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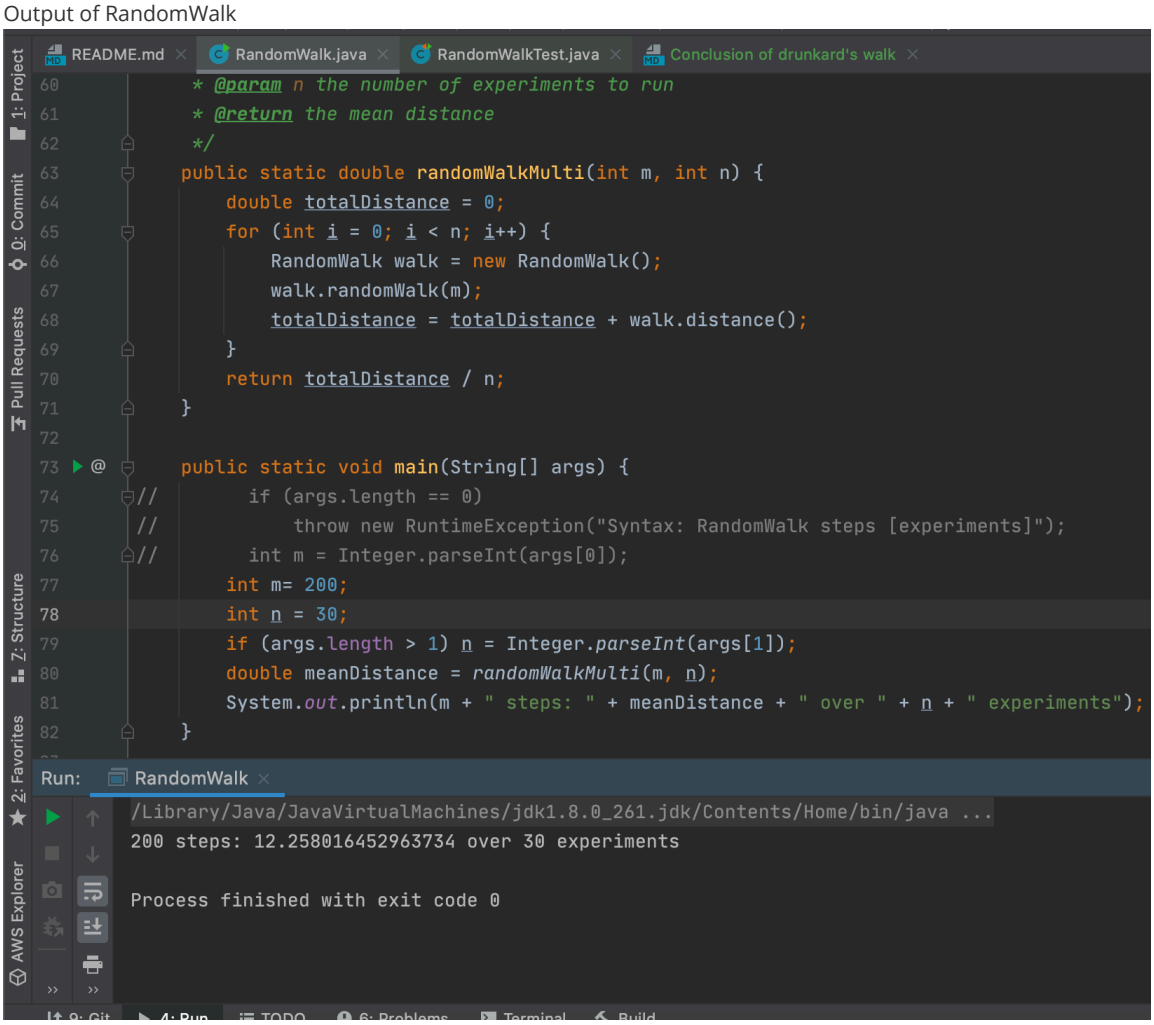
Task

Question:

