Universidad del País Vasco Euskal Herriko Unibertsitatea

COURSE GUIDE 2025/26

Faculty 345 - Faculty of Engineering - Bilbao **Cycle** .

Degree GITECI30 - Bachelor`s Degree in Industrial Technology Engineering **Year** Third year

COURSE

26677 - Advanced Numerical Methods **Credits, ECTS:** 6

COURSE DESCRIPTION

This subject is part of the "Advanced Sciences Module", where it intends to deepen the mathematical knowledge acquired by the student in the subjects of the "Basic Formation Module". The additional abilities acquired in this subject will place the graduate in Industrial Technology Engineering in a good position to benefit from the Master and also to work in engineering companies.

The subject will start by developing interpolation methods, which will later be applied to the numerical integration and differentiation of functions. Systems of differential equations (initial-value and boundary-value problems) will also be solved. Most of the methods studied will also be implemented in Matlab/Octave.

COMPETENCIES/LEARNING RESULTS FOR THE SUBJECT

COMPETENCIES:
* Abilities for the numerical resolution of a wide range of mathematical problems that arise in engineering.
* Ability to apply theoretical knowledge on interpolation and numerical integration and differentiation to engineering problems.
* Ability to apply theoretical knowledge on differential equations and systems, and their stability, to the numerical resolution of linear and non-linear, first and higher-order systems of differential equations appearing in many engineering problems.
* Dexterity in the implementation of the methods studied in the classroom programming them in Matlab/Octave, as well as in judiciously using its readily-implemented methods.

RESULTS:
The attainment of the competencies of the subject will enable the student to solve mathematical problems arising in many areas of modern engineering. The student will be able to apply theoretical knowledge on numerical analysis in order to obtain approximate numerical solutions to various problems they may encounter when exercising their professional activity. Specifically the student will attain:
* Skills in the use of computers to apply sophisticated numerical schemes to solve engineering problems with functions to be interpolated, integrated or differentiated, with understanding of the truncation and rounding errors incurred.
* Skills for symbolic manipulation and for numerical evaluation and approximation in engineering problems modeled by means of linear and non-linear, first and higher-order differential equations and systems thereof, with understanding of the errors incurred and their stability issues.
* Skills to use the Matlab/Octave computing environment, both at the user and programming levels. This will be an important problem-solving asset not only in this subject, but also in other academic subjects and in the student’s future professional activity.

Theoretical and Practical Contents

1. Function interpolation: Lagrange and Newton polynomials (divided differences, finite differences), osculating polynomials, piecewise polynomial functions (splines).
2. Numerical integration: formulas of interpolatory type, stability and convergence. Simple and compound Newton-Cotes and Gaussian quadrature (Gauss-Legendre, Gauss-Laguerre, Gauss-Hermite, Gauss-Chebyshev).
3. Ordinary differential equations, initial-value problems: linear and non-linear equations and systems of equations of first and higher orders. Single-step explicit and implicit methods, linear multistep methods, predictor-corrector methods.
4. Numerical differentiation: interpolatory formulas, instability, optimal step size.
5. Boundary problems: shoot method for linear and non-linear problems, finite-difference methods.

TEACHING METHODS

* Lectures in which the theoretical concepts of the subject will be explained.
* Problem classes in which some exemplary exercises will be solved some others will be proposed for the student to solve.
* Computer lab sessions in which the student will learn to use the Matlab/Octave programming language and environment. This will be applied to the direct implementation of the numerical methods as studied in the classroom and to the judicious use of some already-implemented methods.
* The student will have access to different materials related to the subject through a teaching online platform (eGela).
* Tutoring hours are also available for the student to consult with their professors.

TYPES OF TEACHING

Types of teaching	M	S	GA	GL	GO	GCL	TA	TI	GCA
Hours of face-to-face teaching	30		15		15				
Horas de Actividad No Presencial del Alumno/a	45		22,5		22,5				

Legend: M: Lecture-based | S: Seminar | GA: Applied classroom-based groups | GL: Applied laboratory-based groups | GO: Applied computer-based groups | GCL: Applied clinical-based groups | TA: Workshop | TI: Industrial workshop | GCA: Applied fieldwork groups

Evaluation methods

- Continuous evaluation
- End-of-course evaluation

Evaluation tools and percentages of final mark

- Written test, open questions 75%
- Exercises, cases or problem sets 25%

ORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT

In the ordinary assessment call (in any modality, with or without continuous assessment) the weight of the written part (with theory and problems) will be 75% of the final grade. The other 25% will be obtained through one or more computer tests related to the practical sessions with Matlab/Octave. To pass the subject, the weighted average of both grades must be at least 5 (over 10). Furthermore, both grades (written and computer) must be at least 4; otherwise the student will fail the subject with grade 4.5 at the most.

The computer test of the ordinary call will take place either during the last regular lab session of the course or on a nearby date announced in advance during the term. Alternatively, the computer test may take place in shorter sessions during the course of the term.

The written test will take place on the official date and time announced at the university’s website. Additionally, if special circumstances make it advisable, previous shorter written tests may be taken in order to lighten the final one.

