIENCE

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Week 1-1: Stacks

Giulia Alberini, Fall 2020

Slides adapted from Michael Langer's

WHAT ARE WE GOING TO DO IN THIS VIDEO?



- **Stacks**

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ABSTRACT DATA TYPE (ADT)

An ADT is a model for a data type. It defines a data type by its behavior from the user's perspective only. It describes the possible values and the set of possible operations on the data type.

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It ignores the details of the implementation.

An ADT is more abstract than a data structure. A data structure is a concrete representation of data which includes the implementation details.

LIST ADT

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

These operations can be defined abstractly, without specifying the implementation details of the data structure (e.g. arraylist, or linked list)

STACK ADT

push(element)

pop()

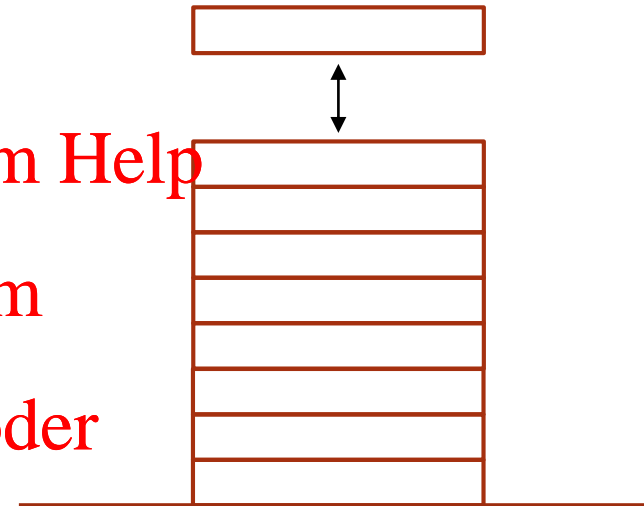
isEmpty()

peek()

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A stack is a list. However, it typically does not have operations to access the list element i directly. Instead one accesses only the element at one end of the list.

HOW TO IMPLEMENT A STACK?

push(e)

pop ()

array list

singly linked list

doubly linked list

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HOW TO IMPLEMENT A STACK?

push(e)

pop ()

array list

singly linked list

doubly linked list

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addLast(e)

removeLast()

*Java ArrayList class doesn't have addLast and removeLast methods

HOW TO IMPLEMENT A STACK?

push(e)

pop ()

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array list

addLast(e)

removeLast()

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singly linked list

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addFirst(e)

removeFirst()

doubly linked list

*Why not use addLast and removeLast with singly linked lists?

HOW TO IMPLEMENT A STACK?

push(e)

pop ()

array list

singly linked list

doubly linked list

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addLast(e)

addFirst(e)

removeLast()

removeFirst()

either row above

EXAMPLE 1: STACK OF INT

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

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time

EXAMPLE 1: STACK OF INT

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

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EXAMPLE 1: STACK OF INT

`push(3), push(6), push(4), push(1), pop(), push(5), pop(), pop(), ...`

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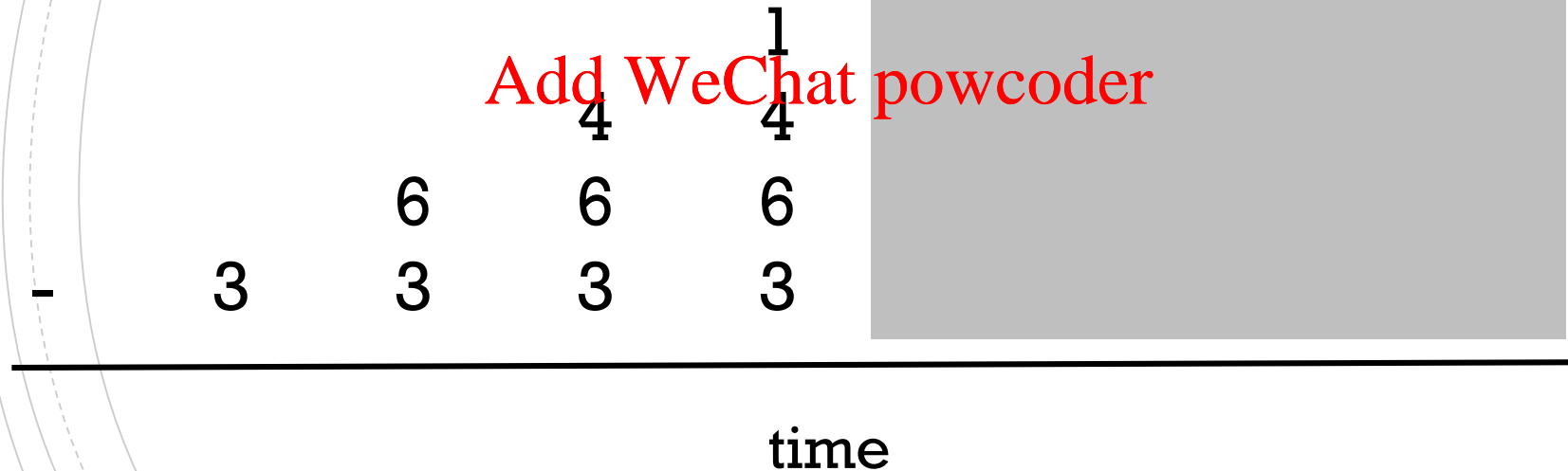
EXAMPLE 1: STACK OF INT