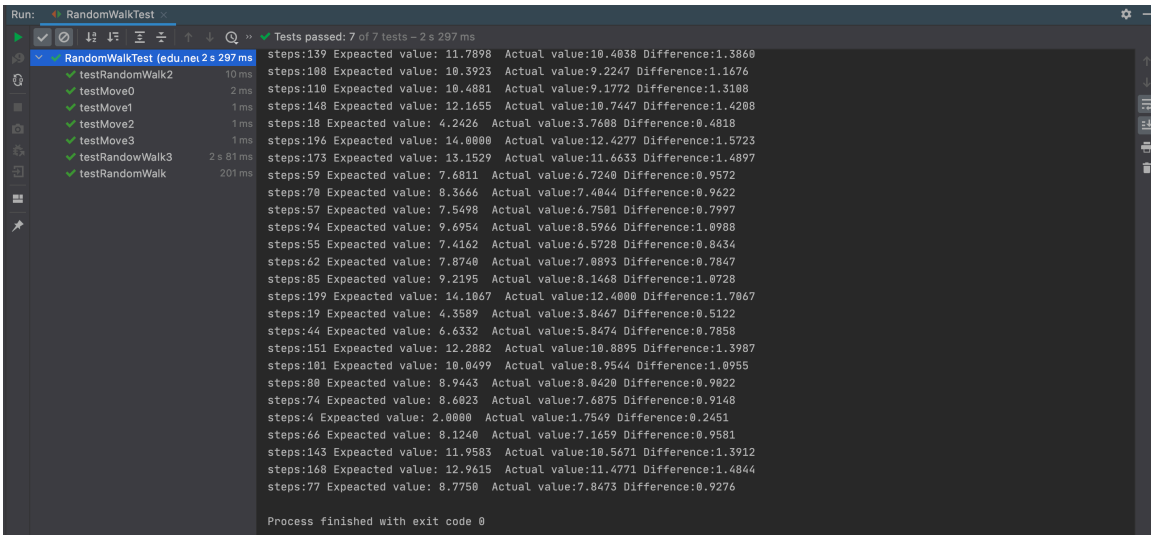
Your submission should include:

1.Your conclusion about the relationship between d and n;
2.Your evidence to support that relationship (screen shot and/or graph and/or spreadsheet);
3.Your code (RandomWalk.java plus anything else that you changed or created);
4.A screen shot of the unit tests all passing.

- Output of RandomWalk



- Tests Results



- My own test

Conclusion

> **n : number of steps**
>
> **d : the distance between the man and the lamp post.**

Delta is the difference between the expected value and the actual value. The more tests, the more likely Delta will be to zero

$$\sqrt{n} = d \pm \Delta$$

Prove

According to the given topic, we can only get the expected value of the distance, that is, to find the following expected value

$$E_n(X^2 + Y^2) = \sum (x^2 + y^2) P(X = x, Y = y)$$

According to the same possibility of the four directions, it can be concluded that

$$P(X = x + 1, Y = y) = P(X = x + 1, Y = y | X = x, Y = y) P(X = x, Y = y) = \frac{1}{4} P(X = x, Y = y)$$

Therefore，for N=n+1 :

$$E_{n+1}(X^2 + Y^2) = \frac{1}{4} \sum [(x+1)^2 + y^2] + [x^2 + (y+1)^2] + [(x-1)^2 + y^2] + [x^2 + (y-1)^2] P(X = x, Y = y)$$

A fter simplificated, we got :

$$E_{n+1}(X^2 + Y^2) = \sum (x^2 + y^2 + 1) P(X = x, Y = y) = E_n(X^2 + Y^2) + \sum P(X = x, Y = y)$$

