# Comprehensive Practice
# Section Two: Expression Evaluation

**Group ID: 1**

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## Problem Statement :

Write a program that evaluates fully parenthesized arithmetic expressions using the standard operators for addition, subtraction, multiplication, and division, and a special operator for exponentiation ("^").

e.g.: (18.4-((2.3*8.5)/(19.5+(2.7^4.9))))

## Our Approach to The Problem:

If we decompose the problem, we find that there's two critical steps to be taken care of in this problem.

First, we look at the steps in general to solve the problem.

1. Take an input (mathematical expression)
2. Tokenize the input- recognize which characters together makes up one token
3. Evaluate the expression – determine which part/sub-expression to be evaluated first.

From above we can see, the two critical parts are tokenization and evaluation.

For tokenization, we create a supporting class called StringSplitter. To handle the evaluation part we use famous Shunting-Yard algorithm by Edsger Dijkstra.

## Psrocedure in Brief OR main() Method from Client Program:

¬ Take input using Scanner and put it into a String variable

¬ Take an instance of StringSplitter to tokenize the input

//create to Stacks in order to implement the Shunting-Yard algorithm.

//number stack for num values, symbmol stack for symbols

¬ NumberStack = new Stack(), symbolStack =new Stack();

¬ Evaluate the expression

¬ If no error encountered, print result

¬ Else print Illegal Expression

## StringSplitter Class:

- Fields:
  - Private Queue<Character> characters;
  - Private String token;
  - Constant String SPECIAL_CHARS="()+-*/^";
- Constructor:
  - Parameter: String line
  - Initialize character
  - Put each char of line into characters queue
- Methods:

- hasNext()
  - if there's no more token returns false, otherwise true

- next()
  - Returns the next token

- findNextToken()

## FindNextToken() or Tokenization:

- Few Ground Rules:
  - No white space
  - If it belongs to any of our special characters, it's a token
  - Numbers together – one token

### Pseudocode – Tokenization:

- Peek if the first elem of the queue is a white space
  - If so - remove()

  //the queue could be empty at this point

- If the queue is empty : token = null
- Else
  - Ch = first element of the queue

    //we'll set token as ch, but before that we need check if ch is legal according to our problem statement

  - If ch is a digit or a dot or a SPECIAL_CHARACTER
    - Initialize token as ch;

- Else
  - print – ch is not legal!!
  - throw IllegalArgumentException

- If (token is not a SPECIAL_CHAR)//then it's a num
  - Boolean done = false; //we're done one done when we took all the contiguous digits as a token
  - while(queue is not empty and not done)
    - Ch2 = queue.peek();
    - If ch2 is a whitespace or special_char: done = true
    - Else if ch2 is a digit or a dot: token = token+queue.remove()
    - Else
      - print - ch2 is not legal!!
      - throw IllegalArumentException

- return token;

## Evaluation() from client class:

## Overview of the method:

- Does two things:
  - Evaluates the expression and returns false if no error encountered
  - Returns true if any error encountered
- Formal parameters:
  - StringSplitter splitter, Stack numStack, Stack symbolStack
- Returns boolean err_flag

## Pseudo-code of Evaluate() Method:

- Boolean err_flag = false;
- While no error and there's more token:
  - Str = next token
  - If str isNumereic: s=numStack.push(str);
- Else
  - If str is "(" or an operator: symbolStack.push(str)
  - Else if str is ")": //go on and evaluate the sub-expr
    - Num2=numStack.pop(), num1 =numStack.pop();
    - Operator = symbolStack,pop();
    - if  operator is not any of "+-*/":
      - print – operator(var)+"is in the place of an operator!!"
      - print – Error in parenthesis \n Check ur Input!!
      - return true;

        - Result = calculate(num1, num2, operator)
        - NumStack.push(result)
        - If symbolStack not empty: symbolStack.pop()
- Else  err_flag = true;
- Return err_flag

