Deliverable 1
SOEN 6011
Prof. P.Kamthan

Nayana Raj Cheluvaraju
40071318
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`https://github.com/nayanarajc/SOEN_6011`

F10:σ

1 Problem 1 -Description

This symbol notifies standard deviation(SD), it is a method that measures extent of variation or separation of data values. The symbol σ is taken from Greek letter sigma. If the value of standard deviation is low it indicates data points are close to the mean, while higher value indicates wider range of values.The values that goes into the function is called as domain, all possible outcome of function is co-domain and actual output from system is called Range. Things required to calculate standard deviation are mean and variance. Mean is calculated by summing up all values and dividing it by total number of values and variance is calculated by taking difference of each, squaring it and then averaging the results. Calculator will compute population and sample standard deviation. The Range for standard deviation is between negative infinity to positive infinity
Properties of Standard Deviation
1. Measures spread-out numbers.
2. It is expressed in same unit as data.
3. Used to measure statistical results such as margin of errors.
4. Using standard deviation, we can calculate normal, extra-large and extra small values.

Population Standard Deviation
This is used when an entire population can be measured, and where every member of a population can be sampled. The following is the equation:

$$\sigma = \sqrt{\tfrac{1}{N}\Sigma_{i=1}^{N}(x_i - \mu)^2}$$

Where xi is one individual value,mu is the mean/expected value, N is the total number of values

Sample Standard Deviation
In this it is not possible to sample every member within a population, so above equation must be modified such that the deviation can be measured through random samples of the population.

$$s = \sqrt{\tfrac{1}{N-1}\Sigma_{i=1}^{N}(x_i - \bar{x})^2}$$

Where xi is one sample value,$\bar{x}$ is the sample mean and N is number of sample value.

2 Problem 2 -Requirements And Assumptions

2.1 Functional Requirements

1: Low priority , 5:High Priority

2.1.1 Input Requirement

When the user enters zero input/input=null, the function shall pop out an error stating "Input cannot be Null". As number divided by zero leads to infinity. (length !=0)
Priority of this requirement: 5

2.1.2 Length Requirement

When the user enters less than two inputs, the function shall display error message "Enter more than one input". This is because minimum length required to calculate standard deviation is 2.(min length=2)
Priority of this requirement: 5

2.1.3 Multiple inputs

User shall be able to enter 'n' inputs from the console provided by function.There is no limit for inputs. Function has to handle inputs.
Priority of this requirement: 3

2.1.4 Handling real numbers

As user enters real numbers, the function shall be able to accept, process it and output's as real numbers.
Priority of this requirement: 3

2.1.5 Calculate Mean

When calculating standard deviation function, the function shall automatically call mean and retrieve result without notice to user.
Priority of this requirement: 4

2.1.6 Calculate variance

When calculating standard deviation function, the function shall calculate variance explicitly or within the function and retrieve result without getting to user notice.
Priority of this requirement: 4

2.1.7 Display Output

User shall be able to see only final output of function which is Standard deviation value, and output will be displayed on console. User shall not have any problem while viewing output.
Priority of this requirement: 5

2.2 Non-Functional Requirements

2.2.1 Performance

It is analysed on how the function responds to given input provided at certain time.

2.2.2 Correctness

Correctness of the function is measurable by checking input-output behaviour.The generated output is verified by comparing results computed manually.

2.2.3 Consistency

The consistency of the function remains same throughout all calculators, as math definition for standard deviation is unchangeable. And consistency of output for all input also remains same.

2.2.4 Accessibility

Defines how easily the function is accessible by all kinds of stakeholders, in different platforms and with integration of hardware.

2.2.5 Usability

The function is easily usable by all stakeholders and also learn-able to achieve specific needs.

2.3 Constraints

1. Interfaces for calculating standard has already been defined and is not bounded to change.
2. Some calculators are region specific.
3. Mode for selecting standard deviation may vary from different calculators.
4. Users from non-mathematical background will have difficulties in accessing function through calculator.