Absolutely

$$\sum P(X = x, Y = y) = 1$$

So, we got

$$E_n(X^2 + Y^2) = n$$

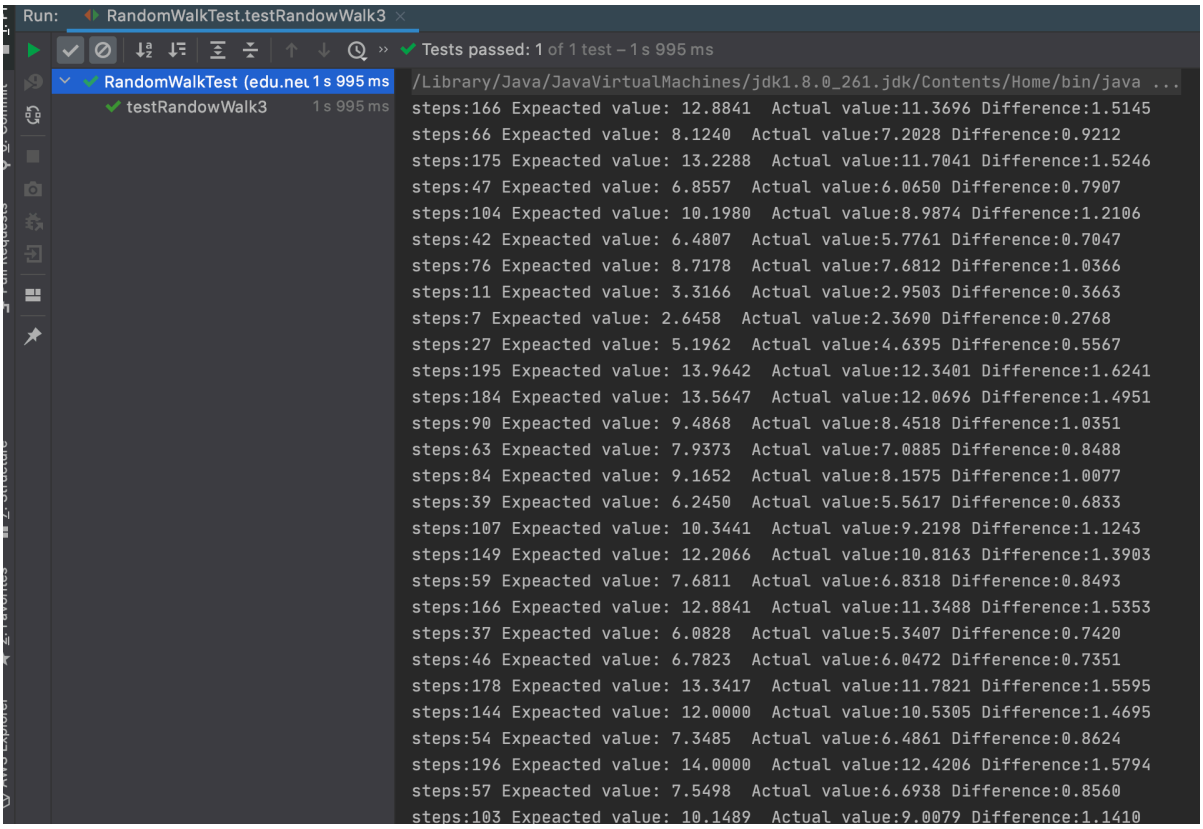
That is to say, the number of steps is the square of the expected Euclidean distance

