## Course plan

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|---|---|---|---|
| **Subject** | **Mathematical Methods in Physics III** | | |
| **Matter** | Mathematics | | |
| **Degree** | Physics | | |
| **Study program** | 469 | **Reference no.** | 45753 |
| **Term** | Second term | **Type** | Compulsory |
| **Level** | Bachelor degree | **Course/Year** | Second year, 2019-2020 |
| **ECTS units** | 6 ECTS | | |
| **Language** | English | | |
| **Lecturer in charge** | José M. Muñoz Castañeda | | |
| **Contact details (E-mail, telephone …)** | Email: jose.munoz.castaneda@uva.es<br>Phone: 983 42 3267<br>Office: B234 | | |
| **Office hours** | Please check the timetable | | |
| **Department** | Física Teórica, Atómica y Óptica | | |

## 1. Placement of the subject in the study program

### 1.1 Context

Mathematical Method in Physics III proved the undergraduate students with basic mathematical tools in functions of one complex variable, the Gamma function, Laplace transforms, and probability theory.

### 1.2 Relationship with other subjects

These lectures are continuation of other previous lectures in Mathematics. In addition these lectures find application in most of the different areas of Physics.

### 1.3 Requirements

It is very convenient that the student has previously passed the Lectures of "Linear Algebra and Geometry" and "Analysis" from the 1st year, as well as Mathematical Methods in Physics I and II from the second year.

## 2. Competencies and capabilities

### 2.1 General

T1: Analysis and synthesis skills
T2: Planning and organization skills
T3: Oral and written communication skills
T4: Problem solving skills
T5: working skills
T7: Individual working an learning skills
T8: Ability to get adapted to new situations
T9: Creativity.

### 2.2 Specific

E2: The student should be able of performing presentations of academic topics to specialized and general public
E4: The student should be able to introduce him/herself to new fields of knowledge.
E6: The student should be able to make the needed simplifications and assumptions to reduce a given problem into a much simpler one.
E7: The student should be able to develop his/her own software and use standard computing software.
E8: The student should be able to search and use bibliography in Physics and other technical areas, as well as use other information resources to deliver papers and other projects.
E9: The student should be able to explain certain concepts
E10: The student should able to be updated about new developments.
E13: The student should be able to use knowledge from other areas of Physics to solve a given problem.
E15: The student should be able to understand the most common mathematical and numerical methods used in Physics

## 3. Aims

- Understand the extension of the concept of a function over the real field to the complex field
- Understand the properties of the main functions in one complex variable.
- Understand the Gamma function and other special functions related
- Understand the Laplace transform, and be able to use it to solve certain kind of problems
- Know and use basics to characterize random variables

## 4. Time distribution for the Lectures

| IN-CLASS ACTIVITIES | HOURS | OUT-OF-CLASS ACTIVITIES | HOURS |
|---|---|---|---|
| Theory | 40 | Individual work | 60 |
| Practical lectures | 20 | Group work | 30 |
| **In-class total time** | **60** | **Out-of-class total time** | **90** |

## 5. Parts of the lectures

### Part 1: Theory of functions in one complex variable

**ECTS:** 3

#### a. Context and justification

The lectures start with a brief overview of the fundamentals concerning the field of complex numbers. Later on the student is introduce to the classical theory of functions in one complex variable and the basic results, as well as some applications in Physics.

#### b. Objectives

Understand the extension of functions in one real variable to the field of complex numbers.
Understand the basic properties of the functions in one complex variable

#### c. Contents

Functions in one complex variable. Analytical functions. Integration in the complex plane. Cauchy theorem and its consequences. The ring of formal series: Laurent and Taylor power series. The residues theorem and its application to compute integrals.

#### d. Teaching methods

Theory and problem solving classes

#### e. Work plan

The lecturer will explain in the theory lectures the key concepts concerning each chapter of this part.

There will be problem solving lectures, in which the students are expected to participate.

#### f. Marking criteria

Problem solving by the students in the class and/or mid term test.
Theory/practical final exam.

#### g. Basic Bibliography

Basic reference: H. Cartan, “The elementary theory of analytic functions of one or several complex variables”. Dover, 1995. It is highly recommended that the students get very familiarized with this reference.

#### h. Extra bibliography


- J.E. Marsden and M.J. Hoffman , Basic Complex Analysis, W.H. Freeman, New York, 1999.
- E. Kreyszig, Advanced Engineering Mathematics, J. Whiley & Sons, 2006.
- A.D. Wunsch, Complex Variables with Applications, Addison-Wesley, 1994.

### i. Necessary resources

## Part 2: Gamma function and Laplace transforms

**ECTS:** 1

### a. Context and justification

The Euler's Gamma function generalizes the concept of the factorial to the complex plane, and it plays a central role in many theoretical practical and hysical problems that would be studied along these lectures.

The Laplace transform is a very powerful tool that enables to transform differential equations into algebraic equations that are much easier to solve and to deal with.

### b. Objectives

Understand the Gamma function as well as other special functions related.
Understand the Laplace transform and its applications.

### c. Contents

The Gamma function, and other special functions related. Laplace transform: definition and properties, translation formula and inversion formula. Application to differential equations.

### d. Teaching methods

Same methods as part 1

### e. Work plan

Same as part 1.

### f. Marking criteria

Same for all the parts

### g. Basic Bibliography

G. Arfken, Mathematical Methods for Physicists, Academic Press, 1985.

### h. Extra bibliography

### i. Necessary resources

## Part 3: Probability and Statistics

**ECTS:** 2

### a. Context and justification

This last part is independent of the other two parts. It is an introduction to the theory of probability and statistics, as well as some of their applications

### b. Objectives

Understand the concepts of probability and frequency. Use basic techniques to characterize random variables. Understand the idea of a random sample, its average and variance.

### c. Contents

Probability spaces. Random variables. Functions of random variables. Random samples. Sample processing. Average and variance of a sample. Estimation of parameters.

### d. Teaching methods

Same method as part 1

### e. Work plan

Same plan as part 1

### f. Marking criteria

Same for all the parts.

### g. Basic Bibliography


- P.L. Meyer, Introductory Probability and Statistical Applications, Addison-Wesley (1971).
- R. Lipschutz, Schaum's Outline of Introduction to Probability and Statistics, McGraw-Hill Education (2011).


### h. Extra bibliography


- R.E. Walpole and R.H. Myers, Probability and Statistics for Engineers and Scientists, Pearson (2013).
- E.B. Mode, Elements of Probability and Statistics, Prentice-Hall (1966).


### i. Necessary resources

## 6. Schedule

| PART | Number of ECTS | Expected timing |
|---|---|---|
| Functions of complex variable | 3 | 10 Feb. – 2 April |
| Gamma function and Laplace transform | 1 | 14 April – 24 April |
| Probability and statistics | 2 | 27 April – 22 May |

## 7. Overview of the marking system

| Procedure | Weight over the final mark | REMARKS |
|---|---|---|
| Problem solving / mid term test | 10% | Mandatory |
| Final exam | 90% | Mandatory |

## 8. Time distribution of students' activities

| IN-CLASS ACTIVITIES | TIME (h) | OUT-OF-CLASS ACTIVITIES | TIME (h) |
|---|---|---|---|
| Theoretical lectures (T/M) | 40 | Autonomous individual work. | 65 |
| Practical lectures (A) | 20 | Preparation of exercises to be handed in. | 25 |
| **In-class total time** | **60** | **Out-of-class total time** | **90** |

## 9. Final remarks