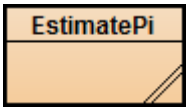
07.05 Assignment Instructions

Instructions: Write a program to calculate the value of ***pi*** by simulating throwing darts at a dart board.



1. Create a new project called 07.05 Challenge Program in the Mod07 Assignments folder.
2. Create a class called EstimatePi in the 7.05 project folder.
3. Read the **Background** section below to learn how to use random numbers to simulate throwing darts. As you have seen with other random simulations, the more trials of a random event, the greater the accuracy of the estimate. This is a perfect situation in which to apply the Monte Carlo Method.
4. Use top-down design and procedural abstraction in this program. In other words, put functional units into methods.
5. Prompt the user for how many darts should be thrown in a trial. (If you enter a very large number, you may have to investigate the use of the **long** primitive data type.) The example below indicates 1500 darts were thrown in each trial.
6. Prompt the user for the number of trials. The example below indicates there were 10 trials.
7. Estimate ***pi*** for each trial.
8. The imaginary circle representing your dartboard should have a radius measuring 1 unit.
9. Use random values for x and y. All values can be positive.
10. Count any (x, y) coordinate that satisfies $x^2 + y^2 <= 1$ within the circle as a hit, any coordinates outside the circle as a miss.
11. Calculate the average of the estimates for all trials and print the results.
12. Use comments throughout the program to document sections of code.
13. Evaluate how many darts/trial it takes for the estimate of ***pi*** to begin to approach 3.141592, both for individual trials and the average.

Background: Imagine you have a dartboard like the one illustrated here: a unit circle inscribed inside a square whose sides are equal to the diameter of the circle, or two times the radius. Assume that you throw darts at the dartboard while blindfolded, so in essence your throws are random and could land anywhere inside the square. This is somewhat analogous to Buffon's Needle.

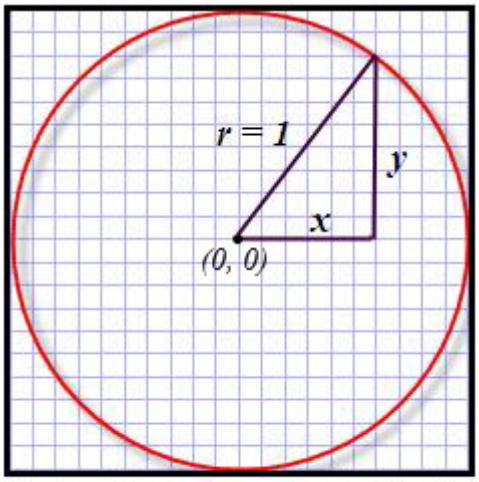
$$\pi \approx 4\left(\frac{h}{n}\right)$$

If you count how many times a dart hits within the circle (h) out of all attempts (n), the value of pi can be estimated with the following calculation.

Imagine a circle with a radius of 1 and a center at (0, 0) is inscribed within a square. You already know how to generate random numbers between 0.0 and < 1.0. Any pair of random numbers the computer chooses can represent the (x, y) coordinates anywhere within the square.

If a hit is defined as any point within the boundaries of the inscribed circle that satisfies the expression $x^2 + y^2 <= 1$, then any point outside the circle does not count as a hit.

Using the Pythagorean Theorem, you can plug in the values of x and y and find the hypotenuse of the triangle. If it is less than the radius of the circle, then you have a hit! Remember, it's just algebra!



$$r^2 = x^2 + y^2$$

Expected Output: When your program runs correctly, the output should resemble the following screen shot:

```
How many darts per trial? 1500
How many trials? 10
Trial [ 1]: pi = 3.117921
Trial [ 2]: pi = 3.133911
Trial [ 3]: pi = 3.171219
Trial [ 4]: pi = 3.107262
Trial [ 5]: pi = 3.107262
Trial [ 6]: pi = 3.155230
Trial [ 7]: pi = 3.157895
Trial [ 8]: pi = 3.195203
Trial [ 9]: pi = 3.211193
Trial [10]: pi = 3.200533
Estimate of pi = 3.155763
```

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