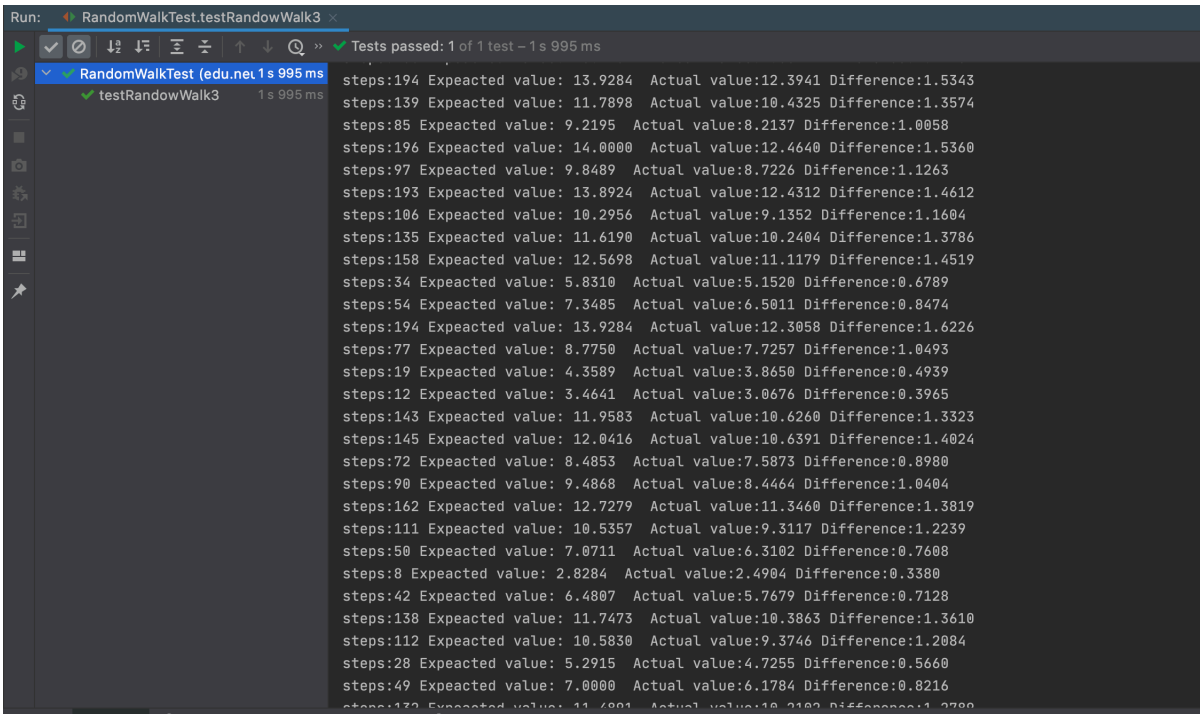
Provement of the test results

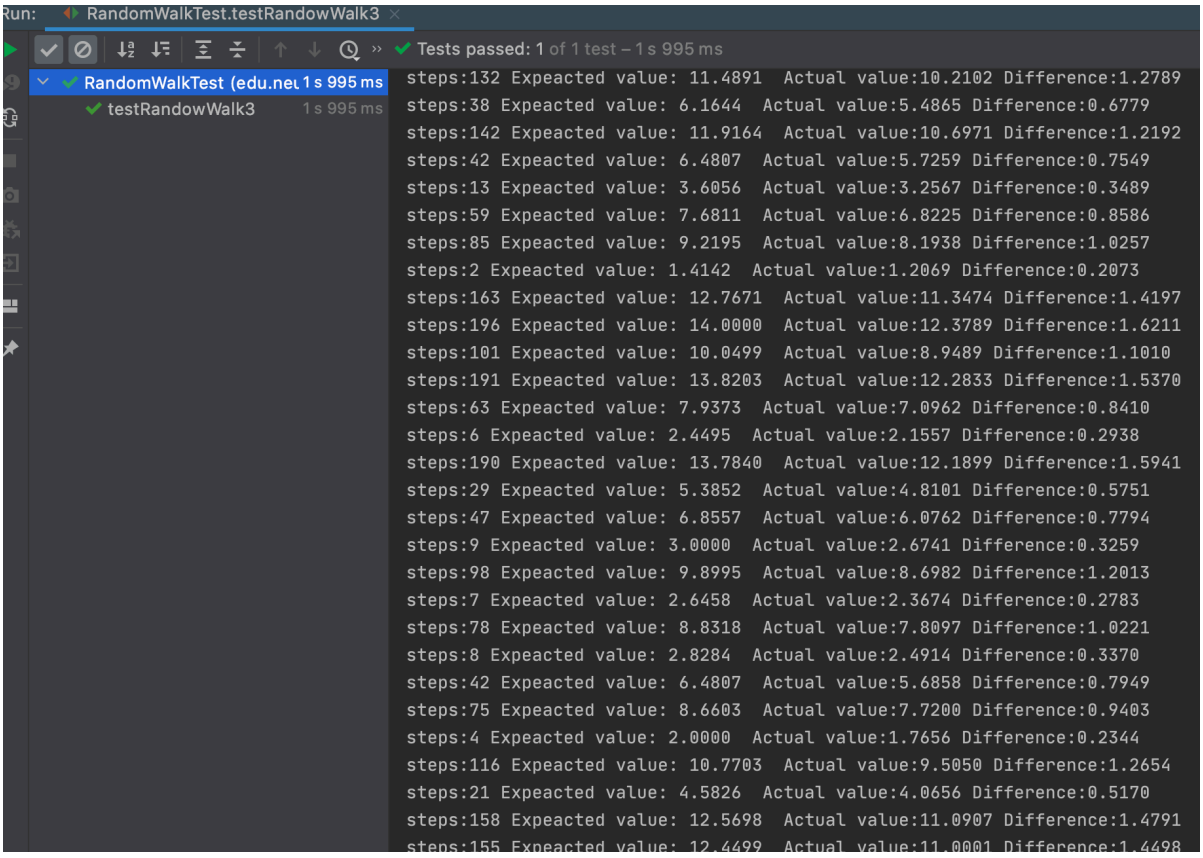
From my now test in the below picture, by comparing the expectation, average and their difference

