

Author

[Lan gao](#)

001568670

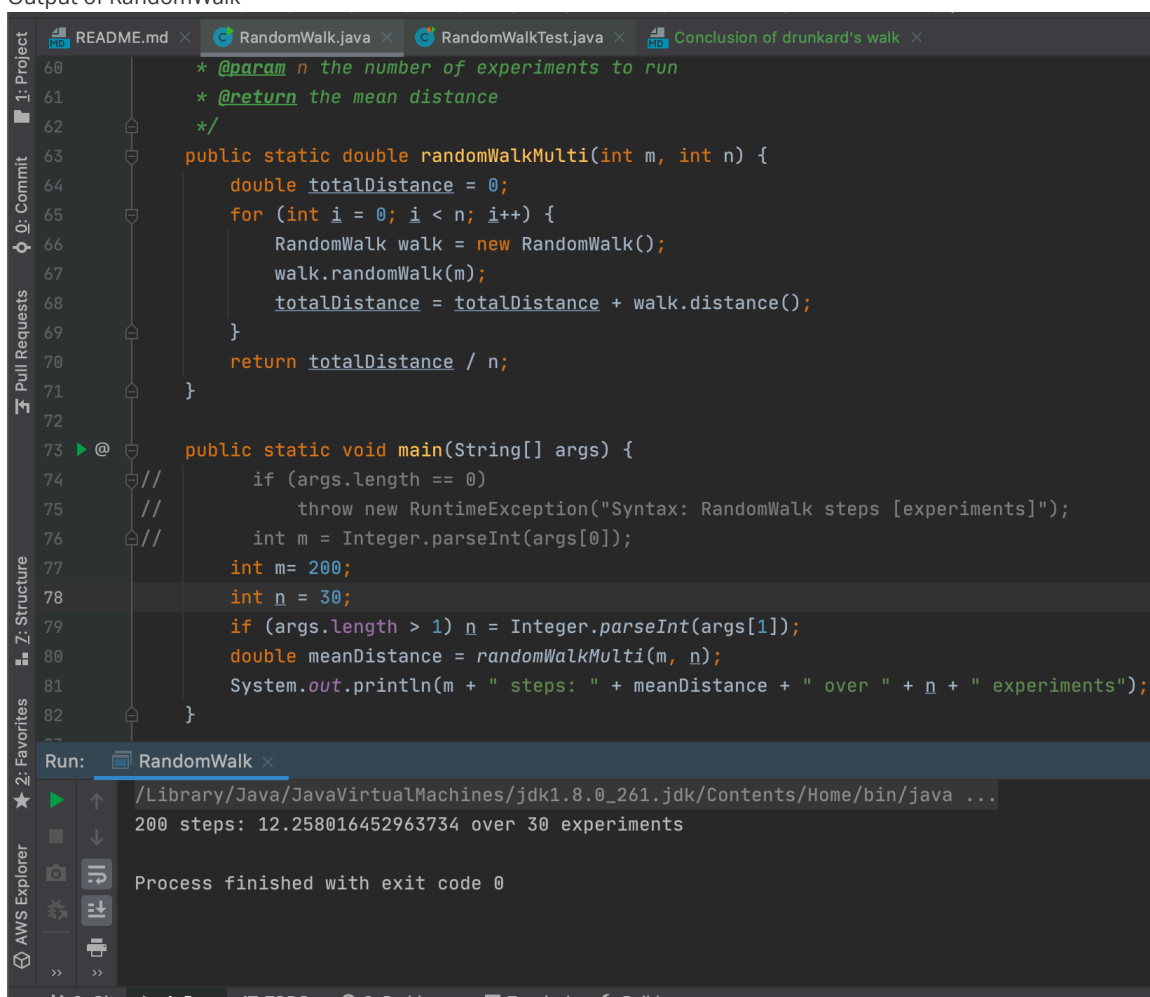
Task

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



The screenshot shows an IDE with the following components:

- Project Explorer:** Shows files README.md, RandomWalk.java, RandomWalkTest.java, and Conclusion of drunkard's walk.
- Code Editor:** Displays the RandomWalk.java file with the following code:

```
60  * @param n the number of experiments to run
61  * @return the mean distance
62  */
63  public static double randomWalkMulti(int m, int n) {
64      double totalDistance = 0;
65      for (int i = 0; i < n; i++) {
66          RandomWalk walk = new RandomWalk();
67          walk.randomWalk(m);
68          totalDistance = totalDistance + walk.distance();
69      }
70      return totalDistance / n;
71  }
72
73  @
74  public static void main(String[] args) {
75      if (args.length == 0)
76          throw new RuntimeException("Syntax: RandomWalk steps [experiments]");
77      //
78      int m = Integer.parseInt(args[0]);
79      int m = 200;
80      int n = 30;
81      if (args.length > 1) n = Integer.parseInt(args[1]);
82      double meanDistance = randomWalkMulti(m, n);
83      System.out.println(m + " steps: " + meanDistance + " over " + n + " experiments");
84  }
```
- Run Console:** Shows the output of the program:

```
/Library/Java/JavaVirtualMachines/jdk1.8.0_261.jdk/Contents/Home/bin/java ...
200 steps: 12.258016452963734 over 30 experiments
Process finished with exit code 0
```

- Tests Results

```

Run: RandomWalkTest
Tests passed: 7 of 7 tests - 2 s 297 ms
RandomWalkTest (edu.neu.2 s 297 ms)
  testRandomWalk2 10 ms
  testMove0 2 ms
  testMove1 1 ms
  testMove2 1 ms
  testMove3 1 ms
  testRandomWalk3 2 s 81 ms
  testRandomWalk 201 ms
steps:139 Expected value: 11.7898 Actual value:10.4838 Difference:1.3868
steps:108 Expected value: 10.3923 Actual value:9.2247 Difference:1.1676
steps:110 Expected value: 10.4881 Actual value:9.1772 Difference:1.3108
steps:148 Expected value: 12.1655 Actual value:10.7447 Difference:1.4208
steps:18 Expected value: 4.2426 Actual value:3.7688 Difference:0.4818
steps:196 Expected value: 14.0000 Actual value:12.4277 Difference:1.5723
steps:173 Expected value: 13.1529 Actual value:11.6633 Difference:1.4897
steps:59 Expected value: 7.6811 Actual value:6.7240 Difference:0.9572
steps:70 Expected value: 8.3666 Actual value:7.4044 Difference:0.9622
steps:57 Expected value: 7.5498 Actual value:6.7501 Difference:0.7997
steps:94 Expected value: 9.6954 Actual value:8.5966 Difference:1.0988
steps:55 Expected value: 7.4162 Actual value:6.5728 Difference:0.8434
steps:62 Expected value: 7.8740 Actual value:7.0893 Difference:0.7847
steps:85 Expected value: 9.2195 Actual value:8.1468 Difference:1.0728
steps:199 Expected value: 14.1067 Actual value:12.4000 Difference:1.7067
steps:19 Expected value: 4.3589 Actual value:3.8467 Difference:0.5122
steps:44 Expected value: 6.6332 Actual value:5.8474 Difference:0.7858
steps:151 Expected value: 12.2882 Actual value:10.8895 Difference:1.3987
steps:101 Expected value: 10.0499 Actual value:8.9544 Difference:1.0955
steps:80 Expected value: 8.9443 Actual value:8.0420 Difference:0.9022
steps:74 Expected value: 8.6023 Actual value:7.6875 Difference:0.9148
steps:4 Expected value: 2.0000 Actual value:1.7549 Difference:0.2451
steps:66 Expected value: 8.1240 Actual value:7.1659 Difference:0.9581
steps:143 Expected value: 11.9583 Actual value:10.5671 Difference:1.3912
steps:168 Expected value: 12.9615 Actual value:11.4771 Difference:1.4844
steps:77 Expected value: 8.7750 Actual value:7.8473 Difference:0.9276
Process finished with exit code 0