## Other Methods in Client Class

- IsNumeric(String str):
    - Return str.matches("-?\\d+(\\.\\d+)?");
- Calculate(double num1, double num2, String operator):
    - Result = num1 “operator” num2;//for details – plz refer to the source code

# Source Code:

# StringSplitter Class:

```
import java.util.LinkedList;
import java.util.Queue;

/**
 * StringSplitter class is a supporting class which helps
us to tokenize a
 * String the way we want.
 *
 * @author emmaka
 * @since
 */

public class StringSplitter {
     // ----------------
Fields-----------------------------
     private Queue<Character> characters;
     private String token;
     public static final String SPECIAL_CHARACTERS = "()
+-*/^";

     // -------------------
Constructor--------------------------
     /**
      * This is the constrcor of StringSplitter class. It
takes a {@code String} from
      * the class that uses this class and tokenizes the
{@code String}. First It
      * puts each {@code char} of the String into a
Queue.
      *
      * @param line A {@code String}
      */
     public StringSplitter(String line) {
          characters = new LinkedList<Character>();
          // put all each char into a queue
          for (int i = 0; i < line.length(); i++) {
               characters.add(line.charAt(i));
          }
     }

     /**
```

```
     * Checks if there's any more token i.e. if the
Queue is empty.
     *
     * @return If no more token, returns false.
Otherwise true.
     */
    public boolean hasNext() {
        if (characters.isEmpty()) {
            return false;
        }
        return true;
    }

    /**
     * This method returns the next token.
     *
     * @return findNextToken() A method.
     */
    public String next() {
        return findNextToken();
    }

    /**
     * This method creates the next token.
     *
     * @return token A {@code String}
     */
    private String findNextToken() {
        // peek ahead and see if the next elem is a
white space
        // If it's, remove it.
        while (!characters.isEmpty() &&
Character.isWhitespace(characters.peek())) {
            characters.remove();
        }

        if (characters.isEmpty()) {
            token = null;
        } else {
            char ch = characters.remove();
            // if ch is either a digit or a dot or a
SPECIAL_CHARACTER
            // initialize token as ch
            if (Character.isDigit(ch) || ch == '.' ||
```

```
SPECIAL_CHARACTERS.indexOf(ch) >= 0)
                    token = "" + ch;
               // else throw IllegalArgumentException
               else {
                    System.out.println(ch + " is not
legal!!");
                    throw new
IllegalArgumentException("Invalid Input!!");
               }

               if (!SPECIAL_CHARACTERS.contains(token)) {
                    boolean done = false;
                    while (!characters.isEmpty() && !
done) {
                         char ch2 = characters.peek();
                         if (Character.isWhitespace(ch2)
|| SPECIAL_CHARACTERS.indexOf(ch2) >= 0) {
                              done = true;
                         } else if
(Character.isDigit(ch2) || ch2 == '.') {
                              token = token +
characters.remove();
                         } else {
                              System.out.println(ch2 + "
is not legal!!\n");
                              // done = true;
                              throw new
IllegalArgumentException("Invalid Input!!");
                         }

                    }

               }

          }
          return token;

     }

}
```