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

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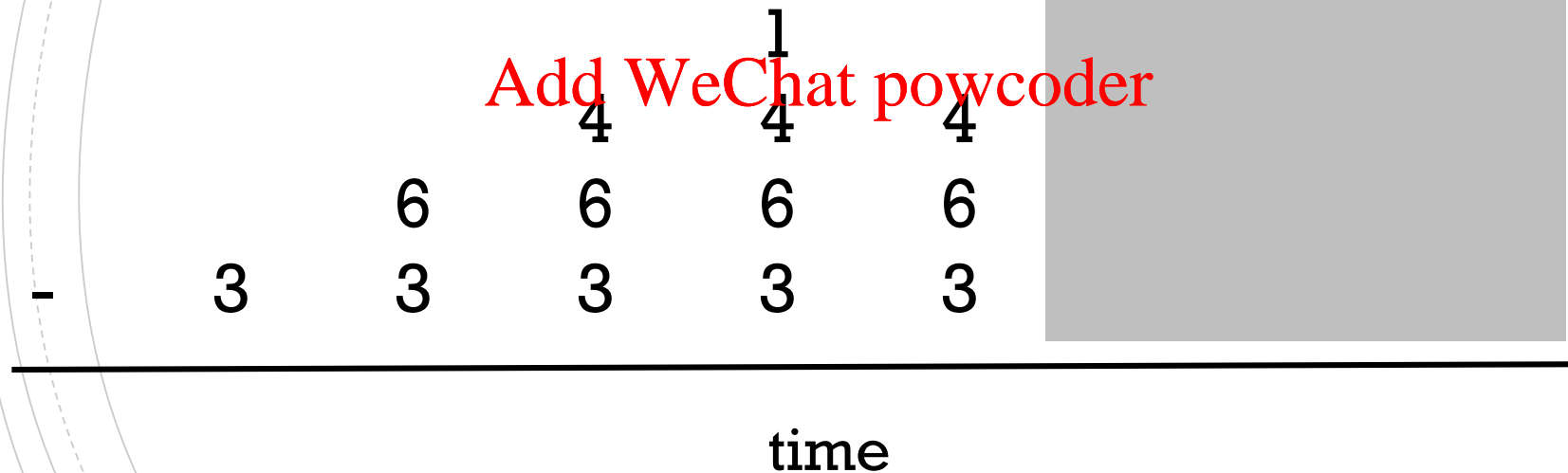
EXAMPLE 1: STACK OF INT

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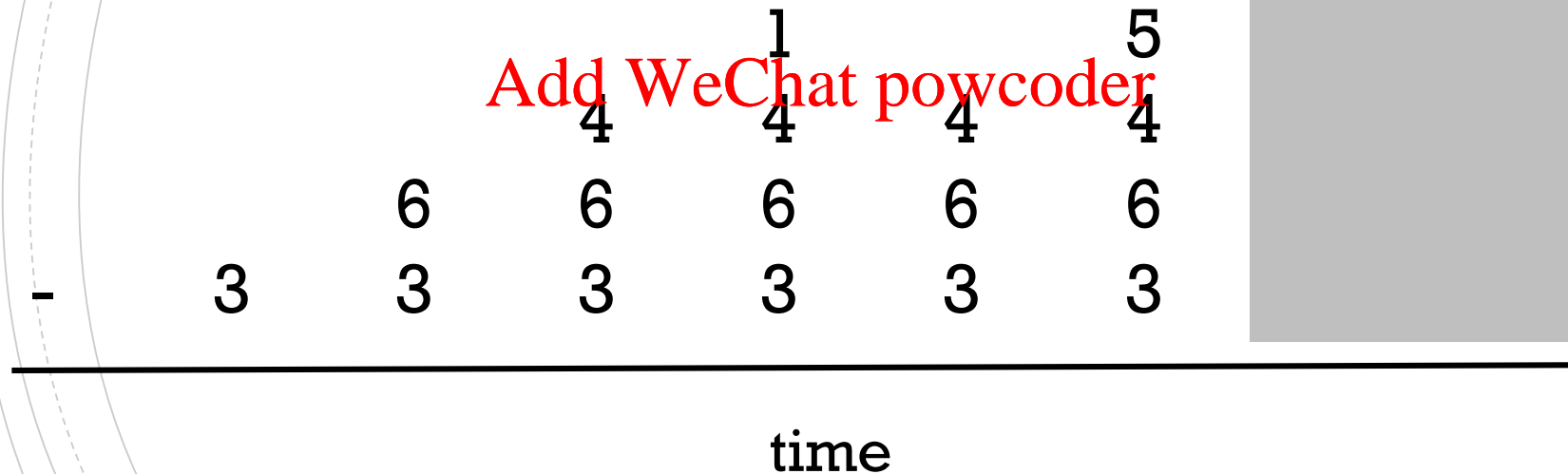
EXAMPLE 1: STACK OF INT