2.4 Assumptions

1. All inputs provided by users are real numbers.
2. Inputs are of population standard deviation.
3. Users will be familiar with accessing functions in calculator.
4. All calculators that supports Math and Statistics contains standard deviation function.
5. Value of standard deviation directly proportional to data points or mean value.

3 Problem 3 - Pseudocode And Algorithm

Algorithm 1 Squareroot(number)- common for both Iterative and Recursive

```
begin:
1. SET Sqrt=number/2
2.     Do
3.         temp=sqrt
4.         Add temp value with (number/temp) and divide whole by 2
5.         CONTINUE WHILE ((temp - result) != 0)
6. RETURN result
end
```

3.1 Using Iterative Approach

Advantages:
1. Easier to understand.
2. Saves memory.
3. Iterative approach can enhance time and space requirement.
4. Fast in execution.

Disadvantages:
1. The iterative repeatedly dynamically allocate or resize memory blocks.
2. Time consuming to Recursive approach.
3. Contains duplicate code.
4. Iteration makes the code longer.

Algorithm 2 calculateMean(array) And CalculateStandardDeviation (array[])

```
begin:
1. SET Counter=0
2.       FOR Counter<length THEN
3.           Add all values
4.          INCREMENT Counter by 1
5. mean= Total/length
6. RETURN mean
end
begin:
1. COMPUTE Mean(array)
2. SET Counter=0
4.       FOR Counter<length THEN
5.           Subtract each value from Mean
6.           Square the subtracted value and keep adding with previous squared values
7.          INCREMENT Counter by 1
9. result= calculatedsum/length
10. COMPUTE Squareroot(result)
11. RETURN computed result
12.REPEAT the algorithm for new value
end
```

3.2 Using Recursive Algorithm

Advantages:

1. Allows to allocate additional automatic objects at each function call.
2. Faster compared to Iterative approach.
3. Makes the problem more elegant.
4. Reduces Time complexity of a program.

Disadvantages:

1. Makes the execution slower.
2. Takes up more of stack storage.
3. Difficult to understand and trace.

Algorithm 3 calcStd(List)

```
begin:
calcAvg(List)
1. COMPUTE calcSum(list,0)
2. Divide sum by size of list
3. RETURN result
end
begin:
calcSum(List, i)
1. IF i< size of list THEN
2.      Add each element(i) with its next element(calcSum(list,i+1))
3.      RETURN result
4. ELSE
5.      RETURN 0
end
begin:
calcpow(List,avg,i)
1. IF i< size THEN
2.      Subtract each value with Avg
3.      Square the result
4.      RETURN square
5. ELSE
6.     RETURN 0
end
begin:
sumSquareDiffs(List,avg,i)
1. IF i< size THEN
2.      COMPUTE calcpow(List,avg,i)
3.      keep adding result of each element
4. ELSE
5.      RETURN 0
end
begin:
calcStd(List)
1. COMPUTE calcAvg(List)
2. COMPUTE sumSquareDiffs(List,avg,i) taking avg value from step2
3. COMPUTE Squareroot(sum) take sum value from step3 and Squareroot() from
algorithm 1
4. RETURN result
end
```

4 Changes from D1 to D2

Added Extra Functional Requirements
2.1.8 Entering consecutive repetition of same number.
2.1.9 Showing difference between sample and population SD

5 Problem 4

5.1 Debuggers

Debugging is the common process of identifying and removing bugs, errors or abnormalities from programs. It is a required skill for all Java developers, because it helps to find subtle bug that are not visible during code reviews or that only happens when a specific condition occurs. The Eclipse Java IDE provides many debugging tools and views grouped in the Debug Perspective to help the you as a developer debug effectively and efficiently. There are many improvements in Eclipse Java Development Tools(JDT) included from Eclipse Oxygen on-wards.
The debuggers used for this project are:
1. Command Line Debuggers
2. IDE Debuggers
The Images for 1 and 2 types have been attached in *Appendix section* at the end.
Challenges faced: Also tried installing Eclipse-Mirur visual Debugger which gives one dimensional view of the debugging result but after installing it was not working.