## Client Class:

```
import java.util.Scanner;
import java.util.Stack;

/**
 * This program takes in a mathematical expression as
input from the keyboard.
 * It uses StringSplitter class to tokenize the input.
Then evaluates it. For
 * this program to evaluate the expression, the
expression needs to be fully
 * parenthesized. The mathematical operations that it can
calculate are
 * +,-,*,/,^ . With invalid input, it might throw
 * {@code IllegalArgumentexception} or simply print
invalid expression. This
 * program implements a variation of the Shunting-Yard
algorithm by Edsgar
 * Dijkstra.
 *
 * @author emmaka
 * @since 8-July-2019
 *
 */

public class Task2 {
     // -----------main method------------
     public static void main(String[] args) {

          @SuppressWarnings("resource")
          // take the input from keyboard using scanner
          // put it into a Strng var.
          Scanner sc = new Scanner(System.in);
          System.out.println("Enter Your Input:");
          String input = sc.nextLine();
          // declare a StringSpliter varible to tokenize
the input
          StringSplitter splitter = new
StringSplitter(input);

          // declare two stacks- numStack to put the
numeric tokens
```

```
          // and symbolstack to put the symbolic tokens.
          Stack<Double> numStack = new Stack<Double>();
          Stack<String> symbolStack = new
Stack<String>();
          // declare a boolean var error
          // the method evaluates the tokens
          // if it encounters any error it returns true,
else false.
          boolean error = evaluate(splitter, numStack,
symbolStack);

          if (error || numStack.size() != 1 || !
symbolStack.isEmpty()) {
               System.out.println("Illegal
Expression!!");
          } else {
               System.out.println("Result = " +
numStack.pop());
          }

          // System.out.println(numStack);
          // System.out.println(symbolStack);

     }

     public static boolean isNumeric(String strNum) {
          return strNum.matches("-?\\d+(\\.\\d+)?");
     }

     /**
      * This method implements the Shunting-yard
algorithm We keep taking tokens from
      * the splitter as long as there's token to process.
We use two stacks- numStack
      * to store the numeric tokens and symboleStack to
store symbolic tokens. When
      * we find a right parenthesis(')'), that means we
have all the information for
      * that sub-expression, thus we evaluate it.
      *
      * We assume the input has no error. We use a
boolean err_flag to recognize it.
      * If an error if an error is encountered, we set it
true.
```

```
      *
      * @param splitter    A {@code StringSplitter} to
get tokens.
      * @param numStack    A {@code Stack} to store the
numeric tokens.
      * @param symbolStack A {@code Stack} to store the
symbols.
      * @return err_flag A {@code boolean}, true if
there's an error.
      */
     static boolean evaluate(StringSplitter splitter,
Stack<Double> numStack, Stack<String> symbolStack) {
          // a boolean flag to recognize any error
          boolean err_flag = false;

          // As long as there's token and no error:
          while (!err_flag && splitter.hasNext()) {
               // take the next token into a String var
str.
               String str = splitter.next();
               // System.out.println("TOken: " + str);
               /**
                * Check if it's numeric if so,turn it
into a double and put it into numStack,
                * else check if it's left parenthesis or
any of the legal operator else if it's
                * a right parenthesis, which means we can
evaluate this sub-expression.
                */
               if (isNumeric(str)) {

     numStack.push(Double.parseDouble(str));
               } else {
                    if (str.equals("(") ||
"+-*/^".contains(str)) {
                         symbolStack.push(str);
                    } else if (str.equals(")")) {
                         // To evaluate this sub-
expression, we pop last two numbers
                         // pass it as formal parameters
of the calculate method
                         double num2 = numStack.pop();
                         double num1 = numStack.pop();
                         String operator =
```

```
symbolStack.pop();
                        if (!"+-*/^".contains(operator))
{
                            System.out.println("'" +
operator + "' in the " + "place of an operator!!");
                            System.out.println("Error
in parenthesis!" + "!\nCheck Your Input!!");
                            return true;
                        }
                        // take the calculated value
from the last sub-expr into
                        // a double var result.
                        double result = calculate(num1,
num2, operator);
                        // push result into numStack
                        numStack.push(result);
                        // if symbolStack not empty
                        // pop from symbolStack
                        if (!symbolStack.isEmpty())
                            symbolStack.pop();
                    } else {
                        System.out.println("The number
'" + str + "' does not seem right!!");
                        err_flag = true;
                        break;
                    }
                }
//              System.out.println("Num Stack: " +
numStack);
//              System.out.println("Symbol Stack: " +
symbolStack);
//              System.out.println("err_flag = " +
err_flag);
            }
            return err_flag;
        }

        /**
         * This method carries out some certain mathematical
operation for given
         * numerics.
         *
         * @param num1     A {@code double}
         * @param num2     A {@code double}
```

```
     * @param operator A {@code String}
     * @param err_flag A {@code boolean}
     * @return result A {@code double}
     */
    static double calculate(double num1, double num2,
String operator) {
          double result = 0;
          if (operator.equals("+")) {
               result = num1 + num2;
          } else if (operator.equals("-")) {
               result = num1 - num2;
          } else if (operator.equals("*")) {
               result = num1 * num2;
          } else if (operator.equals("^")) {
               result = Math.pow(num1, num2);
          } else if (operator.equals("/")) {
               result = num1 / num2;
          }

          return result;
    }

}
```

