Course plan

Subject	**Fundamentals of *Mathematica* for Students of Science**		
Matter	Cross-disciplinary		
Degree	Physics, Mathematics, Chemistry, Engineering		
Study program	------	**Reference no.**	---------
Term	Second term	**Type**	Cross-disciplinary
Level	Bachelor degree	**Course/Year**	2021-2022
ECTS units	3 ECTS		
Language	English		
Lecturer in charge	Luis Miguel Nieto		
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Office hours	Please check the timetable		
Department	Física Teórica, Atómica y Óptica		

1. Placement of the subject in the study program

1.1 Context

Mathematica is a fully integrated system for technical computing. Among the capabilities it offers are:

- an interactive front end with notebook interface
- numerical calculations with (practically) unlimited precision
- symbolic manipulation
- special functions
- graphics

Within a *Mathematica* notebook you can develop solutions to complex problems that combine symbolic derivations, numerical calculations, and graphical displays in an interactive document. The tools provided by *Mathematica* will help you focus more on conceptual development and visualization than on details of algebra or procedural programming.
Mathematica program is free available on Campus computers, and can be also installed in personal computers under Campus licence. It works under Linux, macOS, Windows, etc.

1.2 Relationship with other subjects

This cross-disciplinary course is related to all those subjects in mathematical methods and physics that the students have taken in previous terms. It contains applications to a number of subjects in a Science curriculum. In a few words, it may be an essential tool for making progress in all Science subjects, in a TFG/TFM or even in advanced research activities.

1.3 Requirements

It is recommendable that the students have acquired the knowledge and capabilities provided by the courses of Linear Algebra and Geometry and Mathematical Analysis.

2. Competencies and capabilities

2.1 General

T1. Analysis and synthesis skills.
T2. Organization capability.
T3. Oral and writing communication skills.

T4. Problem solving strategies.
T5. Team work capability.
T6. Autonomous work and learning capabilities.
T7. Skills of adaptation to new mathematical methods.
T8. Capability to apply generic methods to particular scenarios.
T9. Creativity.

2.2 Specific

E1.Capability to deliver a presentation on academic topics and research work.
E2. Capability to get into new fields of study and research.
E3. Capability to work out the necessary approximations to make complicated problems manageable.
E4. Computation skills leading to the development of original software, as well as to the application of conventional software packages.
E6. Teaching skills at academic level.
E7. Capability to integrate the knowledge from different areas in order to apply it to solve complex problems.
E8. Understanding of the most common mathematical methods, both analytical and numerical ones.

3. Aims

Leaning the basics of the program.
Learning to solve problems in several disciplines, either Mathematics, Physics, Chemistry, Engineering, etc.
Learning to use the many available tools to solve more complicated and research problems.
Learning programming with *Mathematica*.

4. Contents

1. Introduction: the front end, help sources, input conventions, and some important functions.
2. Basic programming tools and techniques. Includes implicit and explicit functions, recursive techniques, scoping and loop commands, conditionals, etc.
3. Central concepts of the *Mathematica* language and its internal representation of expressions.
4. Manipulation of the basic data structure and efficient programming.
5. Basic visualization tools and embellishments.
6. Manipulation and simplification of algebraic expressions, solutions to equations, eigensystems, etc.
7. Differentiation, integration, Taylor series
8. Symbolic and numerical solutions to ordinary differential equations.
9. Symbolic and numerical computations involving dimensioned quantities and their units.
10. Storing and retrieving information from files.
11. Subtleties of algebra with complex variables.
12. Recursive functions, dynamic programming, and stability of recurrence relations.
13. The strategy and mechanics of developing packages.
14. Brief *Mathematica* introduction for physics laboratory.
15. Applications:
    a. Algebra.
    b. Analysis: Real and Complex.
    c. Statistics.
    d. Fractals.
    e. Differential equations: Ordinary and Partial.
    f. Dynamical systems and chaos.
    g. Mechanics.
    h. Electrostatics and Electrodynamics.
    i. Quantum Mechanics.
    j. Special and General Relativity.
    k. Other advanced topics.

5. Methodology

- Practical sessions in the computing class.

6. References

1. Mathematica by Example, M. L. Abell and J. P. Braselton, Academic Press (2017).
2. A Mathematica Primer for Physicists, J. Napolitano, CRC Press (2018).
3. Classical Mechanics with Mathematica, A. Romano and A. Marasco, Birkhauser (2018).

7. Time distribution of students' activities

IN-CLASS ACTIVITIES	TIME (h)	OUT-OF-CLASS ACTIVITIES	TIME (h)
Laboratory/computing sessions (L)	30	Autonomous individual and team work	45
In-class total time	**30**	**Out-of-class total time**	**45**

9. Assessment

PROCEDURE	OVERALL WEIGHT	REMARKS
Several assignments will be offered to be addressed at home.	60-100%	Compulsory
Final exam. It will contain practical questions to be assessed in a 10 point grading scale.	0-40%	Compulsory