Introduction to Nuclear and Particle Physics

Course requirements

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Classes

Tuesday 15:30 - 17:30 A05
Thursday 16:00 - 18:00 AI 101
Friday 16:00 - 18:00 AI 101

Would it be possible to change the Friday class? Options: earlier on Friday (8-10), Wednesday (16-18) or Monday after 14:00.

Attendance is not mandatory and it will not affect the grades.

If you decide that you do not want to take the class after all, make sure to unregister from the class. Otherwise the class will be failed.

Syllabus

Course description:

This course introduces the students to the Standard Model (SM) of particle physics, explore its constraints and success, and connects the nuclear and particle phenomenology to the experimental methods and applications.
Course starts giving students basic tools and introductory concepts in subatomic physics and continues with the fundamental particle's phenomenology and role of the mediator forces, nuclear phenomenology, and radioactivity.
Next, the course covers the basics on electroweak interaction and Quantum Electro-Dynamic (QED) theory, and experimental facts, being the content of the unit completed by the basic description of the strong interaction and Quantum Chromodynamics (QCD) fitting to the SM frame for subatomic particles. Last part of the course will account for selected applications of nuclear and particle physics also giving students a forward-looking vision of nuclear and particle physics challenges, discoveries, and achievements ahead and technology aims.

Syllabus

Course Contribution to professional training:

The basic knowledge provided in this course is essential to understand and work with modern fundamental particle and radiation technology. Classroom guidelines allows student to learn key features of matter structure, the Standard Model of particle physics, which explains the fundamental forces in nature, except for gravity. Based on theory and experiments, the student can track particles, performs energy measurements, assessment of nuclear and particle decays (figures or merits and observables) which are mediated by the electroweak and strong forces and overall, they can understand how matter works at the subatomic scale and the expected results and uncertainties of such studies. The students overcome theory and experimental challenges related to this exciting particle and nuclear physics field and advanced engineering field.

Syllabus

Course objectives:

- Become familiar with the Standard Model of Particle Physics.
- Learning about Nuclear Models.
- Comprehend the rules, symmetries, for QCD and QED phenomenology.
- Connect theory and experiments, identify constraints and be able to discuss the uncertainties.
- Review nuclear and particle physics evolution and be capable to participate in discussions about its progress.

Syllabus

Units:

1	Introduction - Fermions, Bosons, and Fields	Basics
2	Relativistic kinematics	
3	Nuclear structure	Nuclear Physics
4	Nuclear decay and Radioactivity	
5	Nuclear reactions	
6	Symmetries	Particle Physics
7	Feynman Calculus	
8	QED	
9	QCD	
10	Detectors	
11	Applications	

Syllabus

Learning outcomes:

LEARNING OUTCOMES	STUDENT IS REQUIRED TO: (EVIDENCE OF LEARNING)	
A.	Know nuclear models and theory behind nuclear reactions	Know the basics of quantum mechanics and relativity describing atoms, nuclei and fundamental particles.
B.	Calculate processes for elementary particle and nuclei reactions and identify/develop detection strategies	Know the quantum fields role, mediators and gauge interactions, perturbation, symmetries, and experimental evidences result of particle-nuclei/particle-particle/particle-radiation-matter interactions.
C.	Know the standard model of particle physics from QCD and QED	Identify mechanisms and types of interaction of fermions and bosons within the standard model of particle physics, probability interactions, forbidden and allowed process, extraction of experimental evidence and uncertainty calculations from theory and experiments.
D.	Applications of Nuclear Technology and further developments	Understand phenomenology, apply the technical knowledge and become prepositive with scientific challenges coming after. Explore the importance of nuclear and radiation safety issues and peaceful uses of nuclear energy.

Syllabus

Methodology:

1. Theoretical classes.
2. Solving problems sessions.
3. Computational workshops.

Evaluation:

- Quizzes (+Homework) **40% of the grade**
- Midterm exam ~ *around the 16th of January 2023* **30% of the grade**
- Final exam ~ *around the 7th of March 2023* **30% of the grade**

Exams, Quizzes (and Homework) will be announced in advance in class and via email.

Academic integrity

Academic integrity is very important.

Cheating in exams will have a penalty of a score 0 for the full exam.

Cheating in the quizzes/homework will have a penalty of a score 0 for the relevant part of the Quiz/homework.

Alway cite the source of information for homework!

Recommended reading

I am going to use material from these books for the class:

Krane, Kenneth: Introductory Nuclear Physics.
Griffiths, David J.: Introduction to Elementary Particles
Brian R. Martin, Graham Shaw: Nuclear and Particle Physics: An Introduction, 3rd Edition (2019)

There are also many other good books on the topic and plenty of online resources.

Resources

My email: hdenes@yachaytech.edu.ec
Please send me an email, so that I know who is in the class.

Private GitHub repository with slides and course information.
I will invite everyone, please let me know if you use a different email for GitHub, so that I can send an invite.

Class representative?