

Narendra Raj R K (001553969)

Program Structures & Algorithms

Spring 2021

Assignment No.1

Table of Contents:

- I. Task**
- II. Output**
- III. Relationship Conclusion**
- IV. Evidence to support the conclusion**
- V. Graphical Representation**
- VI. Unit Tests Result**

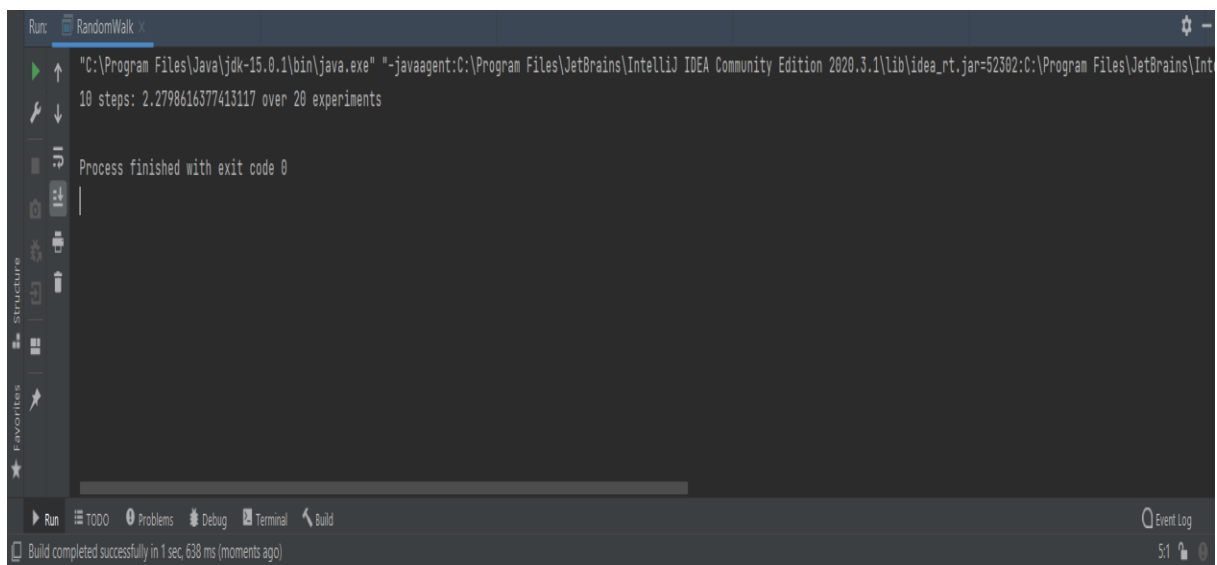
Task:

The following are the steps that were carried out,

- Cloned from the class repository and worked on ***RandomWalk.java*** file under randomwalk directory.
- Added logic to the functions - **move()**, **randomWalk()** & **distance()** that were asked to be implemented.
- Ran the main class in **RandomWalk.java** and got the desired output.

Output:

Following is a snap of the Sample Output, for the inputs: Number of Steps as 10 and Number of Experiments as 20



```
Run: RandomWalk
"C:\Program Files\Java\jdk-15.0.1\bin\java.exe" "-javaagent:C:\Program Files\JetBrains\IntelliJ IDEA Community Edition 2020.3.1\lib\idea_rt.jar=52302:C:\Program Files\JetBrains\IntelliJ IDEA Community Edition 2020.3.1\bin" -Dfile.encoding=UTF-8
10 steps: 2.2798616377413117 over 20 experiments

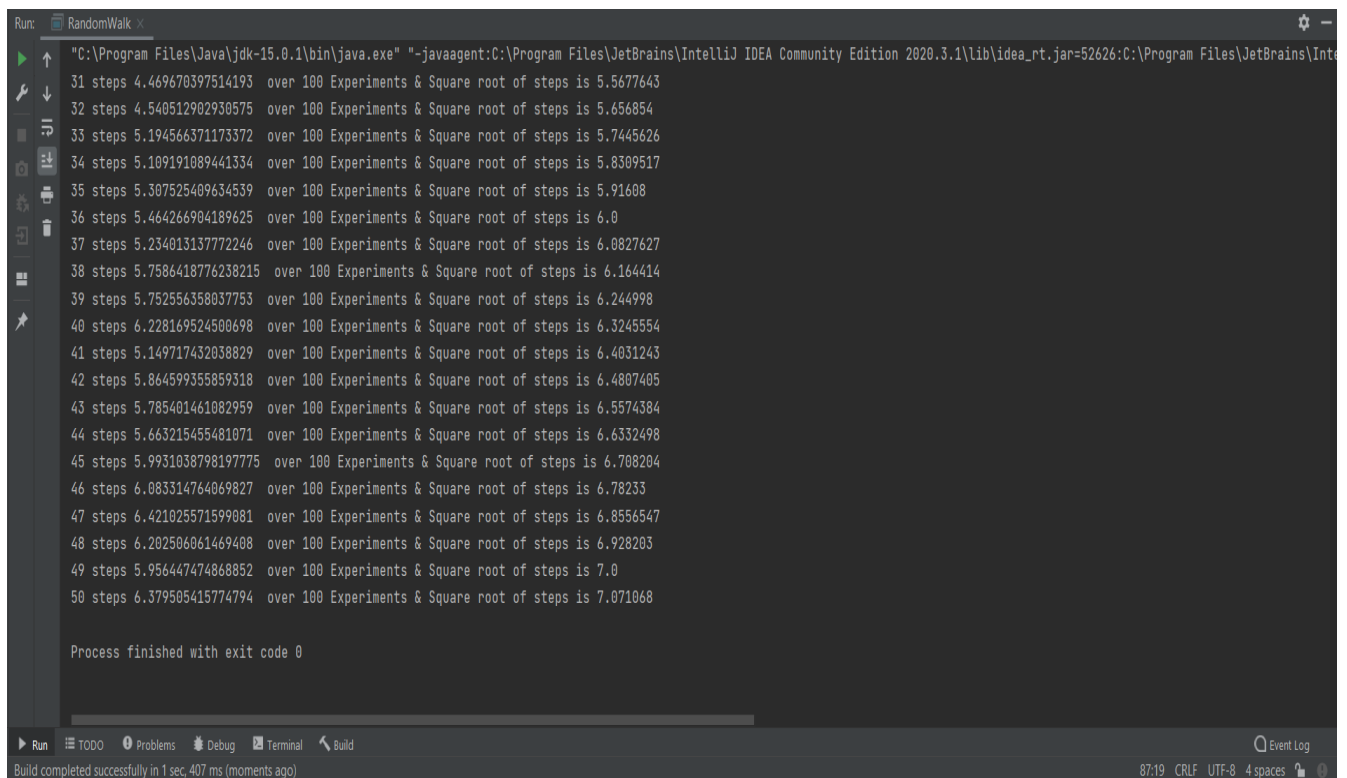
Process finished with exit code 0

Build completed successfully in 1 sec, 638 ms (moments ago)
```

Relationship Conclusion:

On running the main method inside the RandomWalk.java file multiple times to figure out and establish the relationship between the Number of Steps (N) and the distance (D) the Drunken man would have covered. I performed the following runs.

Run 1: Number of Steps (N) – 20 Different Values of N; Number of Experiments – 100 for each value of N.



