Physics through Computational Thinking

The Monte Carlo method

Auditya Sharma and Ambar Jain
Dept. of Physics, IISER Bhopal

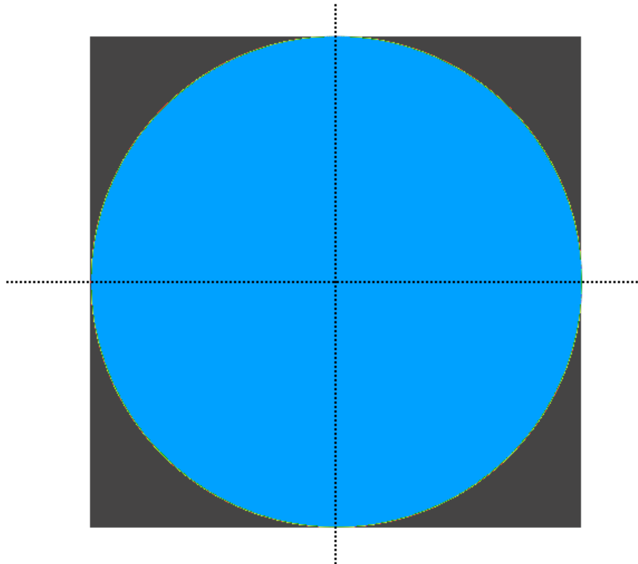
Outline

In this module we look at

1. Another Monte Carlo method to compute π

Estimating π

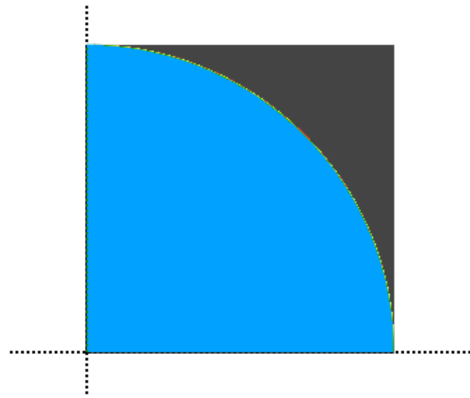
- Strategy for calculating π using random number is straightforward. Consider a circle embedded in a square, such that radius of circle is 1 and sides of the square are 2.
- If we randomly and uniformly generate points in the square and count the points that fall inside the circle what fraction of points will lie inside the circle? In other words if I throw darts randomly inside the square bounding the dartboard, what is the probability of landing inside the dartboard?



- The probability is given by

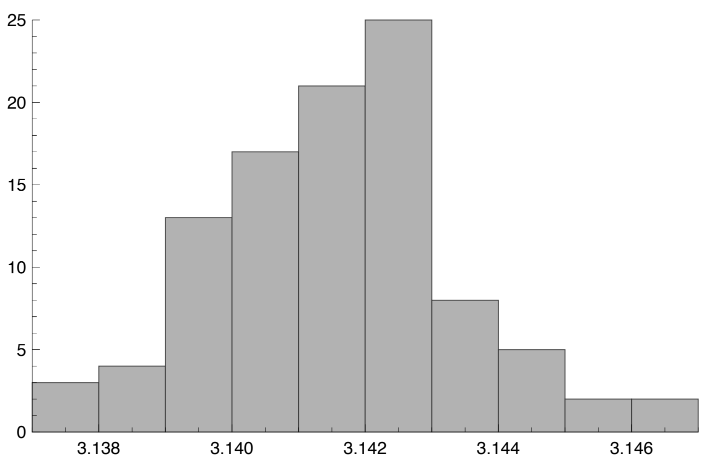
$$P_{\text{circle}} = \frac{\text{Area of Circle}}{\text{Area of Square}} = \frac{\pi}{4} \tag{1}$$

- In practice, using the 4-fold symmetry of the problem, we can solve this problem by throwing points in just the first quadrant. That saves lot of computational time as we need to generate only one-quarter of the random numbers otherwise required.



```
dataset = Table[nMax = 1 000 000;
    (1/nMax) (Table[If[(RandomReal[{0, 1}, 2]^2 // Total) ≤ 1, 1, 0], {nMax}] // Total) 4.0, {100}]; // Timing
Histogram[dataset]
```

```
{11.9217, Null}
```



- The Histogram above tells us how accurately we have determined the value of π using the Monte Carlo Method.