1.Java debugger(JDB): is a tool used to debug java program in command Line. It implements the java platform debugger architecture. It helps in detecting and fixing bugs in program with help of java debug interface.
Advantages
1. Allows breakpoints, an explicit way of stop or pause application.
2. Enables stepping process, its a debugger feature that lets you to execute line by line.
3. It also throws uncaught exception with its cause.
Disadvantages
1. It is slow compared to IDE debuggers.
2. Complete visual flow of debugging process in not available.
3. Not user friendly, as compared to IDE.

2. IDE Debugger: These are built in debugging tool with eclipse for java. Eclipse allows to begin java program in debug mode. It has all features that consists in JDB and also allows extra features such as watchpoint-is a break-point set on field. Exception breakpoints, method breakpoints, step filter, hit count, remote debugging and drop to frame- allows to select level of frame.

Advantages
1. Debug perspective offers additional view.
2. Stepping commands(stop,start,resume) are easily accessible, as its built as buttons.

3. Enables creation of own debugger.
4. Consumes less time and effort for organizing resource, provides shortcuts and track mistakes.
Disadvantages
1. As high end desktop application, these cannot run on production machine.
2. Possibility of remote debugging will be ruled out for complex environments.
3. Learning curve- maximizing benefits will require lot of time and patience.
4. Will not fix bad code,coding standard or performance problems.

5.2 Quality Attributes

Program is set such that it satisfies quality as expected by user.
1. ***Correctness***:
Is satisfied by verifying the results of standard deviation given from the program. This is achieved by comparing with manual calculation or calculating from online tool.Unit testing is also written such that it measures correctness.
2. ***Efficiency***:
Measured by time taken to run the program and display the output. Here the program is utilizing minimum amount of resources as all functions are implemented and in same class memory required is also less.All these results in more efficiency.
3. ***Maintainable***:
As the program is structured using coding standards it is easily maintainable and flexible to future changes. User can easily follow the program. GUI is also maintainable and extendable as its structured and simple to handle.
4. ***Robust***:
safety measures are taken to cope up with the errors during execution by incorporating *try and catch block* with letting user know from proper message popup and also GUI buttons are made clear so its less prone to errors.
5. ***Usable***: Program is divided into different function so that each function can be executed individually and can be reused in other programs easily.Usage is also not restricted to once.
Challenges faced:
1. Tried installing Ecipse-Jdepend and Eclipse-JDeodorant for estimating quality attributes, but after installation had hard time finding them.
2. Lack of explanation in documentation and as they are huge required information is hard to find.

5.3 Quality Checker

Quality of the program or source code is verified by exposing code under checking tools. For this project there are two tools used: 1.Checkstyle and 2.PMD .

5.3.1 Checkstyle

The source code standard Checkstyle checks are applicable to java program and requires no external libraries. Checkstyle provides many checks such as naming,location of annotation,nested blocks,constant names,empty block, illegal token, type, javadoc, tags, method name, count and much more.

Advantages
1. Portability between IDE's - If we want to use visual studio or my team member is using other IDEs still it exhibits consistency.
2. Easy to use as its integrated as an external tool designed which can be hooked into the code easily. Whereas in Eclipse styler we need to locate the plugin to do same task.
3. Ability of creating own rules- checkstyle provide user to add his own custom rules.

Disadvantages
1. Errors are fixed manually, there is no automatic fix.
2. The symbol used to display errors are same as eclipse warnings which leads to confusion.
3. Few errors are not understandable.
4. It just mentions error does not say in which part user should keep doing trial and error to fix it.

5.3.2 Eclipse-PMD

PMD is a static source code analyzer which finds programming flaws such as unused variables, empty catch blocks, unnecessary object creation, and so forth. Once installed, every time while saving work it also checks for potential problems like possible bugs, duplicate, dead or complicated code.Eclipse PMD offers quick fixes that automatically fixes the problem which can be of single fix or all occurrences in entire code. It categorizes errors based on severity. This is bit advanced tool compared to checkstyle with having more features as its packed with 149 rules.