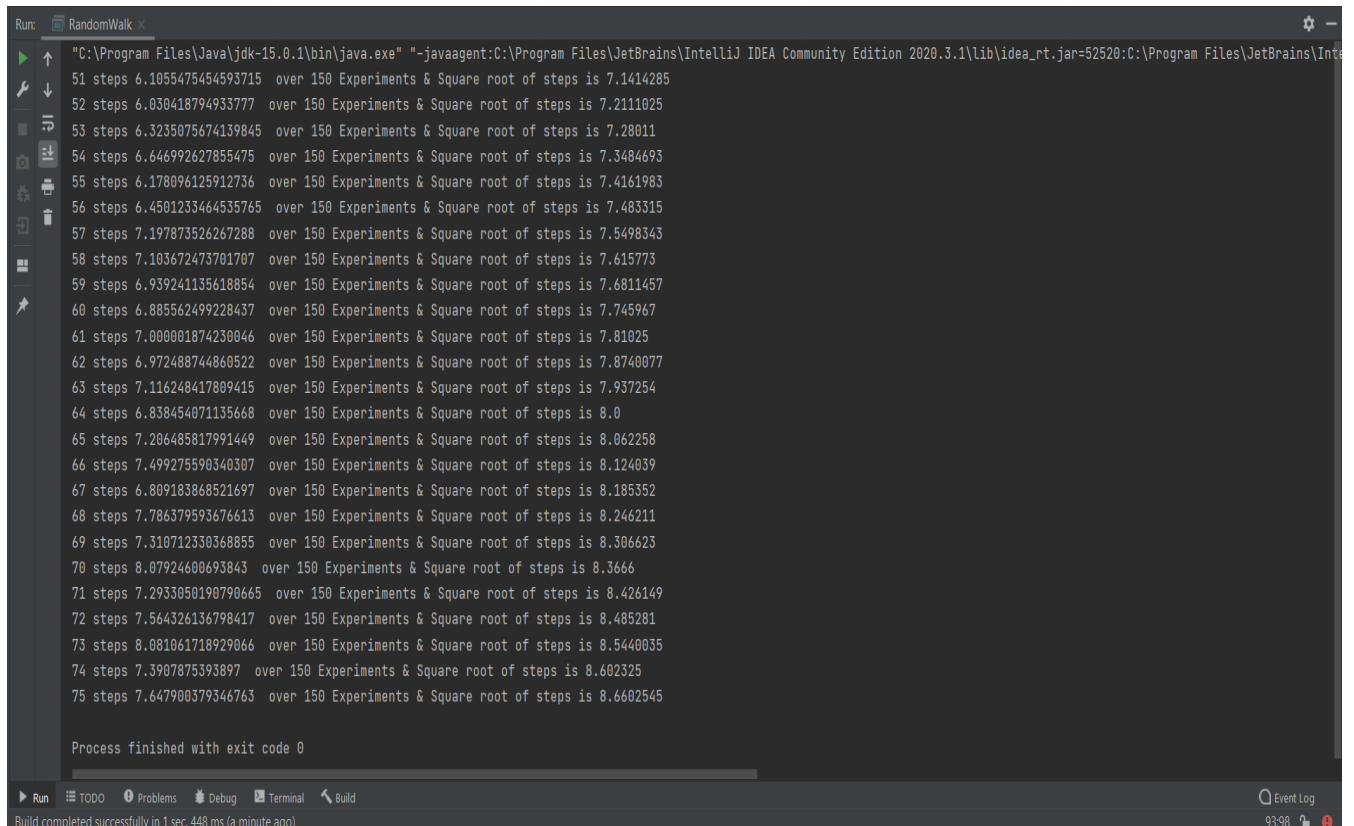
```
Run: RandomWalk
"C:\Program Files\Java\jdk-15.0.1\bin\java.exe" "-javaagent:C:\Program Files\JetBrains\IntelliJ IDEA Community Edition 2020.3.1\lib\idea_rt.jar=52626:C:\Program Files\JetBrains\IntelliJ IDEA Community Edition 2020.3.1\bin" -Didea.config.path=C:\Program Files\JetBrains\IntelliJ IDEA Community Edition 2020.3.1\config -Didea.copyright.path=C:\Program Files\JetBrains\IntelliJ IDEA Community Edition 2020.3.1\copyright -Didea.home.path=C:\Program Files\JetBrains\IntelliJ IDEA Community Edition 2020.3.1\bin -Didea.jre.path=C:\Program Files\Java\jdk-15.0.1\bin -Didea.platform.prefix=JavaSE -Didea.vendor.id=jetbrains -Didea.version=2020.3.1 -jar C:\Program Files\JetBrains\IntelliJ IDEA Community Edition 2020.3.1\bin\idea_rt.jar 52626
31 steps 4.469670397514193 over 100 Experiments & Square root of steps is 5.5677643
32 steps 4.540512902930575 over 100 Experiments & Square root of steps is 5.656854
33 steps 5.194566371173372 over 100 Experiments & Square root of steps is 5.7445626
34 steps 5.109191089441334 over 100 Experiments & Square root of steps is 5.8309517
35 steps 5.307525409634539 over 100 Experiments & Square root of steps is 5.91608
36 steps 5.464266904189625 over 100 Experiments & Square root of steps is 6.0
37 steps 5.234013137772246 over 100 Experiments & Square root of steps is 6.0827627
38 steps 5.7586418776238215 over 100 Experiments & Square root of steps is 6.164414
39 steps 5.752556358037753 over 100 Experiments & Square root of steps is 6.244998
40 steps 6.228169524500698 over 100 Experiments & Square root of steps is 6.3245554
41 steps 5.149717432038829 over 100 Experiments & Square root of steps is 6.4031243
42 steps 5.864599355859318 over 100 Experiments & Square root of steps is 6.4807405
43 steps 5.785401461082959 over 100 Experiments & Square root of steps is 6.5574384
44 steps 5.663215455481071 over 100 Experiments & Square root of steps is 6.6332498
45 steps 5.9931038798197775 over 100 Experiments & Square root of steps is 6.708204
46 steps 6.083314764069827 over 100 Experiments & Square root of steps is 6.78233
47 steps 6.421025571599081 over 100 Experiments & Square root of steps is 6.8556547
48 steps 6.202506061469408 over 100 Experiments & Square root of steps is 6.928203
49 steps 5.956447474868852 over 100 Experiments & Square root of steps is 7.0
50 steps 6.379505415774794 over 100 Experiments & Square root of steps is 7.071068

Process finished with exit code 0

Run | TODO | Problems | Debug | Terminal | Build
Build completed successfully in 1 sec, 407 ms (moments ago) 87:19 CRLF UTF-8 4 spaces
```

Note: I would like to bring to your notice that I have made some modifications inside the main method() of RandomWalk file to execute the program for different values of 'm' – Number of Steps at one shot, to assign the number of experiments value and have also tinkered the print statements. Apart from these minor adjustments that do not compromise the integrity of the code I haven't modified anything.

