UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Laboratorio di Fisica Computazionale

2021-1-F1701Q119

Aims

Study and implementation of computing techniques for
solving physics problems.

Contents

Basic methods: Interpolation, Integration, Differential equations, Monte Carlo methods.

Applications: simulation of a classical gas using molecular dynamics; computation of cross sections in field theory and high energy physics

Detailed program

Operating environments and programming languages:
- Overview of c, c++, Fortran90, Python, Maxima.
- Main libraries and graphics programs.
- Basic notions of the Unix/Linux OS.

Elementary numerical methods:
- Polinomial Interpolation; Lagrange and Newton construction (method of divided differences).
- Interpolation error. Interpolation on equally spaced points. Cebysev interpolation.

Integration:

Numerical integration: elementary methods, Gaussian integration, adaptive integration.

Differential equations:
Euler and midpoint method. Runge-Kutta method.

Monte Carlo integration: Central Limit Theorem; Monte Carlo integration techniques.
Importance sampling, stratified sampling, adaptive methods. Multidimensional integrators (Vegas, Mint).
Generation of parameters with a given probability distribution.

Molecular Dynamics: System of soft spheres at finite temperatures:
Integration of large systems of differential equations. Leap Frog and Verlet methods. Symplectic methods. Shadow Hamiltonian. Implementation of a code for molecular dynamics. Measurement of thermodynamic quantities.

Automatic calculation of Feynman graphs using algebraic methods (with Maxima) and numerical methods (helicity amplitudes.) Costruction of a Monte Carlo generator for an elementary process of high energy physics.

Prerequisites

Classical Mechanics, Quantum Mechanics, Lab of computer science.

Teaching form

Lecture and laboratory activity.
Because of the Covid-19 emergency, the laboratory will not be available.
The lectures will be given in streaming, and will be recorded and made available to the students. During the laboratory hours, a streeming meeting platform will be available, for asking questions and examining problems with code developement.

Lab hours are on Friday from 10 to 12 and from 14 to 17.

Textbook and teaching resource

Numerical Recipes, W. H. Press, S. A. Teukolsky, W. T. Vetterling, B. P. Flannery.

W. Feller, An introduction to probability theory and its application.
Trattatello di Probabilità, E. Marinari, G. Parisi.

D. C. Rapaport, “The Art of Molecular Dynamics Simulation,” Cambridge University Press (2004).

VEGAS -An Adaptive Multi-dimensional Integration Program, P. Lepage

MINT: A Computer program for adaptive Monte Carlo integration and generation of unweighted distributions

Paolo Nason (Sep 13, 2007) e-Print: 0709.2085 [hep-ph]

Semester

First and second semesters.

Assessment method

The students must prepare a written report which summarizes the theoretical material of the course and contains a presentation of the code developed during the course and the relative results. The report will be discussed in an oral exam, during which the general knowledge of the course programme will be verified.

Office hours

On request.