## Sample Input and Output:

**Sample Input 1: ( 18.4 - ( ( 2.3 * 8.5 ) / ( 19.5 + ( 2.7 ^ 4.9 ) ) ) )**

**Output:**

```
<terminated> Task2 (1) [Java Application] /usr/lib/jvm/java-8-oracle/bin/java (Jul 9, 2019, 5
Enter Your Input:
( 18.4 - ( ( 2.3 * 8.5 ) / ( 19.5 + ( 2.7 ^ 4.9 ) ) ) )
Result = 18.26916243990851
```

**Sample Input 2: ( 18.4 - ( 2.3 * 8.5 ) / ( 19.5 + ( 2.7 ^ 4.9 ) ) ) )**

**//wothout the second left parenthesis**

**Output:**

```
<terminated> Task2 (1) [Java Application] /usr/lib/jvm/java-8-oracle/bin/java (Jul 9, 2
Enter Your Input:
( 18.4 - ( 2.3 * 8.5 ) / ( 19.5 + ( 2.7 ^ 4.9 ) ) ) )
'(' in the place of an operator!!
Error in parenthesis!!
Check Your Input!!
Illegal Expression!!
```

### Sample Input 3: (5.0.0+1)

### Output:

```
<terminated> Task2 (1) [Java Application] /usr/lib/jvm/j
Enter Your Input:
(5.0.0+1)
The number '5.0.0' is not valid!!
Illegal Expression!!
```

### Sample Input 4: (5.a+1)

### Output:

```
<terminated> Task2 (1) [Java Application] /usr/lib/jvm/java-8-oracle/bin/java (Jul 9, 2019, 5:21:08 PM)
Enter Your Input:
(5.a+1)
a is not legal!!

Exception in thread "main" java.lang.IllegalArgumentException: Invalid Input!!
        at StringSplitter.findNextToken(StringSplitter.java:93)
        at StringSplitter.next(StringSplitter.java:53)
        at Task2.evaluate(Task2.java:79)
        at Task2.main(Task2.java:40)
```

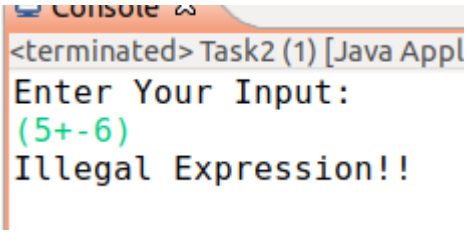
### Sample Input 5: (5@6)

### Output:

```
<terminated> Task2 (1) [Java Application] /usr/lib/jvm/java-8-oracle/bin/java (Jul 9, 2019, 5:24:37 P
Enter Your Input:
(5@6)
@ is not legal!!
Exception in thread "main"
java.lang.IllegalArgumentException: Invalid Input!!
        at StringSplitter.findNextToken(StringSplitter.java:93)
        at StringSplitter.next(StringSplitter.java:53)
        at Task2.evaluate(Task2.java:79)
        at Task2.main(Task2.java:40)
```

**Sample Input 6: (5+-6)**

**Output:**




**Summary:** While doing this task, the first problem I would say I faced was understanding the problem. Then understanding how the StringSplitter class works or its purpose. Because If it were splitting up the input, we can also do that using String.split() method.

Another part was difficult to understand that why can't we use delimiter in this case. Also as Java has a pretty rich library , there's a StringTokenizer class in Java.

Figuring out the right way was pretty insightful in terms of programming and problem solving.