Run 2: Number of Steps (N) – 25 Different Values of N; Number of Experiments – 150 for each value of N

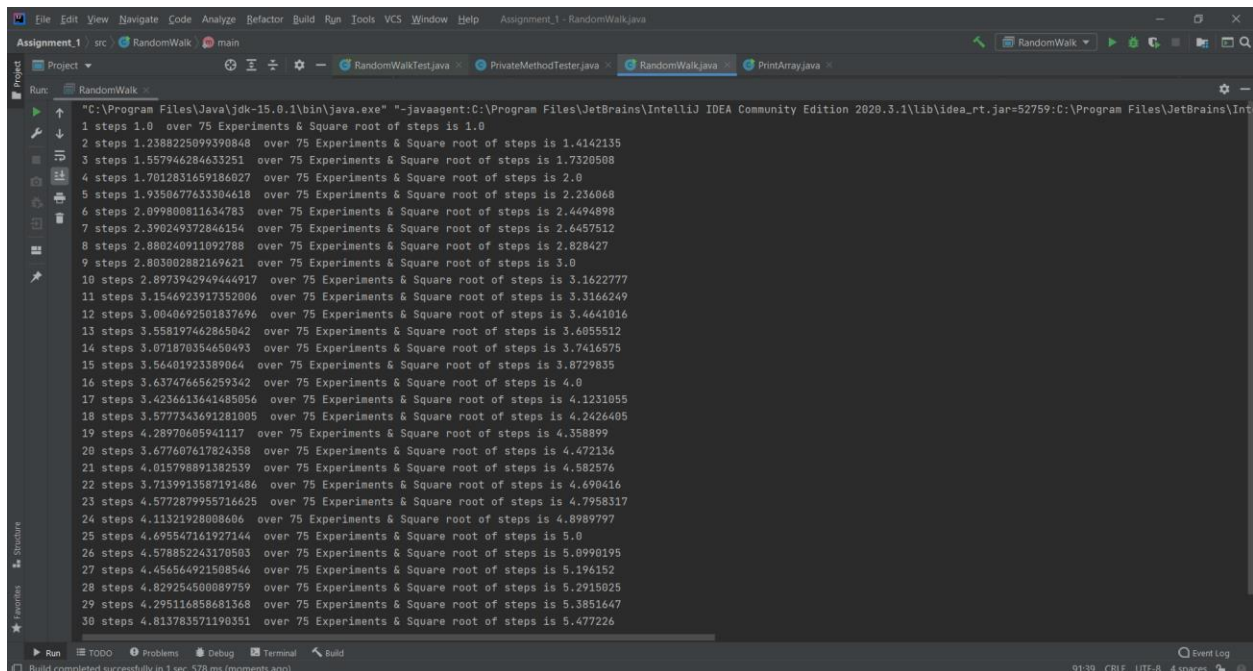


```
Run: RandomWalk x
"C:\Program Files\Java\jdk-15.0.1\bin\java.exe" "-javaagent:C:\Program Files\JetBrains\IntelliJ IDEA Community Edition 2020.3.1\lib\idea_rt.jar=52520:C:\Program Files\JetBrains\Int
51 steps 6.1055475454593715 over 150 Experiments & Square root of steps is 7.1414285
52 steps 6.030418794933777 over 150 Experiments & Square root of steps is 7.2111025
53 steps 6.3235075674139845 over 150 Experiments & Square root of steps is 7.28011
54 steps 6.646992627855475 over 150 Experiments & Square root of steps is 7.3484693
55 steps 6.178096125912736 over 150 Experiments & Square root of steps is 7.4161983
56 steps 6.4501233464535765 over 150 Experiments & Square root of steps is 7.483315
57 steps 7.197873526267288 over 150 Experiments & Square root of steps is 7.5498343
58 steps 7.103672473701707 over 150 Experiments & Square root of steps is 7.615773
59 steps 6.939241135618854 over 150 Experiments & Square root of steps is 7.6811457
60 steps 6.88562499228437 over 150 Experiments & Square root of steps is 7.745967
61 steps 7.000001874230046 over 150 Experiments & Square root of steps is 7.81025
62 steps 6.972488744860522 over 150 Experiments & Square root of steps is 7.8740077
63 steps 7.116248417809415 over 150 Experiments & Square root of steps is 7.937254
64 steps 6.838454071135668 over 150 Experiments & Square root of steps is 8.0
65 steps 7.206485817991449 over 150 Experiments & Square root of steps is 8.062258
66 steps 7.499275590340307 over 150 Experiments & Square root of steps is 8.124039
67 steps 6.809183068521697 over 150 Experiments & Square root of steps is 8.185352
68 steps 7.786379593676613 over 150 Experiments & Square root of steps is 8.246211
69 steps 7.310712330368855 over 150 Experiments & Square root of steps is 8.306623
70 steps 8.07924600693843 over 150 Experiments & Square root of steps is 8.3666
71 steps 7.2933050190790665 over 150 Experiments & Square root of steps is 8.426149
72 steps 7.564326136798417 over 150 Experiments & Square root of steps is 8.485281
73 steps 8.081061718929066 over 150 Experiments & Square root of steps is 8.5440035
74 steps 7.3907875393897 over 150 Experiments & Square root of steps is 8.602325
75 steps 7.647900379346763 over 150 Experiments & Square root of steps is 8.6602545

Process finished with exit code 0

Run | TODO | Problems | Debug | Terminal | Build
Build completed successfully in 1 sec 448 ms (a minute ago) | 93.98 | Event Log
```