Advantages
1. Scalability is high as tool runs well for very large source code.
2. Comply with coding standards and delivery quality code.
3. Used by teams to change the nature of code reviews.
4. Reduces software maintenance cost. As its open source tool and time spent is less.
5.PMD can also be customized to meet organization coding standard and quality.

Disadvantages
1. Even this intend user to correct errors manually.Cannot find runtime issues
2. As PMD comes by rules there is certain time clash of rules when used with other tools.
3. The documentation guide is overwhelming to users, it does not give examples of output or how to best run PMD.
4. Creating new rule requires understanding of Abstract syntax tree(AST).

Images for both checkstyle and PMD are added in Appendix section.

6 Problem 6- Unit Testing

6.1 Traceability Record

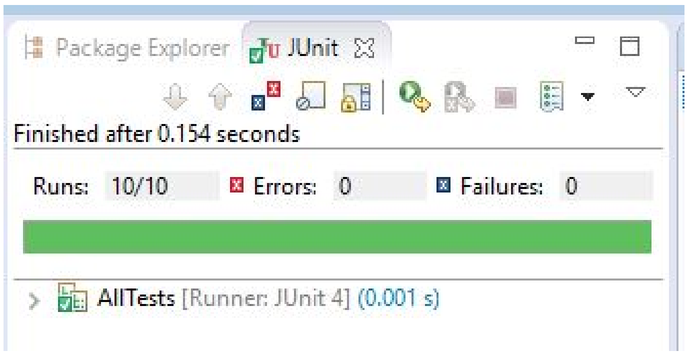
The below table shows the mapping of test case with requirements.

Table 1: Table shows Traceability Record.

Test Case	Test Case Name	Related Requirement(s)
1	CalculateMeanTest	2.1.5
2	CalculateStdDevTest	2.1.6
3	CalculateStdDevTest	2.1.4
4	CalculateStdDevTest	2.1.3
5	Graphical user Interface	2.1.2
6	Graphical user Interface	2.1.1
7	Graphical user Interface	2.1.7
8	CalculateStdDevTest	2.1.8
9	CalculateStdDevTest	2.1.9

The diagram below shows the results of testing. For testing Junit framework is used and test results have been tracked.

Figure1: Shows the results of JUnit



Finished after 0.154 seconds

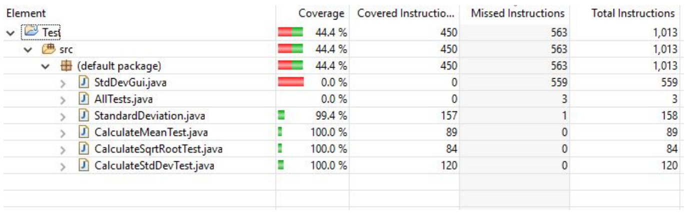
Runs: 10/10 Errors: 0 Failures: 0

AllTests [Runner: JUnit 4] (0.001 s)

result.JPG

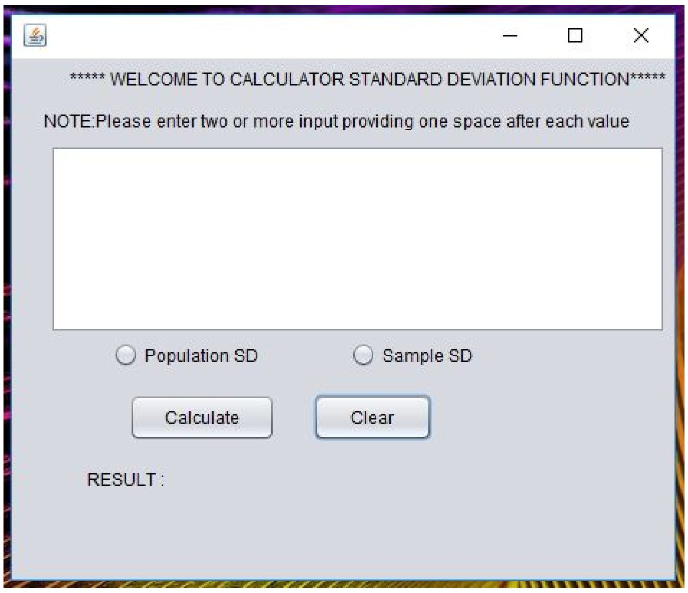
Below diagram shows the coverage of testing. Test results for GUI are not written as all the error messages are visible in the interface.