In any case the student will have the right to be evaluated by the final-assessment system. To exercise this right, the student must follow the instructions in Article 8 (Chapter 2) on the Assessment Systems of the Norms regulating students’ Assessment in the official Degree titles. In this case, the final test of the ordinary call will consist of two parts:
- a written test (theory + problems) weighting 75% of the final grade;
- a computer test (Matlab/Octave), weighting the other 25%.
In order to pass the subject, both grades must be 4 or more and their weighted average must be 5 or more.

Students will appear as NOT PRESENT ("NO PRESENTADO") in the ordinary call if and only if they do not sit the written test, regardless of whether they had sat the computer test or not. If a student sits the computer test but not the written one, they will appear as Not Present in the ordinary call, but any grade of 4 or more will be kept for the extraordinary call (see its assessment below). If a student sits the written test but not the computer test, their final grade in the ordinary call will be computed (weighted) as with grade 0 in the computer part.

Under no circumstances will any grade be kept from one academic year to another.

Students must bring an official ID document to all tests. They must also bring a non-programmable calculator to the written tests. The use of any other electronic device or written material will be forbidden.

During the computer tests, it will not be allowed to use any materials or resources (classroom notes, code, or any form of external assistance) unless otherwise stated explicitly and in advance by the teacher. It will always be allowed to use the Matlab/Octave built-in help system.

EXTRAORDINARY EXAMINATION PERIOD: GUIDELINES AND OPTING OUT

The test of the extraordinary assessment call will have two parts: a written one (theory + problems), weighting 75% of the final grade, and a practical, computer one, weighting the other 25%. Both will be held on the same date with a short break in between.

Students with at least 5 points in the written part in the ordinary call only need to sit the computer part. Students with at least 4 points in the computer part in the ordinary call only need to sit the written part. In other words, grades 5 or more in the written test of the ordinary call and grades 4 or more in the computer test(s) in the ordinary call will be kept for the extraordinary call, unless the student decides to resit any of them in order to improve their grade. In that case, the valid grade will be the last one, regardless of whether it is better or not.

To pass the subject, the weighted average of both grades must be at least 5 (over 10). Furthermore, both grades (written and computer) must be at least 4; otherwise the student will fail the subject with grade 4.5 at the most.

Under no circumstances will any grade be kept from one academic year to another.

Students must bring an official ID document to both tests (written and computer). They must also bring a non-programmable calculator to the written one. The use of any other electronic device or written material will be forbidden.

During the computer tests, it will not be allowed to use any materials or resources (classroom notes, code, or any form of external assistance) unless otherwise stated explicitly and in advance by the teacher. It will always be allowed to use the Matlab/Octave built-in help system.

MANDATORY MATERIALS

* Advanced Numerical Methods Classroom Notes (Theory and Exercises) I and II. By the Professors of the Subject. Online teaching platform (eGela).
* Advanced Numerical Methods Computer Practicals. By the Professors of the Subject. Online teaching platform (eGela).

BIBLIOGRAPHY

Basic bibliography

* Ampliación de Métodos Numéricos: Notas de Clase. In Spanish. By the Professors of the Subject. Online teaching platform (eGela) and Publishing Service of the Faculty of Engineering of Bilbao.
* Ampliación de Métodos Numéricos: Prácticas de Laboratorio. In Spanish. By the Professors of the Subject. Online teaching platform (eGela) and Publishing Service of the Faculty of Engineering of Bilbao.
* Burden R.L., Faires J.D., 2009: Análisis Numérico, Grupo Ed. Iberoamérica.
* Conte S.D., de Boor C., 2005: Análisis Numérico, McGraw-Hill.
* Lindfield G., Penny J., 2000: Numerical Methods using MATLAB, Prentice Hall.
* Mathews J.H., Fink K.D., 2000: Métodos Numéricos con MATLAB, Prentice Hall.

Detailed bibliography

* Kincaid D., Cheney W., 2007: Análisis Numérico. Las matemáticas del cálculo científico, Addison-Wesley Iberoamericana.
* Lambert J.D., 1991: Numerical Methods for Ordinary Differential Systems: The Initial Value Problem, Wiley.
* Stoer J., Bulirsch R., 2002: Introduction to Numerical Analysis, Springer Verlag.

Journals

Web sites of interest

https://egela.ehu.eus/
http://ingeniaritza-bilbao.ehu.eus
http://www.ehu.eus
http://www.mathworks.com
http://www.octave.org
http://www.octave-online.net

OBSERVATIONS

This subject is all about numerical methods, so their computer implementation is considered as an important part of it. This is the rationale behind the requirement of reaching at least 4 points in the computer part of the subject. Furthermore, dexterity in the use of Matlab/Octave is a very important asset for the professional activity of an engineer, and one the labor market duly values.

If a student has a very good mark in the written part and a very poor mark in the computer part, their final grade may appear as 4.5 points, but their real "distance" to passing the subject is not 0.5 points, but the one separating them from getting at least 4 points in the computer part.

It is emphatically advised that students try to attend all the computer sessions, either in person or online, but if that is not possible, they should acquire their computer proficiency by other means (e.g. in the School’s open computer rooms, or at home). Their assessment in the computer part of the subject will be based solely on their objective performance in the computer test(s), not on their attendance to the practical sessions.