Run 3: Number of Steps (N) – 30 Different Values of N; Number of Experiments – 75 for each value of N



```
"C:\Program Files\Java\jdk-15.0.1\bin\java.exe" "-javaagent:C:\Program Files\JetBrains\IntelliJ IDEA Community Edition 2020.3.1\lib\idea_rt.jar=52759:C:\Program Files\JetBrains\IntelliJ IDEA Community Edition 2020.3.1\bin" -Dfile.encoding=UTF-8
1 steps 1.0 over 75 Experiments & Square root of steps is 1.0
2 steps 1.2388225099390848 over 75 Experiments & Square root of steps is 1.4142135
3 steps 1.557946284633251 over 75 Experiments & Square root of steps is 1.7320508
4 steps 1.7812831659186027 over 75 Experiments & Square root of steps is 2.0
5 steps 1.9358677653304618 over 75 Experiments & Square root of steps is 2.236068
6 steps 2.099800811634783 over 75 Experiments & Square root of steps is 2.4494898
7 steps 2.390249372846154 over 75 Experiments & Square root of steps is 2.6457512
8 steps 2.880240911092788 over 75 Experiments & Square root of steps is 2.828427
9 steps 2.803002882169621 over 75 Experiments & Square root of steps is 3.0
10 steps 2.8973942949444917 over 75 Experiments & Square root of steps is 3.1622777
11 steps 3.1546923917352006 over 75 Experiments & Square root of steps is 3.3166249
12 steps 3.0040692501837694 over 75 Experiments & Square root of steps is 3.4641016
13 steps 3.558197462865842 over 75 Experiments & Square root of steps is 3.6055512
14 steps 3.071870354650493 over 75 Experiments & Square root of steps is 3.7416575
15 steps 3.56401923389864 over 75 Experiments & Square root of steps is 3.8729835
16 steps 3.637476656259342 over 75 Experiments & Square root of steps is 4.0
17 steps 3.4236613641485056 over 75 Experiments & Square root of steps is 4.1231055
18 steps 3.5777343691281005 over 75 Experiments & Square root of steps is 4.2426405
19 steps 4.28970605941117 over 75 Experiments & Square root of steps is 4.358899
20 steps 3.677607617824358 over 75 Experiments & Square root of steps is 4.472136
21 steps 4.015798891382539 over 75 Experiments & Square root of steps is 4.582576
22 steps 3.7139913587191486 over 75 Experiments & Square root of steps is 4.690416
23 steps 4.5772879955716625 over 75 Experiments & Square root of steps is 4.7958317
24 steps 4.11321928008606 over 75 Experiments & Square root of steps is 4.8989797
25 steps 4.695547161927144 over 75 Experiments & Square root of steps is 5.0
26 steps 4.578852243170503 over 75 Experiments & Square root of steps is 5.0990195
27 steps 4.456564921508546 over 75 Experiments & Square root of steps is 5.196152
28 steps 4.829254500089759 over 75 Experiments & Square root of steps is 5.2915025
29 steps 4.295116858681368 over 75 Experiments & Square root of steps is 5.3851647
30 steps 4.813783571190351 over 75 Experiments & Square root of steps is 5.477226
```

On plotting these datapoints in an excel and analyzing the value of **D** (distance) and **N** (Number of Steps) carefully, I have inferred that the value of **Distance (D)** **increases** as the **value of Number of Steps (N) increases** and hence I would like to conclude the following expression to deduce a relationship between D and N.

$$D \propto \sqrt{N}$$

That the **Distance(D) covered** by the Drunken Man during the Random Walk experiment is **directly proportional to the Square root of the value of Number of Steps(N)**.