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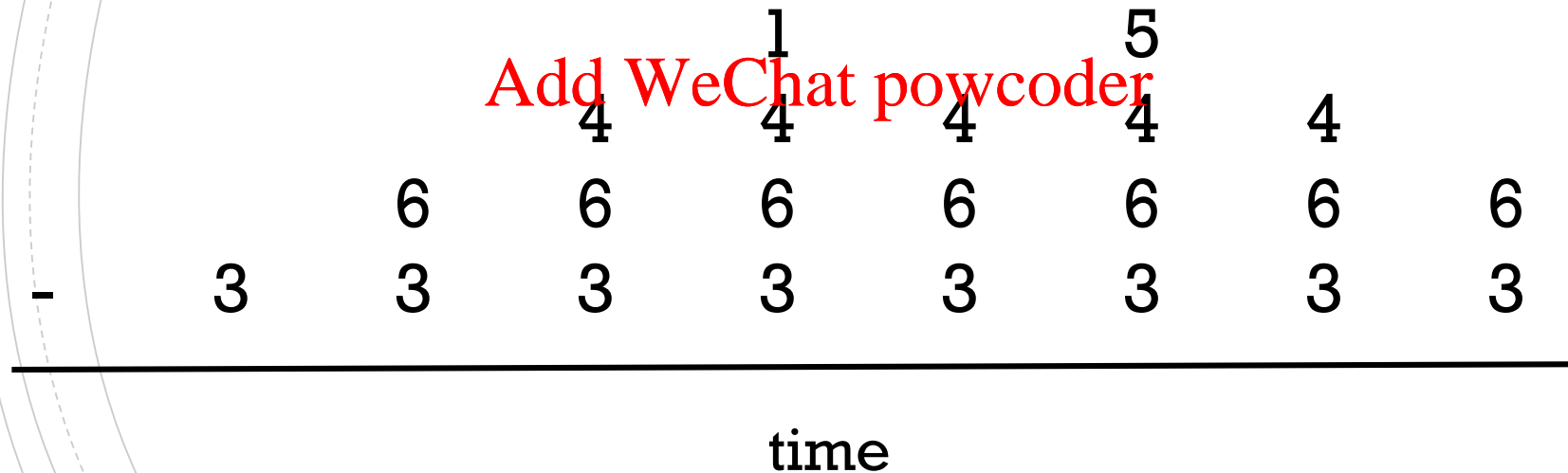
EXAMPLE 1: STACK OF INT

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

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EXAMPLE 2 - BALANCING PARENTHESES

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

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

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How?

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EXAMPLE 2 - BALANCING PARENTHESES

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

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

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How? When we reach a *left* parenthesis, we *push* it onto the stack.

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When we reach a *right* parenthesis, we compare it to top of the stack. If it matches, then we *pop*, otherwise we found an error.

EXAMPLE 2 - BALANCING PARENTHESES

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

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((([

EXAMPLE 2 - BALANCING PARENTHESES

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

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(((([((((

EXAMPLE 2 - BALANCING PARENTHESES

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

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EXAMPLE 2 - BALANCING PARENTHESES

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

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EXAMPLE 2 - BALANCING PARENTHESES

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

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`(((((_ [_`

etc

EXAMPLE 2 - BALANCING PARENTHESES

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

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Does not match left bracket on top of stack.
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(
(
(
[
(
(
(

BALANCING PARENTHESES - PSEUDOCODE

Algorithm: decide if parentheses are matched.

```
while (there are more tokens) { // We refer to brackets as "tokens". This is the
    token = get next token      // more general term using in string parsing.
    if token is a left parenthesis
        push(token)
    else {
        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.

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EXAMPLE 3: HTML TAGS

Supposed you'd like to write the following sentence:

I am bold. *I am italic.* <https://powcoder.com>

In html, you would write: Add WeChat powcoder

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

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>
```

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These tags can be thought of as brackets.

EXAMPLE 3: HTML TAGS

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

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EXAMPLE 3: HTML TAGS

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

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

`< i >` **Error: mismatch** between `<i>` ``

`` ``

Most web browsers will interpret it correctly, however.

EXAMPLE 3: HTML TAGS

Suppose you want:

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

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The correct way to write it is:

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

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

EXAMPLE 3: HTML TAGS

What problems can arise if you write it incorrectly?

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

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... 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?

EXAMPLE 3: HTML TAGS

What problems can arise if you write it incorrectly?

