



# Informatik I

Exercise session 4

Autumn 2019

# Homework

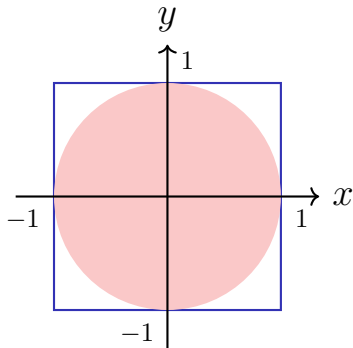
- Questions?

# Monte Carlo Simulation

**Monte Carlo Simulation:** Use randomness to solve problems.  
Wide area of applications in applied mathematics, all natural sciences and engineering

# Estimate $\pi$ using Monte Carlo Simulation

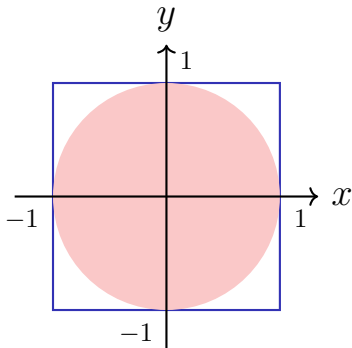
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Idea: simulate random variable with uniform distribution on the unit square  $[0, 1] \times [0, 1]$ .

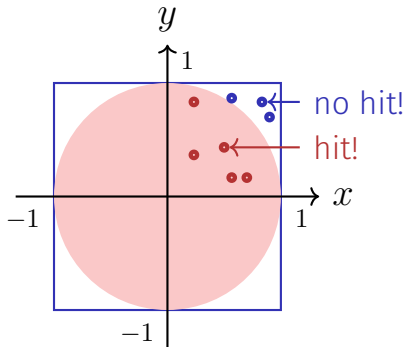


# Estimate $\pi$ using Monte Carlo Simulation

$$\frac{\text{circle area}}{\text{square area}} = \frac{\pi}{4}$$

Idea: simulate random variable with uniform distribution on the unit square  $[0, 1] \times [0, 1]$ .

$$\frac{\text{number hits}}{\text{number trials}} \cdot 4 \approx \pi.$$



# Task

- Conduct an experiment: estimate  $\pi$  using the Monte Carlo method above.
- Execute the experiment for number of trials 1, 2, 4, 8, ...,  $n$ ,  $n$  should be asked from the user.
- Output the number of trials and the estimation of  $\pi$  each time.

Hint: a pseudo-random number uniformly distributed on  $[0, 1)$  can be obtained via **Math.random()**.

# Extension

Deterministic formulas to approximate  $\pi$ :

$$Sum_1 : \frac{\pi}{4} = 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \dots$$

$$Sum_2 : \frac{\pi}{2} = 1 + \frac{1}{3} + \frac{1 \cdot 2}{3 \cdot 5} + \frac{1 \cdot 2 \cdot 3}{3 \cdot 5 \cdot 7} + \dots$$

Compare the approximation accuracy of the different methods.



# Solution on next slide

spoiler ahead – do not open (yet)

# Estimate $\pi$ using Monte Carlo Simulation

```
public class Main {
    public static void main(String[] args){
        int n = In.readInt();
        for (int trials = 1; trials <= n; trials*=2){
            int hits = 0;
            for (int i = 0; i<trials; ++i){
                double x = Math.random();
                double y = Math.random();
                if (x * x + y * y <= 1){
                    hits++; }
            }
            double pi = (double)hits / trials * 4;
            Out.println("trials=" + trials + ", pi=" + pi);
        }
    }
}
```