Evidence to support the Conclusion:

On analyzing the below Datapoints generated for different values of Number of Steps, one could notice that the mean distance covered increases when the N also increases.

Steps	Distance	Number of Experiments	Sqrt of Steps
31	4.728325621	100	5.5677643
32	5.379922427	100	5.656854
33	5.061433773	100	5.7445626
34	5.368115827	100	5.8309517
35	4.969436454	100	5.91608
36	5.470528818	100	6
37	5.425015133	100	6.0827627
38	5.98616674	100	6.164414
39	5.458802073	100	6.244998
40	5.775251806	100	6.3245554
41	5.52570178	100	6.4031243
42	5.172112216	100	6.4807405
43	6.093740301	100	6.5574384
44	6.056497117	100	6.6332498
45	5.613788043	100	6.708204
46	6.417456801	100	6.78233
47	6.702508929	100	6.8556547
48	5.701773837	100	6.928203
49	5.920983263	100	7
50	6.174489031	100	7.071068

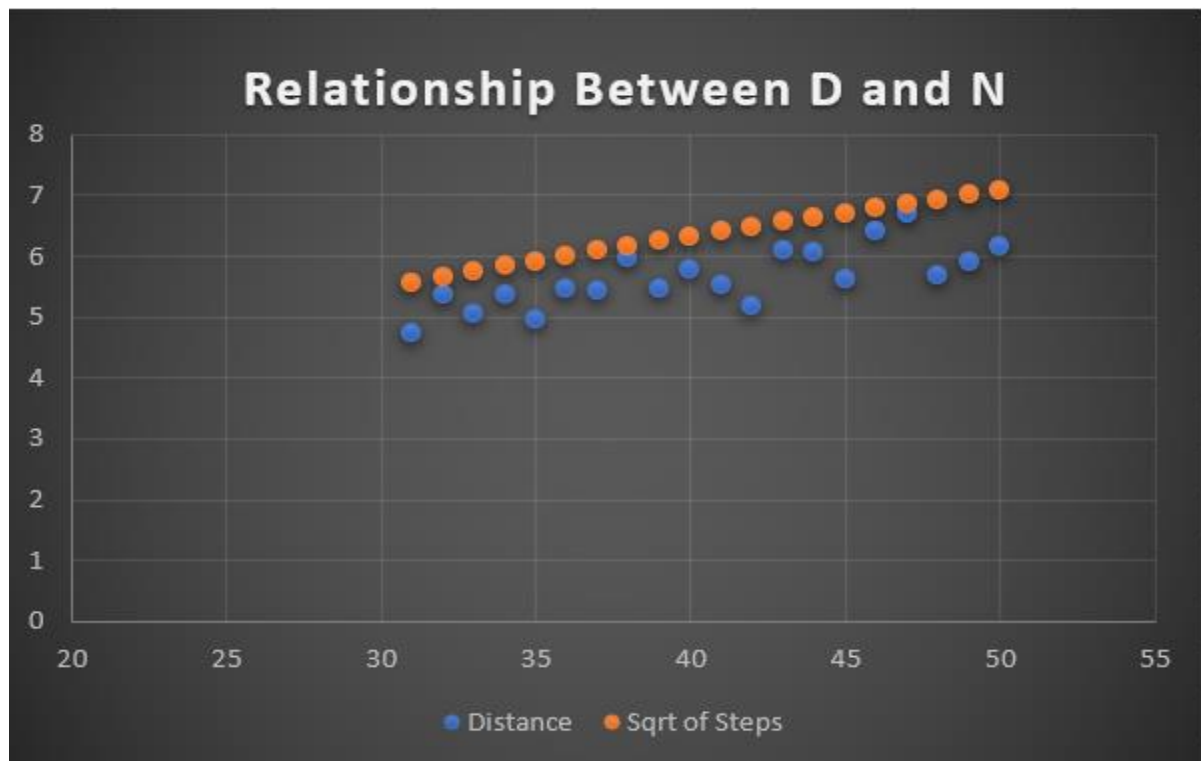
Datapoint 2

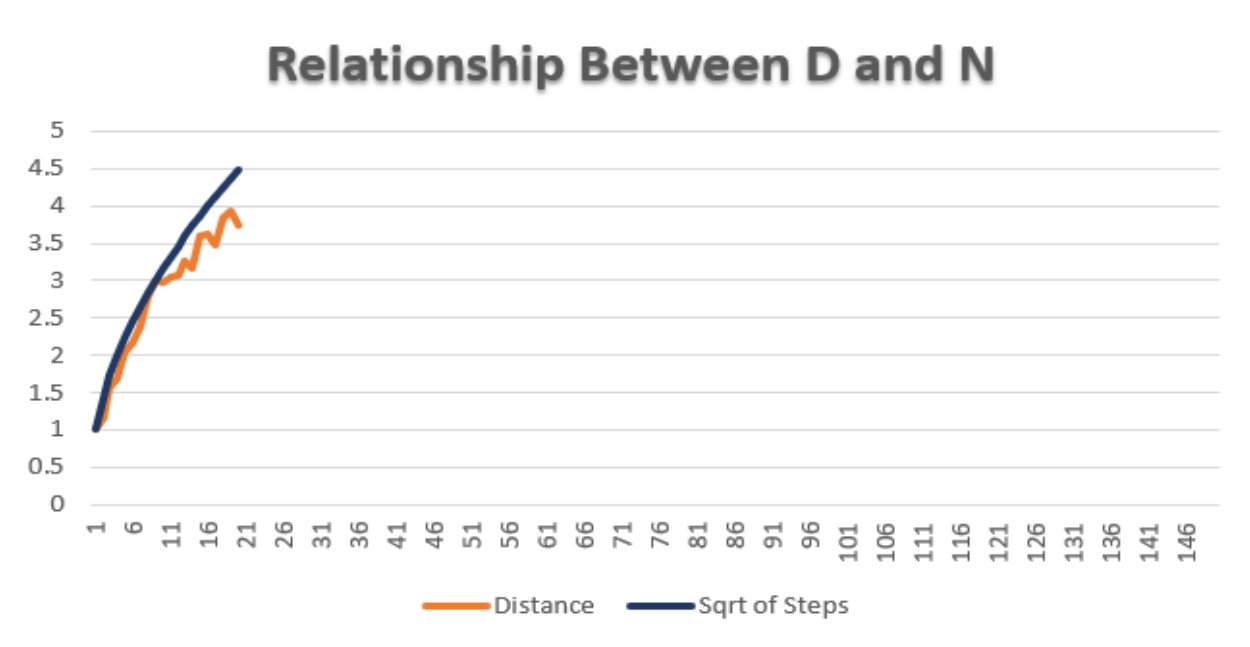
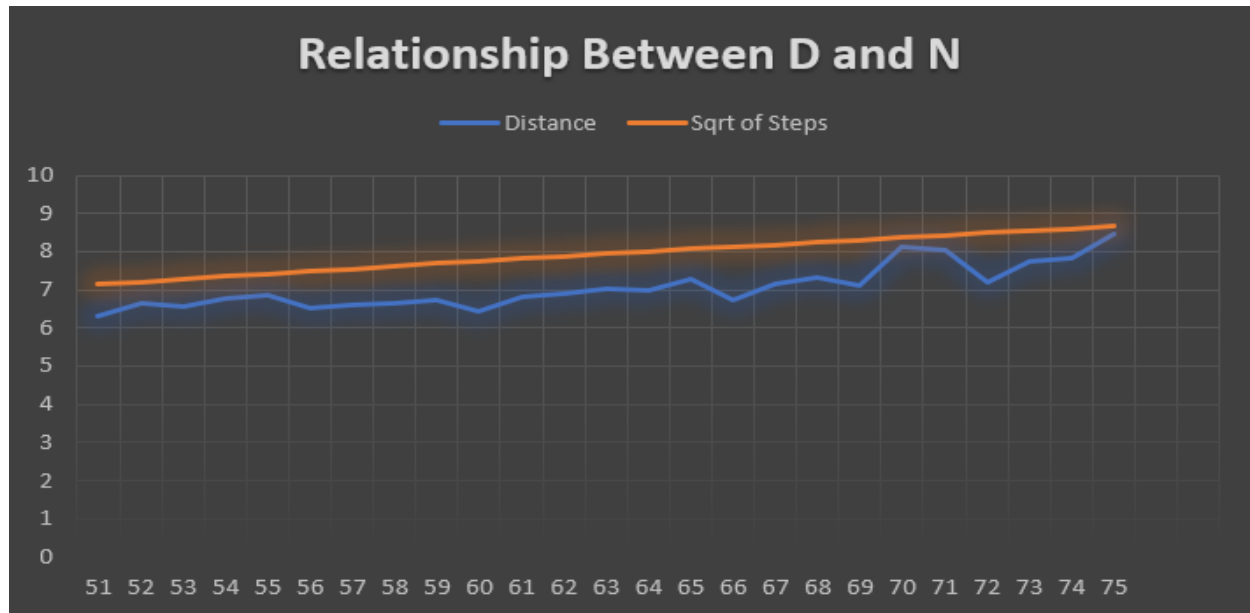
Steps	Distance	Number of Experiments	Sqrt of Steps
1	1	75	1
2	1.14320154	75	1.4142135
3	1.56813204	75	1.7320508
4	1.67053697	75	2
5	2.04652341	75	2.236068
6	2.15489539	75	2.4494898
7	2.38507598	75	2.6457512
8	2.77687904	75	2.828427
9	2.99600152	75	3
10	2.98259587	75	3.1622777
11	3.04686246	75	3.3166249
12	3.07921738	75	3.4641016
13	3.26849931	75	3.6055512
14	3.17602152	75	3.7416575
15	3.59321348	75	3.8729835
16	3.61472324	75	4
17	3.48018576	75	4.1231055
18	3.84478098	75	4.2426405
19	3.93751939	75	4.358899
20	3.74088455	75	4.472136