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

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... 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**

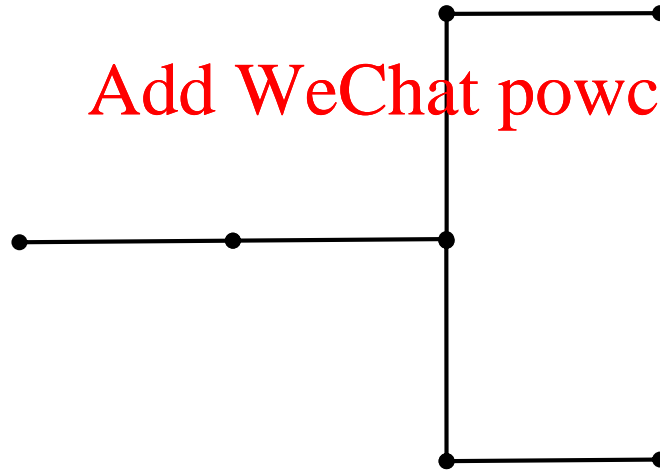
EXAMPLE 4: STACKS IN GRAPHICS

Define a 'programming language' for drawing simple figures like this:

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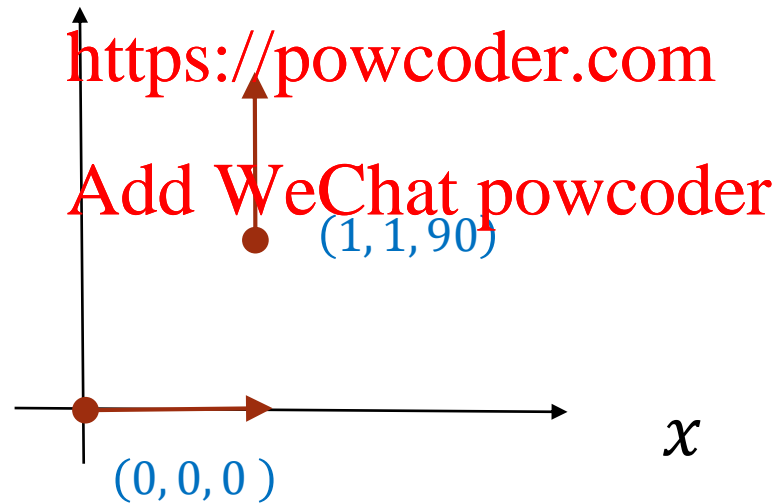
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EXAMPLE 4: STACKS IN GRAPHICS

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

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

EXAMPLE 4: STACKS IN GRAPHICS

Let instructions be symbols :

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

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R - turn right 90 degrees (changes θ)

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L - turn left 90 degrees (changes θ)

[- push state (x, y, θ)

] - pop state, and go to that state

EXAMPLE 4: STACKS IN GRAPHICS

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

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

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D D R D L D

$(0, 0)$ <https://powcoder.com>

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EXAMPLE 4: STACKS IN GRAPHICS