Figure2: Shows the test coverage for StandardDeviation.java file



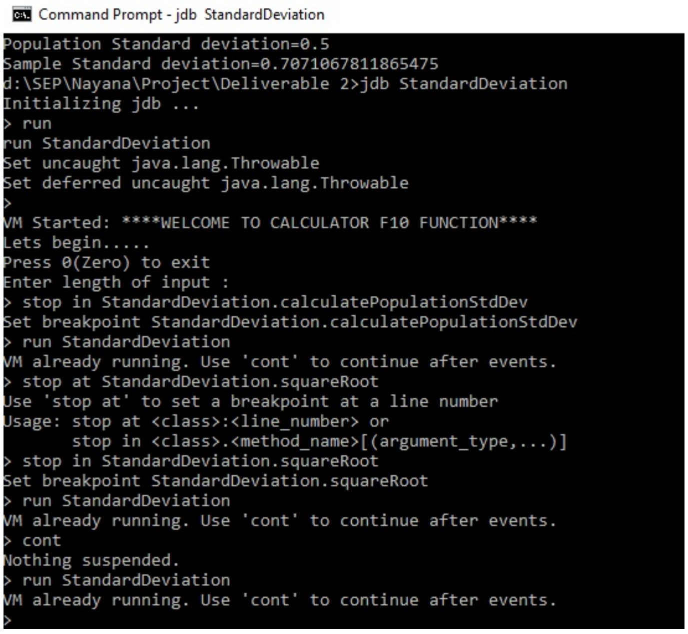
Element	Coverage	Covered Instructio...	Missed Instructions	Total Instructions
Test	44.4 %	450	563	1,013
src	44.4 %	450	563	1,013
(default package)	44.4 %	450	563	1,013
StdDevGui.java	0.0 %	0	559	559
AllTests.java	0.0 %	0	3	3
StandardDeviation.java	99.4 %	157	1	158
CalculateMeanTest.java	100.0 %	89	0	89
CalculateSqrtRootTest.java	100.0 %	84	0	84
CalculateStdDevTest.java	100.0 %	120	0	120

This project have been implemented and interfaced using graphical(GUI) user interface. For GUI implementation Java swings have been used. Below diagram shows the snippet of Interface. Figure3: Shows the Graphical User Interface(GUI)


***** WELCOME TO CALCULATOR STANDARD DEVIATION FUNCTION*****
NOTE:Please enter two or more input providing one space after each value
Population SD
Sample SD
Calculate
Clear
RESULT :

