Universitat Autònoma de Barcelona

2023/2024

Advanced Mathematical Methods

Code: 100167
ECTS Credits: 5

Degree	Type	Year	Semester
2500097 Physics	OT	3	1

Contact

Name: Santiago Peris Rodriguez

Email: santiago.peris@uab.cat

Teaching groups languages

You can check it through this link. To consult the language you will need to enter the CODE of the subject. Please note that this information is provisional until 30 November 2023.

Teachers

Santiago Peris Rodriguez

Pere Masjuan Queralt

Prerequisites

It is advisable to have studied the following subjects:
Calculus in one variable
Vector Calculus
Differential equations

Objectives and Contextualisation

This subject introduces some basic mathematical concepts
needed in physics in general, and in physics / Quantum mechanics

and field theories, in particular. It is intended that the student
achieve the understanding of the concepts of Hilbert space, operators, di

and, especially, groups. It wants to give an integrative vision

of concepts that appear in different fields in physics. At the same time, the student will have to acquire the capacity to apply them with agility for different types of problems.

Competences

- Act with ethical responsibility and respect for fundamental rights and duties, diversity and democratic values.
- Apply fundamental principles to the qualitative and quantitative study of various specific areas in physics
- Be familiar with the bases of certain advanced topics, including current developments on the parameters of physics that one could subsequently develop more fully
- Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, and before both specialist and general publics
- Develop the capacity for analysis and synthesis that allows the acquisition of knowledge and skills in different fields of physics, and apply to these fields the skills inherent within the degree of physics, contributing innovative and competitive proposals.
- Make changes to methods and processes in the area of knowledge in order to provide innovative responses to society's needs and demands.
- Take account of social, economic and environmental impacts when operating within one's own area of knowledge.
- Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
- Use mathematics to describe the physical world, selecting appropriate tools, building appropriate models, interpreting and comparing results critically with experimentation and observation
- Work independently, have personal initiative and self-organisational skills in achieving results, in planning and in executing a project

Learning Outcomes

1. Classify representations of the most simple groups.
2. Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, in front of both specialist and general publics.
3. Determine the effect on the observables of symmetry transformation.
4. Determine the observables that characterise representation.
5. Determine the representation that characterizes a particular physical system.
6. Determine the symmetry group (exact or approximate) associated with a physical system.
7. Explain the explicit or implicit code of practice of one's own area of knowledge.
8. Identify situations in which a change or improvement is needed.
9. Identify symmetry groups associated with the laws of physics.
10. Identify symmetry groups associated with theories of fundamental interactions.
11. Identify symmetry groups in addition to their particle and crystallography representations, associated with atomic physics.
12. Identify the social, economic and environmental implications of academic and professional activities within one's own area of knowledge.
13. Obtain representation of simple symmetry groups.
14. Relate continuous groups with the Lie algebra to which they are associated.
15. Relate the symmetries of nature with the appropriate symmetry group (exact or approximate).
16. Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
17. Use the tensor calculus.
18. Work independently, take initiative itself, be able to organize to achieve results and to plan and execute a project.

Content

PROGRAM

1. Hilbert spaces

1.1 Pre-Hilbert spaces.

2.2 Hilbert spaces.

2. Operators.

2.1 Linear operators.

2.2 Eigenvalues and eigenvectors.

3. Distributions

4. Introduction to group theory

4.1 Definition and motivation (symmetires)

4.2 Exemples: SO(3), SU(2), SU(N) (relation with unitary operators).

4.3 Lie algebras (generators of the continuous group)

4.4 su(N) (relation with selfadjoint operators) and relation with su(2) with so(3)

5. Representations

6. Tensorial methods

Methodology

This course develops mathematical language and calculation tools that are basic
for advanced physics subjects. The personal work of the student is funda
Classroom sessions will be divided into:
Lectures: The teacher will present the basic concepts and reasoning of e
Subject, with the support of examples.
Problem classes: Among a collection of problems, the teacher
will solve in detail a selection. Students will have to work on their own the

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Activities

Title	Hours	ECTS	Learning Outcomes

Type: Directed		
Blackboard lectures: the profesor will expone basic concepts and arguments for each subject, with the support of detailed examples.	27	1.08
Practical lectures: among a problems collection, the professor will solve a set of them. The rest will be solved by the students.	14	0.56
Type: Autonomous		
Individual and groupal work solving problems	28	1.12
Selective homework	11	0.44
Study of teoretical foundations	37	1.48

Assessment

Grading (Ordinary)

Midterm exam: 45% of the grade.

Final exam: 50% of the grade.
Exercises to be delivered: 5% of the grade.
Following rules of the university, to be able to take the make-up exam, th
Make-up exam: 95 % of the grade.

Grading ("Avaluació Unica")

A)Final Exam (55 % of the final grade): this is a written, individual, exam at the end of the semester.

B)Oral Exam (45 % of the final grade) : this is an individual exam, at the end of the semester.

C)Make-up Exam (55% of the final grade): this is an optional exam. The grade in this exam will replace the grade in A) (avaluacio unica) in all cases.

D)Oral Make-up Exam (45 % of the final grade): this is an optional exam. The grade in this exam will replace the grade in B) (avaluacio unica) in all cases.

Both gradings will have the final exam the same day. Idem concerning the make-up exam.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Final exam	50%	2.5	0.1	1, 2, 6, 4, 3, 5, 7, 9, 10, 11, 12, 8, 13, 16, 14, 15, 18, 17
Homework	5%	0.25	0.01	1, 2, 6, 4, 3, 5, 7, 9, 10, 11, 12, 8, 13, 16, 14, 15, 18, 17
Make-up exam	95%	3	0.12	1, 2, 6, 4, 3, 5, 7, 9, 10, 11, 12, 8, 13, 16, 14, 15, 18, 17
Midterm exam	45%	2.25	0.09	2, 7, 12, 8, 16, 18, 17

Bibliography

Basic bibliografy.

P. Szekeres, *A course in Modern Mathematical Physics*.

Elvira Romera et al., Métodos matemáticos: Problemas de espacios de Hilbert, operadores lineales y espectros

G. Arfken, *Mathematical Methods for Physics.*

Advanced and complementary bibliography.

J.J. Sakurai, *Modern Quantum Mechanics*.

J.F. Cornwell, *Group theory in Physics.*

H. Georgi, *Lie Algebras in particle physics.*

L. Abellanas i A. Galindo, *Espais de Hilbert*.

S.K. Barbarian, *Introducció a l'espai de Hilbert.*

L. Schwartz, *Métodos Matemáticos para las ciencias físicas.*

Software

Not concieved.