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Computational Physics II
SS 2018

Deadline: 30. May 2018
Please turn in a written documentation of your results and submit the programs to Jonathan Prexl at *jonathan.prexl@physik.uni-marburg.de*

6.1. Buffon's needle problem

In the 18th century, Georges-Louis Leclerc, Comte de Buffon, posed the following problem: Suppose we have a floor made of parallel strips of wood, each the same width, and we drop a needle onto the floor. What is the probability that the needle will lie across a line between two strips?
To be specific, we let d be the distance between the strips and $\ell < d$ the length of the needle. Set up a Monte Carlo simulation to determine this probability $p(\rho)$ for different ratios $\rho = \ell/d <$. What values do you get for different ρ?
How can you improve the computations for small ρ? What can you say about $p(\rho)/\rho$?

6.2. Travelling salesman: exact solution

The traveling salesman problem asks for the shortest path that connects a given list of N cities without doubling a path or visiting a city twice. Numbering all cities from 1 to N, any sequence of N integers without repetition is a possible path.
Obtain the positions of the cities as pairs of N random numbers in the square $[0, 1] \times [0, 1]$, with distance being defined by the Euclidean distance.
As a step towards the Monte Carlo determination of short paths, write a program that determines the shortest path for $N = 2, \ldots, 9$ cities.
Now implement the analog of the Metropolis algorithm for a Monte Carlo simulation:

- a path is a sequence of cities, i.e. an arbitrary permutation of the numbers $1, \ldots, N$.
- for a new path, pick two cities at random and exchange their positions in the list.
- if he new path is shorter, keep it
- if the new path is longer by $\Delta\ell$; accept it with probability $\exp(-\Delta\ell/T)$, where T is the "temperature".

When the temperature is high, almost all paths will be accepted. To obtain optimal paths, lower the temperature gradually until no improvements are observed for some time.