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

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

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D D R D L D

$(0, 0)$ <https://powcoder.com>
Add WeChat powcoder $(2, 0)$



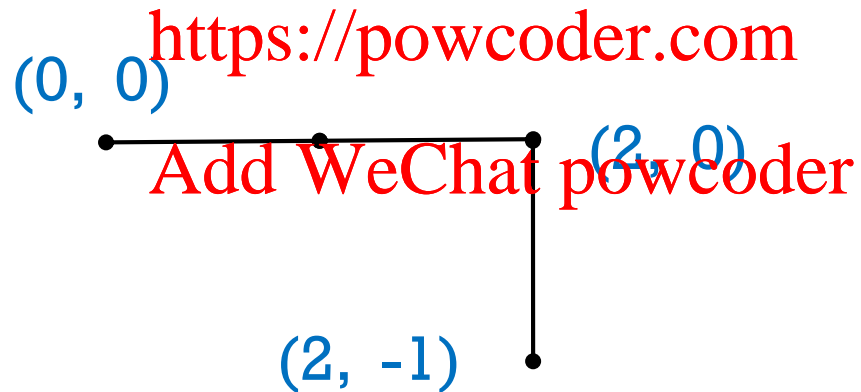
EXAMPLE 4: STACKS IN GRAPHICS

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

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

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D D R D L D



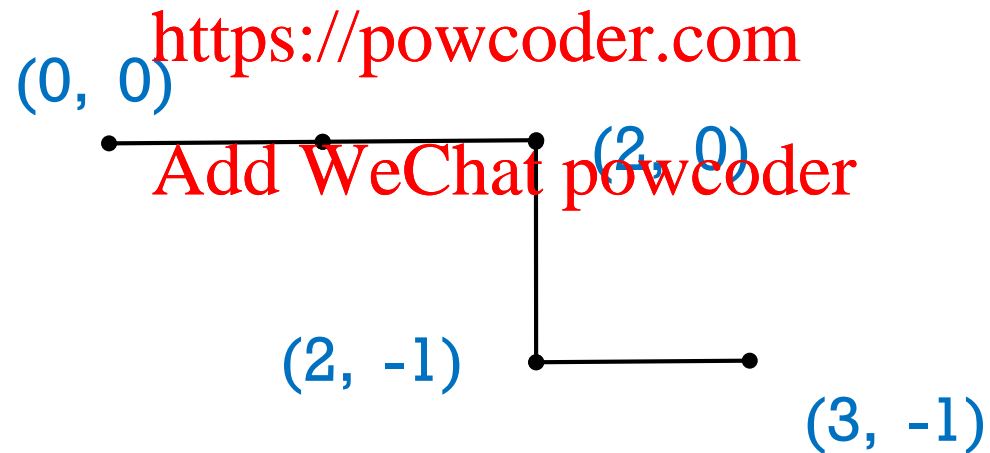
EXAMPLE 4: STACKS IN GRAPHICS

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

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

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D D R D L D



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

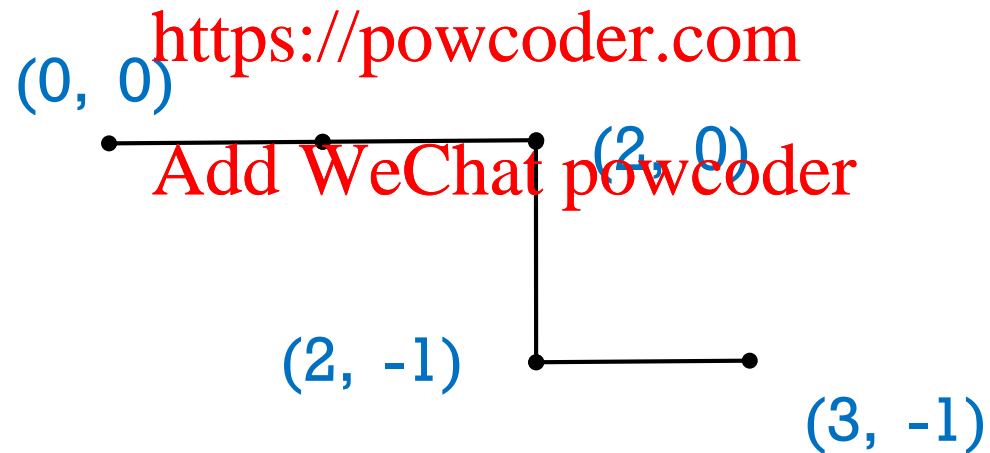
EXAMPLE 4: STACKS IN GRAPHICS

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

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

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D D [R D L D]



Q: What will be the final pen state?

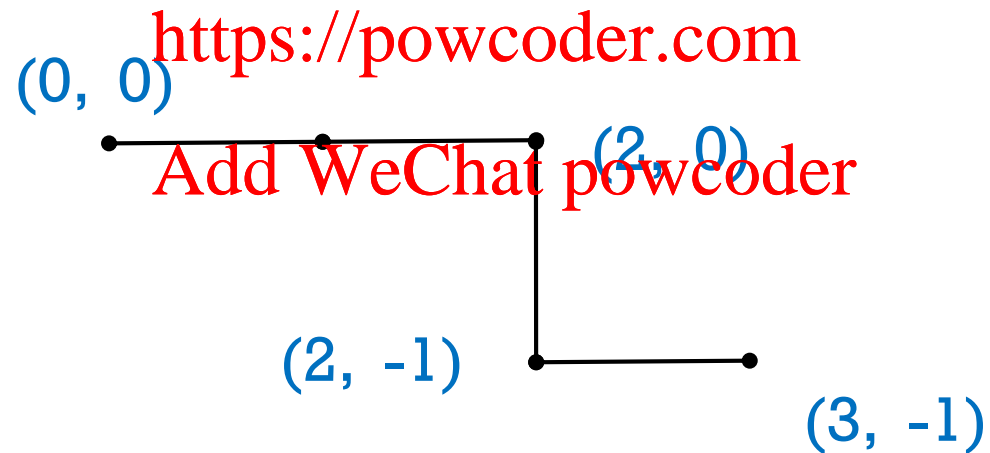
EXAMPLE 4: STACKS IN GRAPHICS

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

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

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D D [R D L D]



Q: What will be the final pen state?

A: $(2, 0, 0)$

EXAMPLE 4: STACKS IN GRAPHICS

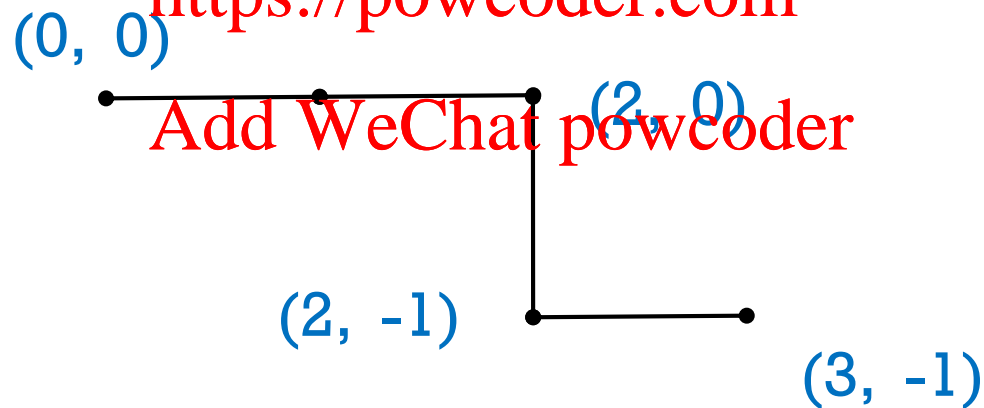
D	-	draw
R	-	turn right
L	-	turn left
[-	push state
]	-	pop state

