UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Computational Physics Laboratory

2526-3-E3001Q066

Aims

Knowledge and understanding: The student will learn the basis of scientific numerical calculus.

Applying knowledge and understanding: The student will learn to apply the concepts of scientific numerical calculus to the study of physically interesting problems using the computer.

Making judgments: The student will develop critical thinking and judgment skills in selecting the most appropriate tool, among those provided during the course, to solve a specific problem.

Communication skills: The student will be expected to acquire a correct and appropriate scientific language suited to the topics covered in the course.

Learning skills: The student will be able to deepen their understanding of specific concepts not covered during the course and to independently pursue advanced study using specialized scientific texts.

Contents

Introduction and basic concepts of computer programming. Methods to numerically solve integrals, ordinary differential equations, linear systems of equations, and their applications.

Detailed program

Introduction and basic concepts

- Representation of Numbers on a Computer, round-off errors and Floating-Point Arithmetic
- Error Propagation, Condition Numbers, and Stability

Interpolation/Optimization

- Interpolations by Polynomials

Topics in Integration

- The Integration Formulas of Newton and Cotes: Trapezoidal rule, Simpson’s rule, Composite rules, etc.
- Gaussian Integration Methods. Error Analysis
- Applications to simple integrals

Systems of Linear Equations

- Techniques and Algorithms for solving Linear Systems
- Data Fitting: Linear Least Squares and the Normal Equation

Finding Zeros and Minimum Points by Iterative Methods

- Development of Iterative Methods and their Convergence
- Basic Methods and Algorithms: Bisection, Newton-Raphson, etc.
- Applications

Eigenvalue Problems

- Introduction and basic facts on Eigenvalues
- Methods for Determining the Eigenvalues and Eigenvectors of a Matrix

Ordinary Differential Equations

- Some Theorems from the Theory of Ordinary Differential Equations
- Techniques for the numerical solution of a differential equation: Euler, Runge-Kutta
- Applications

Prerequisites

Teachings of previous years. No particular coding skills are required other than very basic concepts of the C programming language, like the general structure of a code and the definition of a variable, of an array, of a function and of a loop.

Teaching form

Activity is carried out in the computer lab "Marco Comi" (room 2026, 2nd floor, building U2). The numerical techniques useful for solving the exercises are presented in a few theoretical lectures; each student works individually with the support of the teacher in case of need.

Textbook and teaching resource

The lecture notes by the teachers will be uploaded on the course webape.

In addition, we recommend the students to consult the following books:

Title: Numerical Mathematics (2nd ed.)
Authors: A. Quarteroni, R. Sacco, F. Saleri
Editor: Springer
Language: English

Title: Scientific Computing with MATLAB and Octave (4th ed.)
Authors: A. Quarteroni, F. Saleri, P. Gervasio
Editor: Springer
Language: English

Title: Introduction to Numerical Analysis (3rd ed.)
Authors: J. Stoer, R. Bulirsch
Editor: Springer
Language: English

Title: Numerical Recipes
Authors: William H. Press, Saul A. Teukolsky, William T. Vetterling, Brian P. Flannery
Editor: CAMBRIDGE UNIVERSITY PRESS
Language: English

Semester

The first instance of the course will take place during the first semester, while a second instance will take place during the second semester. Students will be split up in the two instances by the teachers.

Assessment method

1. In the computer lab the student has to solve numerically a number of execises by writing computer codes.
2. Every student collects the results of the study in a written report. The report (in pdf format) as well as the codes and the results of the numerical study have to be sent to the teacher by email at least two weeks before the exam.
3. The exam, oral, consists in the discussion of the report and the solutions of the exercises.

The overall evaluation is determined from the oral exam (3.) and informed by the lab activity (1.) and the final report(2.).

If desired, (Erasmus) students can give the exam in English (both the oral part and the written report).

The students that will attend the course during the first or second semester will be evaluated by the corresponding teachers.

Office hours

By fixing an appointment via e-mail with the teacher of the corresponsping semester (first and second)

Sustainable Development Goals

QUALITY EDUCATION