Datapoints 3

Steps	Distance	Number of Experiments	Sqrt of Steps
51	6.295631786	150	7.1414285
52	6.630384326	150	7.2111025
53	6.546053712	150	7.28011
54	6.784217763	150	7.3484693
55	6.839024583	150	7.4161983
56	6.537996841	150	7.483315
57	6.598882069	150	7.5498343
58	6.634932955	150	7.615773
59	6.748021269	150	7.6811457
60	6.430710566	150	7.745967
61	6.828318668	150	7.81025
62	6.889632528	150	7.8740077
63	7.02516093	150	7.937254
64	6.998551237	150	8
65	7.273039471	150	8.062258
66	6.732868318	150	8.124039
67	7.163436338	150	8.185352
68	7.331062099	150	8.246211
69	7.103560485	150	8.306623
70	8.144414748	150	8.3666
71	8.034321648	150	8.426149
72	7.214703784	150	8.485281
73	7.758663307	150	8.5440035
74	7.820290682	150	8.602325
75	8.451887957	150	8.6602545

Graphical Representation

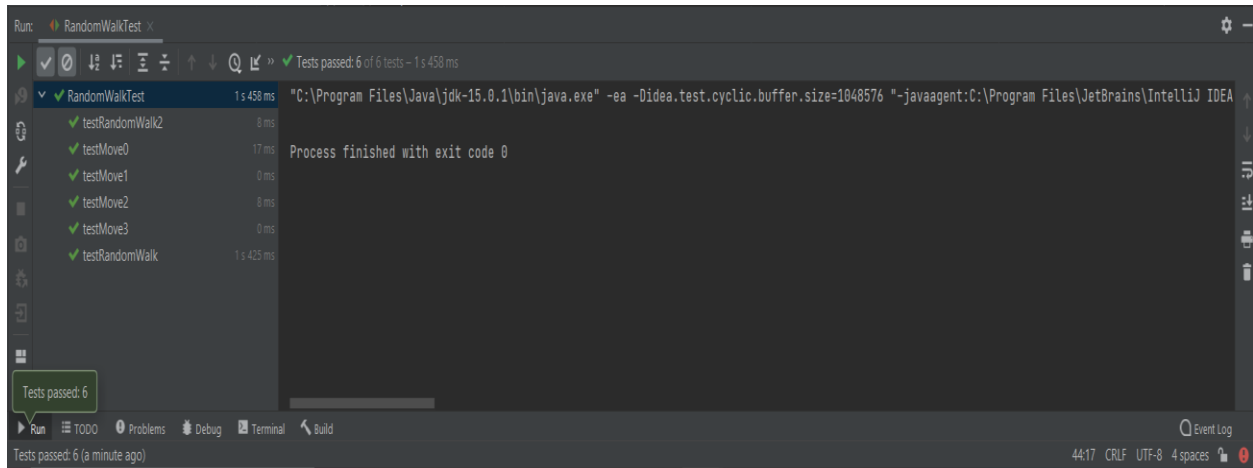




Please be informed that these Graphical Representations are available with much more details in the spreadsheet that I am attaching along in the .zip file.

Unit Tests Result:

- All 6 Test Cases Passing as Expected



Thank you for the read 😊 !!