7 Appendix

Figure1: Command-line Debugger used for F10 function

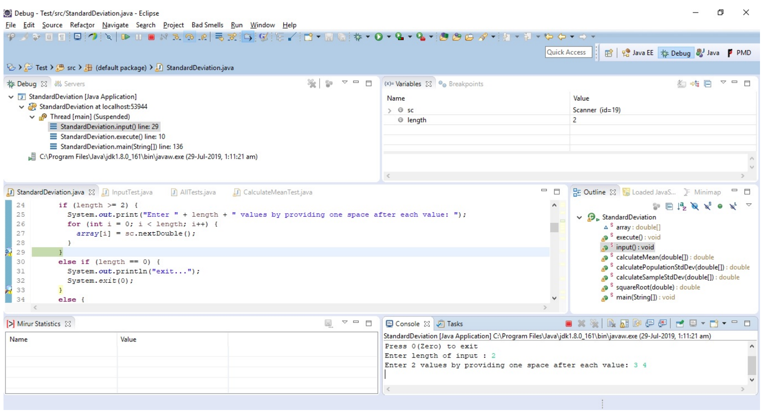


```
Command Prompt - jdb  StandardDeviation
opulation Standard deviation=0.5
ample Standard deviation=0.7071067811865475
:\SEP\Nayana\Project\Deliverable 2>jdb StandardDeviation
nitializing jdb ...
 run
un StandardDeviation
et uncaught java.lang.Throwable
et deferred uncaught java.lang.Throwable

M Started: ****WELCOME TO CALCULATOR F10 FUNCTION****
ets begin.....
ress 0(Zero) to exit
nter length of input :
 stop in StandardDeviation.calculatePopulationStdDev
et breakpoint StandardDeviation.calculatePopulationStdDev
 run StandardDeviation
M already running. Use 'cont' to continue after events.
 stop at StandardDeviation.squareRoot
se 'stop at' to set a breakpoint at a line number
sage: stop at <class>:<line_number> or
       stop in <class>.<method_name>[(argument_type,...)]
 stop in StandardDeviation.squareRoot
et breakpoint StandardDeviation.squareRoot
 run StandardDeviation
M already running. Use 'cont' to continue after events.
 cont
othing suspended.
 run StandardDeviation
M already running. Use 'cont' to continue after events.

```

Figure2: Eclipse IDE-Debugger



```
StandardDeviation [Java Application]
  StandardDeviation at localhost:53944
    Thread [main] (Suspended)
      StandardDeviation.input() line: 29
      StandardDeviation.execute() line: 10
      StandardDeviation.main(String[]) line: 136
  C:\Program Files\Java\jdk1.8.0_161\bin\javaw.exe (29-Jul-2019, 1:11:21 am)
```

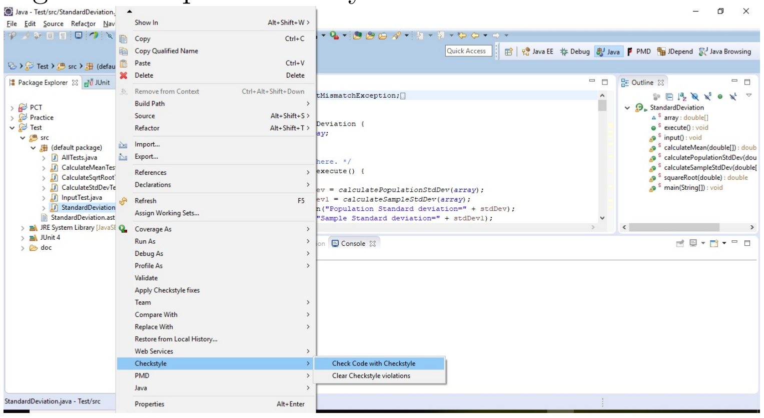
Name	Value
sc	Scanner (id=19)
length	2

```java
      if (length >= 2) {
        System.out.print("Enter " + length + " values by providing one space after each value: ");
        for (int i = 0; i < length; i++) {
          array[i] = sc.nextDouble();
        }
      }
      else if (length == 0) {
        System.out.println("exit...");
        System.exit(0);
      }
      else {
```

```
StandardDeviation [Java Application] C:\Program Files\Java\jdk1.8.0_161\bin\javaw.exe (29-Jul-2019, 1:11:21 am)
Press 0(Zero) to exit
Enter length of input : 2
Enter 2 values by providing one space after each value: 3 4
```

StandardDeviation
array : double[]
execute() : void
input() : void
calculateMean(double[]) : double
calculatePopulationStdDev(double[]) : double
calculateSampleStdDev(double[]) : double
squareRoot(double) : double
main(String[]) : void
Mirur Statistics