```

- My own test

```

@Test
public void testRandomWalk3(){
    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 Expected value: %.4f Actual value: %.4f Difference: %.4f\n", steps, expected, average,
            assertEquals(expected, average, delta: 3);
    }
}

```

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 $N = n + 1$:

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

After simplified, 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 testRandomWalk3(){
    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 Expected value: %.4f Actual value: %.4f Difference: %.4f\n", steps, expected, average,
            assertEquals(expected, average, delta: 3);
    }
}
```

The the conclusion above can be proved by the result below

```
Run: RandomWalkTest.testRandomWalk3
Tests passed: 1 of 1 test - 1 s 995 ms

RandomWalkTest (edu.net 1 s 995 ms)
testRandomWalk3 1 s 995 ms
/Library/Java/JavaVirtualMachines/jdk1.8.0_261.jdk/Contents/Home/bin/java ...
steps:166 Expected value: 12.8841 Actual value:11.3696 Difference:1.5145
steps:66 Expected value: 8.1240 Actual value:7.2028 Difference:0.9212
steps:175 Expected value: 13.2288 Actual value:11.7041 Difference:1.5246
steps:47 Expected value: 6.8557 Actual value:6.0650 Difference:0.7907
steps:104 Expected value: 10.1980 Actual value:8.9874 Difference:1.2106
steps:42 Expected value: 6.4807 Actual value:5.7761 Difference:0.7047
steps:76 Expected value: 8.7178 Actual value:7.6812 Difference:1.0366
steps:11 Expected value: 3.3166 Actual value:2.9503 Difference:0.3663
steps:7 Expected value: 2.6458 Actual value:2.3690 Difference:0.2768
steps:27 Expected value: 5.1962 Actual value:4.6395 Difference:0.5567
steps:195 Expected value: 13.9642 Actual value:12.3401 Difference:1.6241
steps:184 Expected value: 13.5647 Actual value:12.0696 Difference:1.4951
steps:90 Expected value: 9.4868 Actual value:8.4518 Difference:1.0351
steps:63 Expected value: 7.9373 Actual value:7.0885 Difference:0.8488
steps:84 Expected value: 9.1652 Actual value:8.1575 Difference:1.0077
steps:39 Expected value: 6.2450 Actual value:5.5617 Difference:0.6833
steps:107 Expected value: 10.3441 Actual value:9.2198 Difference:1.1243
steps:149 Expected value: 12.2066 Actual value:10.8163 Difference:1.3903
steps:59 Expected value: 7.6811 Actual value:6.8318 Difference:0.8493
steps:166 Expected value: 12.8841 Actual value:11.3488 Difference:1.5353
steps:37 Expected value: 6.0828 Actual value:5.3407 Difference:0.7420
steps:46 Expected value: 6.7823 Actual value:6.0472 Difference:0.7351
steps:178 Expected value: 13.3417 Actual value:11.7821 Difference:1.5595
steps:144 Expected value: 12.0000 Actual value:10.5305 Difference:1.4695
steps:54 Expected value: 7.3485 Actual value:6.4861 Difference:0.8624
steps:196 Expected value: 14.0000 Actual value:12.4206 Difference:1.5794
steps:57 Expected value: 7.5498 Actual value:6.6938 Difference:0.8560
steps:103 Expected value: 10.1489 Actual value:9.0079 Difference:1.1410
```

```
Run: RandomWalkTest.testRandomWalk3 x
Tests passed: 1 of 1 test - 1 s 995 ms
RandomWalkTest (edu.neu) 1 s 995 ms
testRandomWalk3 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
steps:132 Expeacted value: 11.4891 Actual value:10.2102 Difference:1.2789
```

```
Run: RandomWalkTest.testRandomWalk3 x
Tests passed: 1 of 1 test - 1 s 995 ms
RandomWalkTest (edu.neu) 1 s 995 ms
testRandomWalk3 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
steps:155 Expeacted value: 12.4499 Actual value:11.0001 Difference:1.4498
```

```
Tests passed: 1 of 1 test - 1 s 995 ms
RandomWalkTest (edu.neu 1 s 995 ms)
testRandomWalk3 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
```