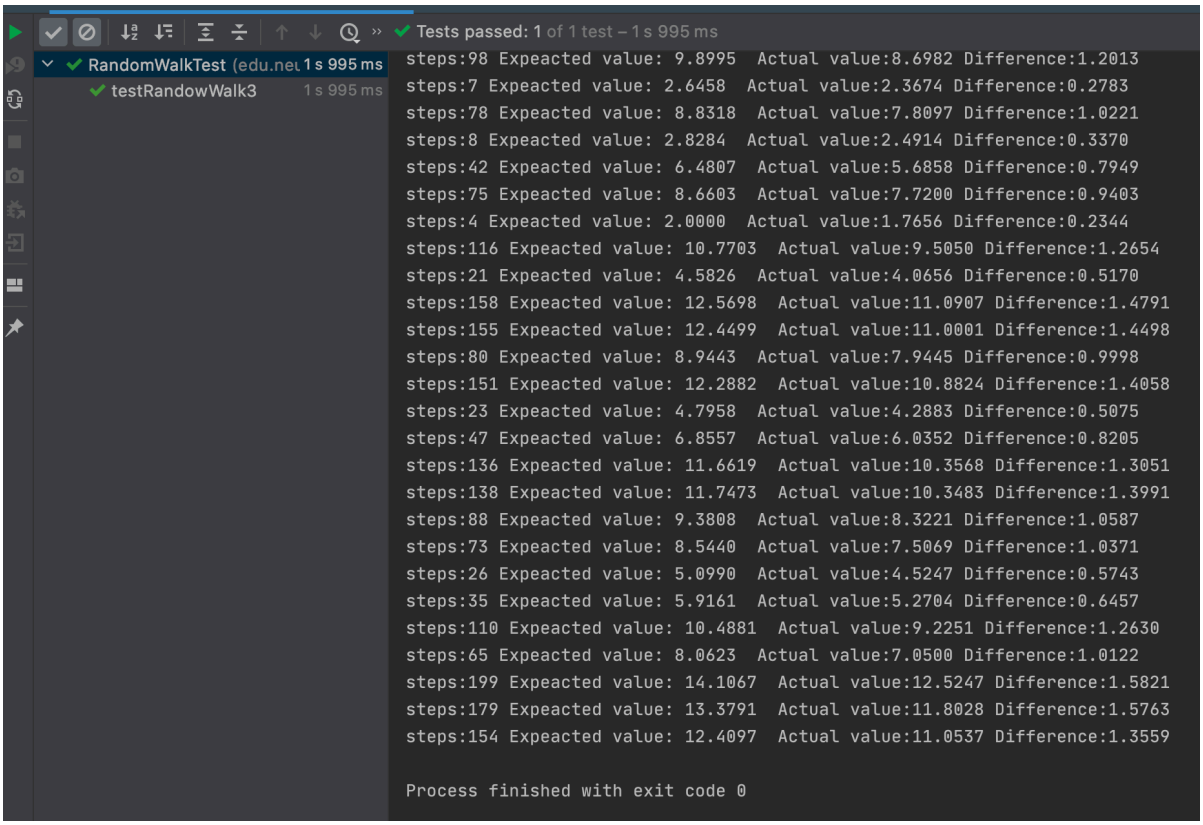
```
@Test
public void testRandowWalk3(){
    Random random = new Random();
    for(int i = 0; i < 100; i++){
        int steps = random.nextInt( bound: 200);
        double expected =Math.sqrt(steps);
        double average = RandomWalk.randomWalkMulti(steps, n: 10000);
        System.out.printf("steps:%d Expeacted value: %.4f  Actual value:%.4f Difference:%.4f\n",steps,expected,avera
        assertEquals(expected,average, delta: 3);
    }
}
}
```

