University of Virginia Fall 2022

PHYS 5720: Subatomic Physics

Lecture Sessions:	Tu,Th 14:00–15:15h	Rm. 113, Warner Hall
Instructor:	Dinko POČANIĆ	*pocanic@virginia.edu*
Office Hours:	We 12-13h, Th 16-17h, and by appointment.	Rm. 165, Physics tel. 924-7691

Course Textbooks

Mark Thompson, *Modern particle physics*, (Cambridge Univ. Press, 2013),

B.Povh, K.Rith, C.Scholz, F.Zetsche, W.Rodejohann, *Particles and nuclei*, 7th ed., (Springer 2015),

David Griffiths, *Introduction to Elementary Particles*, 2nd ed., (Wiley-VCH, 2008).

Other useful textbooks are:

Francis Halzen and Alan Martin, *Quarks and Leptons*, (Wiley, New York, 1984),
Brian R. Martin and Graham Shaw, *Nuclear and particle physics: an introduction*, 3rd ed., (Wiley, 2019),
Brian R. Martin and Graham Shaw, *Particle Physics*, 4th ed., (Wiley, 2017),
Donald H. Perkins, *Introduction to High Energy Physics*, 4th ed., (Cambridge Univ. Press, 2000),
Byron P. Roe, *Particle Physics at the New Millenium*, (Springer, 1996),
H. Frauenfelder and E. Henley, *Subatomic Physics*, 2nd ed., (Prentice Hall, Englewood Cliffs, 1991).

Class Organization

This is a "field survey" course meant to acquaint the interested advanced undergraduate or beginning graduate student with the foundations, recent achievements, and current status of the field of elementary particle and nuclear physics. The course nature and its audience require that it be taught on a phenomenological level rather than a rigorous theoretical one. The class provides a springboard for study of field theory for those students who wish to study the subject more deeply. The main prerequisite for the class is a working knowledge of quantum mechanics at the undergraduate level (completion of the PHYS 3550/3560 course series, or equivalent).

Solving concrete problems related to the course subject matter is essential for gaining a functional understanding of the topics studied. For this reason the course will include weekly homework assignments as well as a midterm and a final exam. Students are allowed and encouraged to solve the homework exercises together, in groups. While the homework submissions will not be pledged, each student is asked to write up independently the solutions that will be turned in. *Gradescope* will be used for HW grading.

Composition of the final grade for the course

- weekly homework assignments — 40 % of final grade,
- one midsemester exam — 30 % of final grade,
- final exam (Sat., 8 Dec 2022, 9:00-12:00h, Rm. 113 Warner) — 30 % of final grade.

Unlike practicing scientists, students of physics are rarely required to give oral presentations. This course is well suited to making short seminar presentations on topics covered in popularly written survey articles. Students will have opportunities to make brief presentation in class on an approved seminar topics. These presentations will bring bonus points counting toward the final grade.

Very Tentative Syllabus (subject to change)

Class		Date	Topics
1.	Tu	23 Aug	Brief history of subatomic physics
2.	Th	25 Aug	Survey of fundamental interactions
3.	Tu	30 Aug	Four-vectors, relativistic transformations
4.	Th	1 Sep	Symmetries and conservation laws
5.	Tu	6 Sep	Discrete symmetries cont'd
6.	Th	8 Sep	Symmetries: more conservation laws
7.	Tu	13 Sep	Basics of nuclear structure
8.	Th	15 Sep	Basics of nuclear dynamics
9.	Tu	20 Sep	Lifetimes and cross sections
10.	Th	22 Sep	Intro. to QED: Dirac equation
11.	Tu	27 Sep	Feynman rules for QED
12.	Th	29 Sep	Lepton-lepton scattering
	Tu	4 Oct	*Fall reading days — no class*
13.	Th	6 Oct	Compton scattering
14.	Tu	11 Oct	Lepton-quark scattering
15.	Th	13 Oct	Form factors, quarks and QCD
16.	Tu	18 Oct	Quark distributions in the nucleon
17.	Th	20 Oct	**Midterm exam**
18.	Tu	25 Oct	The quark parton model; Bjorken scaling
19.	Th	27 Oct	Weak interactions: Fermi theory
20.	Tu	1 Nov	Weak interactions: muon decay
21.	Th	3 Nov	Weak interactions: pion decay
	Tu	8 Nov	*Election day — no class*
22.	Th	10 Nov	Neutrino scattering, Z boson
23.	Tu	15 Nov	CVC, Cabibbo mixing, GIM mechanism, WNC
24.	Th	17 Nov	Neutrino oscillations
25.	Tu	22 Dec	Beyond the Standard Model: supersymmetry
	Th	24 Nov	*Thanksgiving break — no class*
26.	Tu	29 Nov	Particle physics and cosmology
27.	Th	1 Dec	Overview of the field and future prospects
28.	Tu	6 Dec	Review
	Th	8 Dec	**Final exam**: 9:00 – 12:00h, Rm. 113 Warner Hall