UAB
Universitat Autònoma de Barcelona

Standard Model: Fundamentals and Phenomenology

Code: 42864
ECTS Credits: 9

2025/2026

Degree	Type	Year
High Energy Physics, Astrophysics and Cosmology	OT	0

Contact

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Teachers

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Teaching groups languages

You can view this information at the end of this document.

Prerequisites

It is recommended to have taken the courses Introduction to the Physics of the Cosmos and Introduction to Quantum Field Theory.

Objectives and Contextualisation

The main purpose of this course is to give an overview of the Standard Model of particle physics, starting from the fundamentals and finishing with the phenomenology.

Competences

- Apply the main principles to specific areas such as particle physics, astrophysics of stars, planets and galaxies, cosmology and physics beyond the Standard Model.
- Formulate and tackle problems, both open and more defined, identifying the most relevant principles and using approaches where necessary to reach a solution, which should be presented with an explanation of the suppositions and approaches.
- Understand the bases of advanced topics selected at the frontier of high energy physics, astrophysics and cosmology and apply them consistently.
- Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.

- Use critical reasoning, analytical capacity and the correct technical language and formulate logical arguments.

Learning Outcomes

1. Analyzing the concept of spontaneous breaking of symmetry .
2. Apply chromodynamics of quantum to strong elementary processes .
3. Apply the Weinberg- Salam theory to electroweak elementary processes.
4. Calculate weak and strong electro sections.
5. Recognize the basics of Weinberg- Salam theory of electroweak interactions
6. Recognize the basis of Quantum Chromodynamics as a theory of strong interactions.
7. Understand the basics of the theory of the Standard Model and its phenomenology.

Content

Fundamentals of the Standard Model:

1. Difficulties of the pre-gauge theory
2. Global and local gauge invariance
3. Spontaneous symmetry breaking, Goldstone bosons and the Higgs mechanism
4. The Standard Model of electroweak interactions
5. Electroweak phenomenology
6. Flavour dynamics
7. Electromagnetic interactions of leptons and hadrons
8. An introduction to Quantum Chromodynamics (QCD)

Phenomenology of the Standard Model:

1. QCD in electron-proton collisions
2. QCD in electron-positron collisions
3. Jet algorithms
4. QCD in hadron-hadron collisions
5. Monte Carlo event generators
6. Top physics
7. Higgs physics
8. Heavy flavor physics
9. Neutrino physics

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Theory Lectures	68	2.72	1, 2, 3, 7, 6, 5
Type: Autonomous			
Discussion, Work Groups, Group Exercises	68	2.72	2, 3, 4
Study of Theoretical Foundations	68	2.72	1, 7, 6, 5

Theory Lectures and Exercises.

Classwork and Homework.

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.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Exam Fundamentals	25%	1.5	0.06	1, 3, 4, 7, 5
Exam Phenomenology	25%	1.5	0.06	2, 3, 4, 7, 6
Homework Fundamentals	25%	7.5	0.3	1, 3, 4, 7, 5
Homework Phenomenology	25%	7.5	0.3	2, 3, 4, 7, 6
Resit Exam	50%	3	0.12	1, 2, 3, 4, 7, 6, 5

One exam and one homework of Fundamentals of the SM, and one exam and one homework of Phenomenology of the SM.

In the case of Fundamentals of the SM, the homework will consist of a selected set of exercises.

In the case of Phenomenology of the SM, the homework will consist of an individual presentation about a selected research article.

For those who fail the course, it is possible to take a resit examination that will consist of a written exam covering all the content.

In order to take part in this resit exam, you have to be evaluated first of the exam and homework of the Fundamentals and Phenomenology parts of the course, respectively.

Single assessment: The students that opted for single assessment evaluation will have to perform a final evaluation that will first consist of a test of the whole syllabus. This test will take place on the same date, time, and place as the test of the continuous assessment modality. Besides, before the exam, the student will deliver 2 homeworks, on one side, with resolved exercises of a selected set of exercises proposed at an earlier date. On the other, a written report of a selected research article also suggested at an earlier date. For the mark, 50% of the final mark will come from the exam and each of the homeworks will count 25%. The students that opted for single assessment evaluation will have the chance of passing the module or improve their mark at the same re-evaluation test as the students that had opted for the continuous assessment option (both exams will be identical and will take place on the same day, time, and in the same place). However, it is mandatory to at least have taken the previous final test. At this test, it is only possible toimprove the mark of the exam. The part of the homeworks can not be improved in the re-evaluation.

Bibliography

Fundamentals of the Standard Model:

- D. Griffiths, *Introduction to Elementary Particles*, Wiley-VCH 2008
- B. R. Martin and G. Shaw, *Particle Physics,* Wiley
- M. E. Peskin, *Concepts of Elementary Particle Physics*, Oxford University Press 2019
- D. Goldberg, *The Standard Model in a Nutshell*, Princeton University Press 2017
- F. Halzen and A. D. Martin, *Quarks & Leptons: An Introductory Course in Modern Particle Physics*, Wiley 1984
- C. Quigg, *Gauge Theories of the Strong, Weak and Electromagnetic Interactions*, Princeton University Press 2013
- T. Cheng and L. Li, *Gauge Theory of Elementary Particle Physics*, Oxford University Press 1988
- J. F. Donoghue, E. Golowich and B. R. Holstein, *Dynamics of the Standard Model*, Cambridge University Press 2014
- P. Langacker, *The Standard Model and Beyond*, CRC Press 2017
- Y. Grossman and Y. Nir, *The Standard Model: From Fundamental Symmetries to Experimental Tests*, Princeton University Press 2023

Phenomenology of the Standard Model:

- F. Halzen and A. D. Martin, *Quarks & Leptons: An Introductory Course in Modern Particle Physics*, Wiley 1984
- R. K. Ellis, W. J. Stirling and B. R. Webber, *QCD and Collider Physics*, Cambridge University Press 2003
- D. H. Perkins, *Introduction to High Energy Physics*, Cambridge University Press 2000
- D. Green, *High Pt Physics at Hadron Colliders*, Cambridge University Press 2009

Software

It is recommended to use Mathematica Student Edition.

Groups and Languages

Please note that this information is provisional until 30 November 2025. You can check it through this link. To consult the language you will need to enter the CODE of the subject.

Name	Group	Language	Semester	Turn
(TEm) Theory (master)	1	English	first semester	morning-mixed