The the conclusion above can be proved by the result below




Run: RandomWalkTest.testRandowWalk3
Tests passed: 1 of 1 test – 1 s 995 ms
RandomWalkTest (edu.nei 1 s 995 ms
testRandowWalk3 1 s 995 ms
steps:194 Expeacted value: 13.9284 Actual value:12.3941 Difference:1.5343
steps:139 Expeacted value: 11.7898 Actual value:10.4325 Difference:1.3574
steps:85 Expeacted value: 9.2195 Actual value:8.2137 Difference:1.0058
steps:196 Expeacted value: 14.0000 Actual value:12.4640 Difference:1.5360
steps:97 Expeacted value: 9.8489 Actual value:8.7226 Difference:1.1263
steps:193 Expeacted value: 13.8924 Actual value:12.4312 Difference:1.4612
steps:106 Expeacted value: 10.2956 Actual value:9.1352 Difference:1.1604
steps:135 Expeacted value: 11.6190 Actual value:10.2404 Difference:1.3786
steps:158 Expeacted value: 12.5698 Actual value:11.1179 Difference:1.4519
steps:34 Expeacted value: 5.8310 Actual value:5.1520 Difference:0.6789
steps:54 Expeacted value: 7.3485 Actual value:6.5011 Difference:0.8474
steps:194 Expeacted value: 13.9284 Actual value:12.3058 Difference:1.6226
steps:77 Expeacted value: 8.7750 Actual value:7.7257 Difference:1.0493
steps:19 Expeacted value: 4.3589 Actual value:3.8650 Difference:0.4939
steps:12 Expeacted value: 3.4641 Actual value:3.0676 Difference:0.3965
steps:143 Expeacted value: 11.9583 Actual value:10.6260 Difference:1.3323
steps:145 Expeacted value: 12.0416 Actual value:10.6391 Difference:1.4024
steps:72 Expeacted value: 8.4853 Actual value:7.5873 Difference:0.8980
steps:90 Expeacted value: 9.4868 Actual value:8.4464 Difference:1.0404
steps:162 Expeacted value: 12.7279 Actual value:11.3460 Difference:1.3819
steps:111 Expeacted value: 10.5357 Actual value:9.3117 Difference:1.2239
steps:50 Expeacted value: 7.0711 Actual value:6.3102 Difference:0.7608
steps:8 Expeacted value: 2.8284 Actual value:2.4904 Difference:0.3380
steps:42 Expeacted value: 6.4807 Actual value:5.7679 Difference:0.7128
steps:138 Expeacted value: 11.7473 Actual value:10.3863 Difference:1.3610
steps:112 Expeacted value: 10.5830 Actual value:9.3746 Difference:1.2084
steps:28 Expeacted value: 5.2915 Actual value:4.7255 Difference:0.5660
steps:49 Expeacted value: 7.0000 Actual value:6.1784 Difference:0.8216


