Academic Year/course: 2022/23

27029 - Numerical Simulation in Ordinary Differential Equations

Syllabus Information

Academic Year: 2022/23
Subject: 27029 - Numerical Simulation in Ordinary Differential Equations
Faculty / School: 100 - Facultad de Ciencias
Degree: 453 - Degree in Mathematics
ECTS: 6.0
Year: 4
Semester: First semester
Subject Type: Optional
Module:

1. General information

1.1. Aims of the course

This is an optional course in the degree of Mathematics. Its goal is to present the essentials of methods for the numerical solution of differential problems.

These approaches and objectives are aligned with the following Sustainable Development Goals (SDGs) of the United Nations 2030 Agenda (https://www.un.org/sustainabledevelopment/es/), in such a way that the acquisition of the learning outcomes of the module provides training and competence to contribute to some extent to their achievement: (4) Quality education, (5) Gender equality, (8) Decent work and economic growth, (9) Industry, innovation and infrastructure, (10) Reducing inequality, (17) Partnerships for the goals.

1.2. Context and importance of this course in the degree

The course belongs to the module *Cálculo científico y simulación numérica*. To take this course it is highly convenient to have passed the courses *Análisis matemático I*, *Análisis matemático II*, *Ecuaciones diferenciales ordinarias*, *Informatica I*, *Análisis numérico I* and *Análisis Numérico II*.

1.3. Recommendations to take this course

The attendace to the class lectures and the computer laboratory sessions is highly recomended, as well as the individual work on the problems posed along the course. It is highly convenient to have passed the subjects *Análisis matemático I* and *II*, *Ecuaciones diferenciales ordinarias*, *Informatica I*, *Análisis numérico I* and *Análisis numérico II*.

2. Learning goals

2.2. Learning goals

At the end of this course students should be able to:

- Know criteria to compare and evaluate several numerical methods taking into account the computational cost.
- Evaluate the numerical results obtained and draw conclusions
- Know how approximate numerically the solution of an initial value problem and estimate the error committed by the numerical method.
- Know the limitations and advantages of the numerical methods under consideration.
- Know some commercial software (e.g. *Matlab*, *Mathematica*...) and free software (e.g. ipython) for the numerical solution of differential problems.

3. Assessment (1st and 2nd call)

3.1. Assessment tasks (description of tasks, marking system and assessment criteria)

As a general rule, the module can be passed either showing a regular work along the academic year, or by a final exam.

- Regular work. During the course, the student results will be evaluated through a periodical supply of exercises or short tasks, together with their active participation during the course (30%). The use of LaTeX in written presentations (50%) is recommended; the evaluation include an oral presentation using Beamer (20%). These evaluations will constitute the final mark.
- Final exam. The aforementioned procedure does not exclude the right, according to the current regulations, to a final exam which, by itself, allows to pass the module.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

The methodology followed in this course is oriented towards the achievement of the learning objectives. It is convenient to have knowledge of Mathematical Analysis, Differential Equations, programming languages and Numerical Analysis.

It favors the understanding of the state of the art numerical methods for the numerical integration of initial value problems in ordinary differential equations, and also boundary problems. A wide range of teaching and learning tasks are implemented, such as theory sessions, laboratory sessions and individual assignments.

Students are expected to participate actively in the class throughout the semester.

Classroom materials will be available via Moodle/personal web page of the professor. These include a repository of the lecture notes used in class, the course syllabus, as well as other course-specific learning materials, including a discussion forum.

Further information regarding the course will be provided on the first day of class.

4.2. Learning tasks

This is a 6 ECTS course organized as follows:

- Lectures (4 ECTS: 40 hours). Lecture notes and a set of problems (and their corresponding solutions) will be available for the students. At the end of each topic, some of the problems will be solved in class by the teacher and the rest will be done individually. The lecturer will also may assign, from those unsolved problems, problems to groups of 4-5 students, which they will submit to the teacher.
- Laboratory sessions (1.5 ECTS: 15 hours). Two-hour sessions that take place approximately every 2 weeks in a computer room. Students are provided in advance with task guidelines for each session. We will use python for the implementation of the algorithms explained in the classroom.
- Assignments (0.5 ECTS: 5 hours). Individual or in groups of two students work on lab reports and different assignments during the course.

The teaching activities and assessment tasks will take place in a face-to-face mode, except in the case that, due to the health situation, the dispositions emitted by the competent authorities and by the University of Zaragoza compel to take them to a greater or lesser extent in a telematic form.

4.3. Syllabus

- Section 1. One-step methods. Consistency, stability and convergence.
- Section 2. Runge-Kutta methods.
- Section 3. Linear multistep methods.
- Section 4. Boundary Value Problems. Shooting methods.
- Section 5. Implementation of the numerical schemes and numerical simulation.

4.4. Course planning and calendar

Schedule of basic activities under the supervisor's guidance:

- Determining your topic, scope and purpose. It is strongly advised that the choice of topic and scope for your final presentation is completed by the first four weeks of the second semester.
- Planning individual tutorials.
- Progress reports (draft revisions).
- Final editing and proofreading. The final version of the presentation will be handed in to the supervisor at least two weeks before the deadline for official submission. The presentation of the presentation must be written in English using Beamer with a duration of twenty minutes.

Further information concerning the timetable, classroom, office hours, assessment dates and other details regarding this course will be provided on the first day of class or please refer to the Facultad de Ciencias website (https://ciencias.unizar.es) and the department website.

4.5. Bibliography and recommended resources

- Ernst Hairer, Syvert Paul Norsett, Gerhard Wanner, Solving Ordinary Differential Equations I. Nonstiff Problems. Springer Series in Comput. Mathematics, Vol. 8, Springer-Verlag 1987, Second revised edition 1993.
- Ernst Hairer, Gerhard Wanner, Solving Ordinary Differential Equations II. Stiff and Differential-Algebraic Problems. Springer Series in Comput. Mathematics, Vol. 14, Springer-Verlag 1991, Second revised edition 1996.
- M. Calvo, J. I. Montijano y L. Rández; Curso de Análisis Numérico (Métodos de Runge-Kutta para la resolución numérica de ecuaciones diferenciales ordinarias). Servicio de Publicaciones de la Universidad de Zaragoza, 1985.
- M. Calvo y J. I. Montijano, L. Rández; Curso de Análisis Numérico (Métodos lineales multipaso para la resolución numérica de ecuaciones diferenciales ordinarias). Servicio de Publicaciones de la Universidad de Zaragoza, 1985.

http://psfunizar10.unizar.es/br13/egAsignaturas.php?codigo=27029