Figure3: Eclipse-CheckStyle



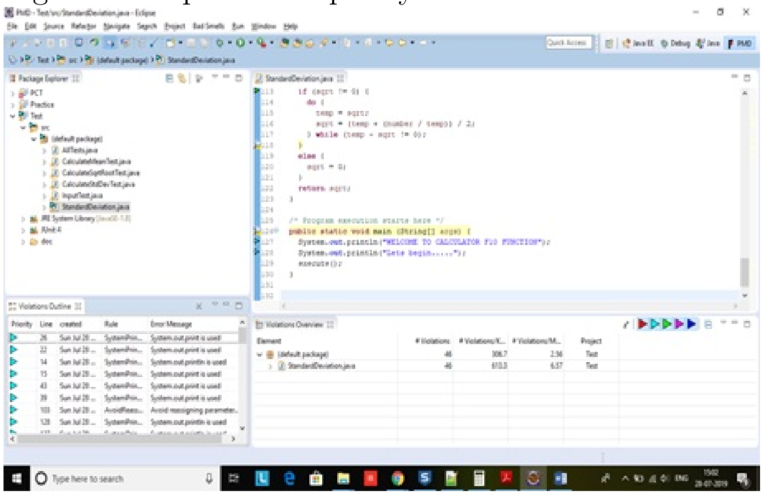
```java
tMismatchException;

Deviation {
ay;

here. */
execute() {

ev = calculatePopulationStdDev(array);
evl = calculateSampleStdDev(array);
n("Population Standard deviation=" + stdDev);
"Sample Standard deviation=" + stdDevl);
```

Figure4: Eclipse-PMD quality checker



```java
    if (sqrt != 0) {
      do {
        temp = sqrt;
        sqrt = (temp + (number / temp)) / 2;
      } while ((temp - sqrt) != 0);
    }
    else {
      sqrt = 0;
    }
    return sqrt;
  }

  /* Program execution starts here */
  public static void main (String[] args) {
    System.out.println("WELCOME TO CALCULATOR FOR FUNCTION");
    System.out.println("Lets begin.....");
    execute();
  }
```

Priority	Line	created	Rule	Error Message
	26	Sun Jul 28 ...	SystemPrin...	System.out.print is used
	22	Sun Jul 28 ...	SystemPrin...	System.out.print is used
	14	Sun Jul 28 ...	SystemPrin...	System.out.println is used
	15	Sun Jul 28 ...	SystemPrin...	System.out.print is used
	43	Sun Jul 28 ...	SystemPrin...	System.out.print is used
	39	Sun Jul 28 ...	SystemPrin...	System.out.print is used
	103	Sun Jul 28 ...	AvoidReass...	Avoid reassigning parameter...
	128	Sun Jul 28 ...	SystemPrin...	System.out.println is used

Element	# Violations	# Violations/K...	# Violations/M...	Project
(default package)	46	308.7	2.56	Test
StandardDeviation.java	46	613.3	6.57	Test

8 Reference

https://ieeexplore.ieee.org/stamp/stamp.jsp
https://www.calculator.net/standard-deviation-calculator.html
https://www.mathsisfun.com/data/

https://tex.stackexchange.com/questions/88388/how-to-have-the-title-at-the-top-of-a-latex-document
https://tex.stackexchange.com/questions/456051/standard-deviation
https://www.reqview.com/doc/iso-iec-ieee-29148-srs-example.html
https://users.csc.calpoly.edu/ jdalbey/SWE/pdl$_s$*td.html*
https : //benpfaff.org/writings/clc/recursion − vs − iteration.html
https : //www.geeksforgeeks.org/how − to − write − a − pseudo − code/
*https : //stackoverflow.com/questions/*29022672*/calculating − standard − deviation − of − array − recursively*
https : //tutorialspoint.com/jdb/
*https : //docs.oracle.com/javase/*7*/docs/technotes/tools/windows/jdb.html*
*https : //dzone.com/articles/definitive−list−*7*−javaIDEhttps : //stackoverflow.com/questions/*1
of − using − checkstyle − rather − than − using − eclipse − built − in − code − formatter
https : //marketplace.eclipse.org/content/eclipse − pmd
https : //www.eclipsezone.com//articles/pmd/
*http : //www.cs.cmu.edu/ aldrich/courses/*654*/tools/hsu − pmd − *07*.pdf*