Run: RandomWalkTest.testRandowWalk3
Tests passed: 1 of 1 test – 1 s 995 ms
RandomWalkTest (edu.nei 1 s 995 ms
testRandowWalk3 1 s 995 ms
steps:132 Expeacted value: 11.4891 Actual value:10.2102 Difference:1.2789
steps:38 Expeacted value: 6.1644 Actual value:5.4865 Difference:0.6779
steps:142 Expeacted value: 11.9164 Actual value:10.6971 Difference:1.2192
steps:42 Expeacted value: 6.4807 Actual value:5.7259 Difference:0.7549
steps:13 Expeacted value: 3.6056 Actual value:3.2567 Difference:0.3489
steps:59 Expeacted value: 7.6811 Actual value:6.8225 Difference:0.8586
steps:85 Expeacted value: 9.2195 Actual value:8.1938 Difference:1.0257
steps:2 Expeacted value: 1.4142 Actual value:1.2069 Difference:0.2073
steps:163 Expeacted value: 12.7671 Actual value:11.3474 Difference:1.4197
steps:196 Expeacted value: 14.0000 Actual value:12.3789 Difference:1.6211
steps:101 Expeacted value: 10.0499 Actual value:8.9489 Difference:1.1010
steps:191 Expeacted value: 13.8203 Actual value:12.2833 Difference:1.5370
steps:63 Expeacted value: 7.9373 Actual value:7.0962 Difference:0.8410
steps:6 Expeacted value: 2.4495 Actual value:2.1557 Difference:0.2938
steps:190 Expeacted value: 13.7840 Actual value:12.1899 Difference:1.5941
steps:29 Expeacted value: 5.3852 Actual value:4.8101 Difference:0.5751
steps:47 Expeacted value: 6.8557 Actual value:6.0762 Difference:0.7794
steps:9 Expeacted value: 3.0000 Actual value:2.6741 Difference:0.3259
steps:98 Expeacted value: 9.8995 Actual value:8.6982 Difference:1.2013
steps:7 Expeacted value: 2.6458 Actual value:2.3674 Difference:0.2783
steps:78 Expeacted value: 8.8318 Actual value:7.8097 Difference:1.0221
steps:8 Expeacted value: 2.8284 Actual value:2.4914 Difference:0.3370
steps:42 Expeacted value: 6.4807 Actual value:5.6858 Difference:0.7949
steps:75 Expeacted value: 8.6603 Actual value:7.7200 Difference:0.9403
steps:4 Expeacted value: 2.0000 Actual value:1.7656 Difference:0.2344
steps:116 Expeacted value: 10.7703 Actual value:9.5050 Difference:1.2654
steps:21 Expeacted value: 4.5826 Actual value:4.0656 Difference:0.5170
steps:158 Expeacted value: 12.5698 Actual value:11.0907 Difference:1.4791


Tests passed: 1 of 1 test – 1 s 995 ms
RandomWalkTest (edu.net 1 s 995 ms
testRandowWalk3 1 s 995 ms
steps:98 Expeacted value: 9.8995 Actual value:8.6982 Difference:1.2013
steps:7 Expeacted value: 2.6458 Actual value:2.3674 Difference:0.2783
steps:78 Expeacted value: 8.8318 Actual value:7.8097 Difference:1.0221
steps:8 Expeacted value: 2.8284 Actual value:2.4914 Difference:0.3370
steps:42 Expeacted value: 6.4807 Actual value:5.6858 Difference:0.7949
steps:75 Expeacted value: 8.6603 Actual value:7.7200 Difference:0.9403
steps:4 Expeacted value: 2.0000 Actual value:1.7656 Difference:0.2344
steps:116 Expeacted value: 10.7703 Actual value:9.5050 Difference:1.2654
steps:21 Expeacted value: 4.5826 Actual value:4.0656 Difference:0.5170
steps:158 Expeacted value: 12.5698 Actual value:11.0907 Difference:1.4791
steps:155 Expeacted value: 12.4499 Actual value:11.0001 Difference:1.4498
steps:80 Expeacted value: 8.9443 Actual value:7.9445 Difference:0.9998
steps:151 Expeacted value: 12.2882 Actual value:10.8824 Difference:1.4058
steps:23 Expeacted value: 4.7958 Actual value:4.2883 Difference:0.5075
steps:47 Expeacted value: 6.8557 Actual value:6.0352 Difference:0.8205
steps:136 Expeacted value: 11.6619 Actual value:10.3568 Difference:1.3051
steps:138 Expeacted value: 11.7473 Actual value:10.3483 Difference:1.3991
steps:88 Expeacted value: 9.3808 Actual value:8.3221 Difference:1.0587
steps:73 Expeacted value: 8.5440 Actual value:7.5069 Difference:1.0371
steps:26 Expeacted value: 5.0990 Actual value:4.5247 Difference:0.5743
steps:35 Expeacted value: 5.9161 Actual value:5.2704 Difference:0.6457
steps:110 Expeacted value: 10.4881 Actual value:9.2251 Difference:1.2630
steps:65 Expeacted value: 8.0623 Actual value:7.0500 Difference:1.0122
steps:199 Expeacted value: 14.1067 Actual value:12.5247 Difference:1.5821
steps:179 Expeacted value: 13.3791 Actual value:11.8028 Difference:1.5763
steps:154 Expeacted value: 12.4097 Actual value:11.0537 Difference:1.3559
Process finished with exit code 0