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

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

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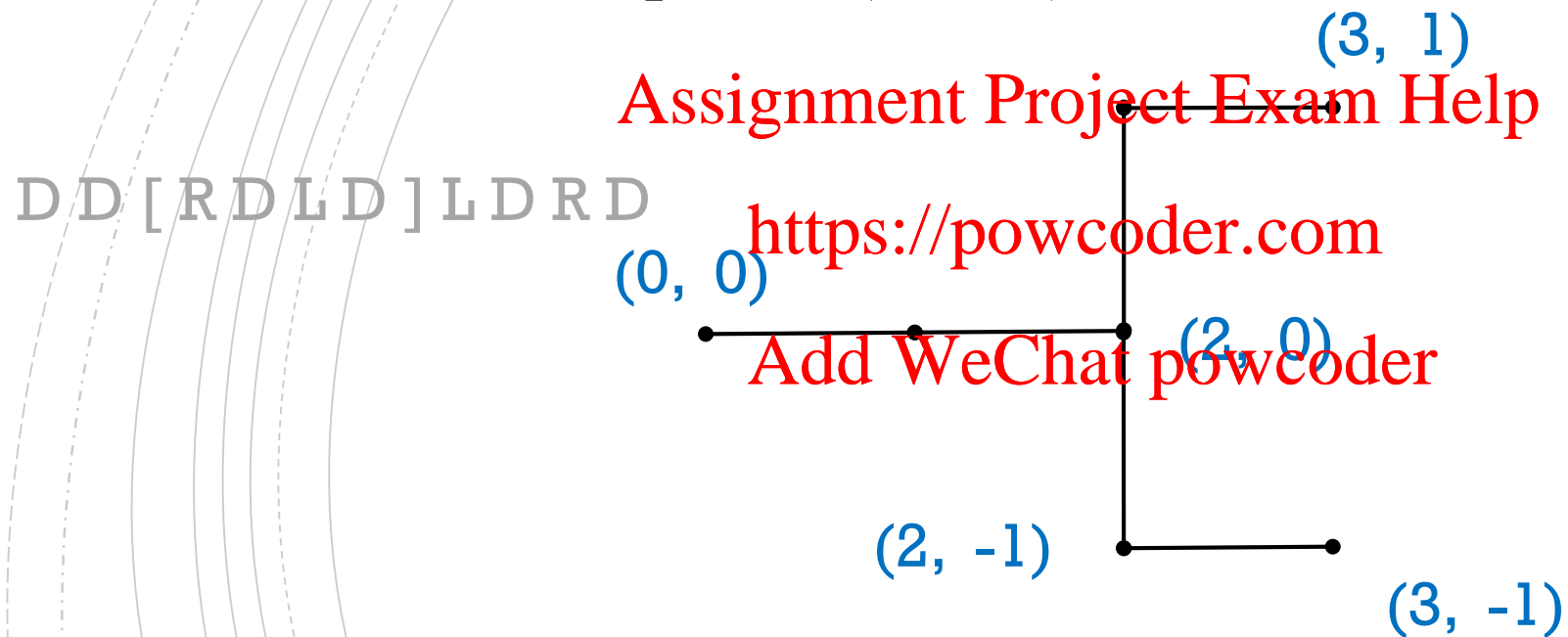


Q: What will be the final pen state?

EXAMPLE 4: STACKS IN GRAPHICS

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

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



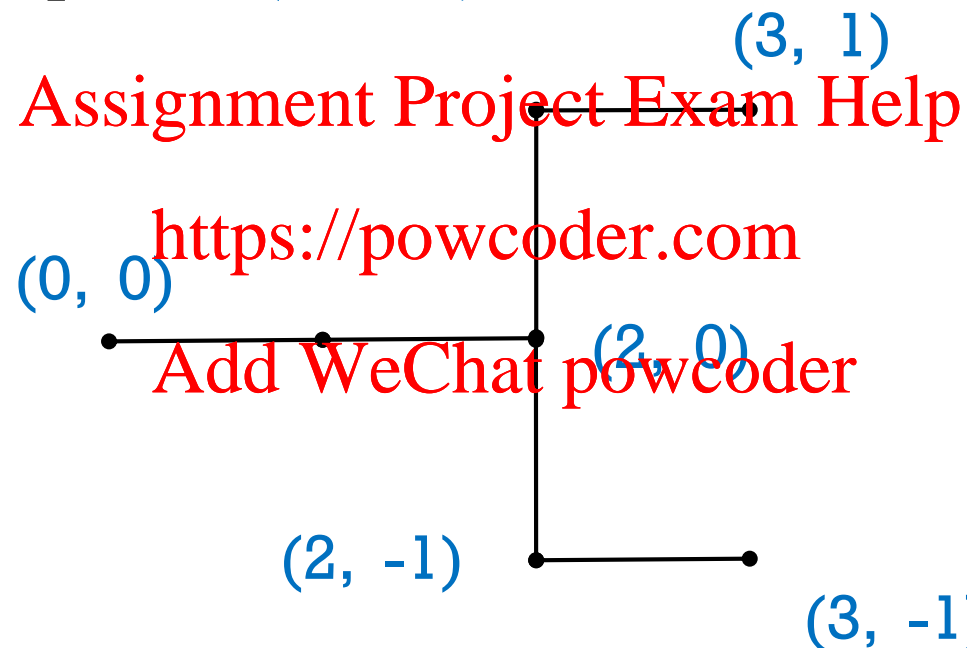
Q: What will be the final pen state?

A: $(3, 1, 0)$

EXAMPLE 4: STACKS IN GRAPHICS

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

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



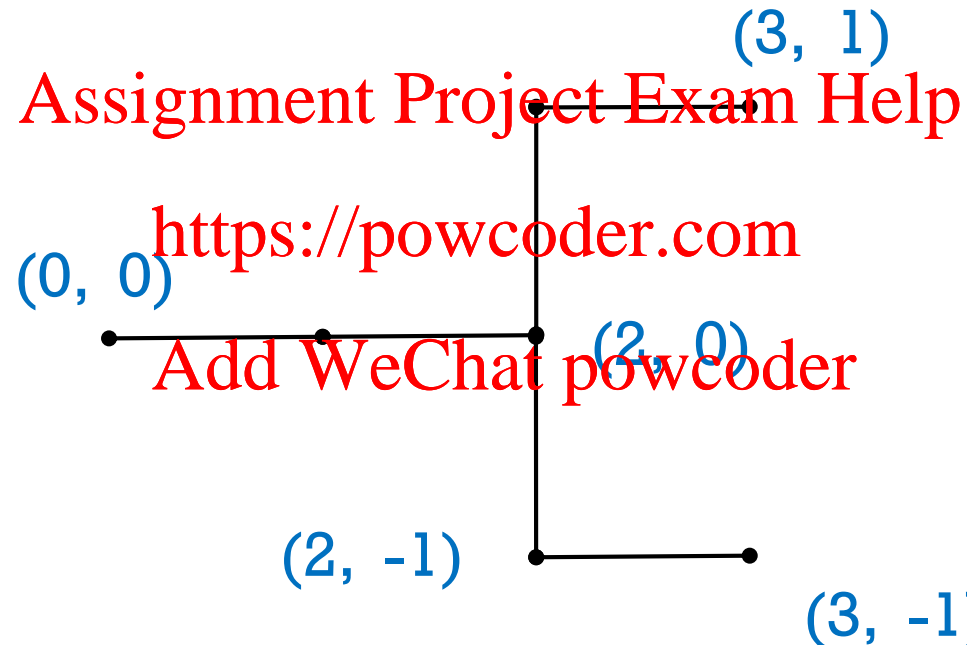
Q: What if we add brackets at the beginning and at the end?

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

EXAMPLE 4: STACKS IN GRAPHICS

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

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



Q: What if we add brackets at the beginning and at the end?

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

A: $(0, 0, 0)$

EXAMPLE 5: "CALL STACK"

```
class Demo {  
    void mA () {  
        mB ();  
        mC ();  
    }  
    void mB () { ... }  
    void mC () { ... }  
  
    public static void main(String[] args) {  
        mA ();  
    }  
}
```

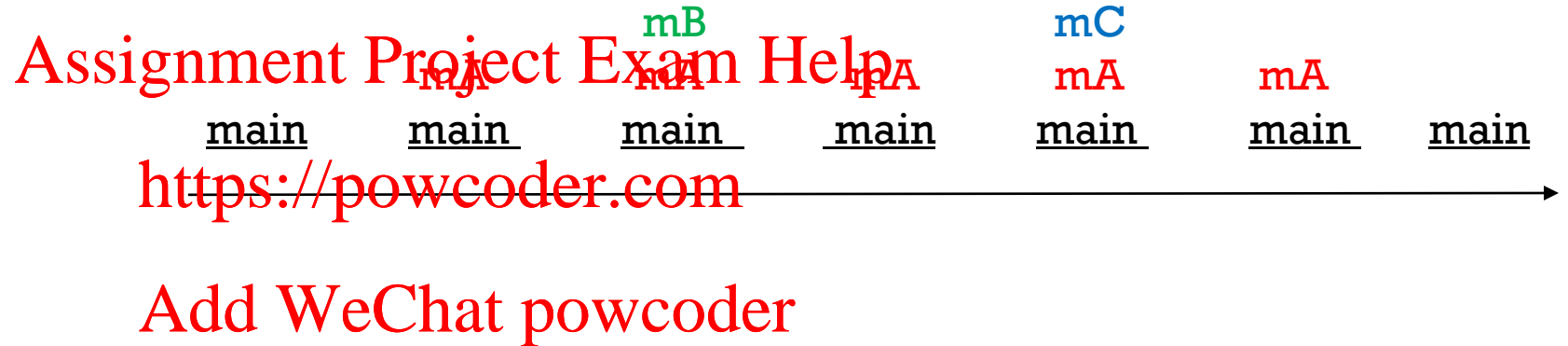
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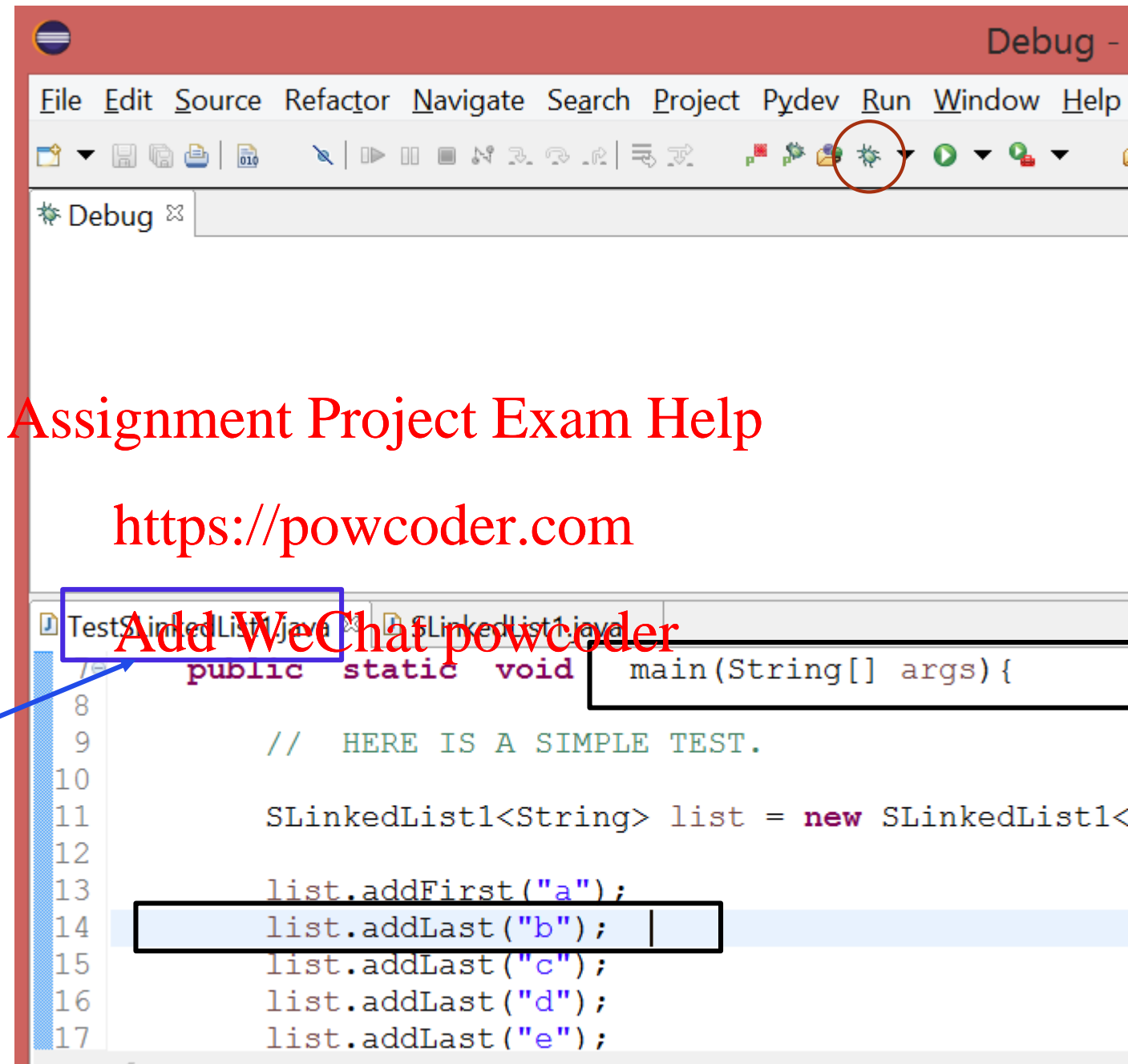
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EXAMPLE 5: "CALL STACK"

```
class Demo {  
    void mA () {  
        mB ();  
        mC ();  
    }  
    void mB () { ... }  
    void mC () { ... }  
  
    public static void main(String[] args) {  
        mA ();  
    }  
}
```



Eclipse debug mode



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

call stack

Debug -

File Edit Source Refactor Navigate Search Project Pydev Run Window Help

Debug

TestSLinkedList1 [Java Application]

linklists.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;
```

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breakpoint in the
SLinkedList1.addLast()
method

OVERFLOW AND UNDERFLOW

- **Stack overflow**

It happens if a stack has a finite capacity, and we attempt to push.

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- **Stack underflow**

It happens if when a stack is empty we attempt to pop.



Coming Soon

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In the next video:

■ Queues <https://powcoder.com>

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