PHYSICS 415/515 - Fall Semester 2025 - ODU

Syllabus - Undergraduate Nuclear and Particle Physics

Class Meetings: 11:00 a.m. – 12:15 p.m. -- Tuesdays and Thursdays
Nuclear and Atomic Physics Conference Room 2108 – Phys. Sciences Build. II
https://ww2.odu.edu/~skuhn/415/Teaching.html

Instructor: Dr. Sebastian Kuhn
Professor, Eminent Scholar and Chair of Physics
Oceanography and Physical Sciences Build. Room 306a
Phone 683 – 5804 - Email: skuhn@odu.edu
WWW: https://ww2.odu.edu/~skuhn/

Office hours: By appointment / in-class announcement (ask me in class or email me!)

Required Textbook: Povh/Rith/Scholz/Zetsche/Rodejohann: Particles and Nuclei, 7th ed., Springer Verlag (2015).

Optional Textbooks: K.S. Krane: Introductory Nuclear Physics, Wiley&Sons
S.S.M. Wong: Introductory Nuclear Physics, Wiley&Sons
W.R. Leo: Techniques for Nuclear and Particle Physics Experiments, Springer.
Gerald Eigen, Detectors in High-Energy Physics Experiments (Open Access Digital Book, Springer)

Useful Links: https://www.thegreatcoursesplus.com/nuclear-physics-explained - Great Courses Video Series by Dr. Lawrence Weinstein (ODU)
https://thecrashcourse.com/courses/nuclear-physics-crash-course-physics-45/
https://www.youtube.com/watch?v=rzq5J_5TZSQ – visualizing the Nucleus

Required Classwork: Attend all Lectures and participate in discussions (20%), submit HW Problem Solutions (30%), take one Midterm Test (15%) and a Final Exam (35%).

For Further Information, Connect to this Course on CANVAS:
202510_FALL_PHYS415_22118

PHYSICS 415/515 - Fall Semester 2025 - ODU

INTRODUCTION

This is a one-semester course on Nuclear and Elementary Particle Physics at the advanced undergraduate / introductory graduate level. My aim is to give an overview of the different subfields of Nuclear and Particle Physics, as well as lay the groundwork for an active understanding of problems at the forefront of today's research. (Due to the rather limited time available, there has to be some selection, of course). The course assumes some basic knowledge of quantum mechanics as well as electromagnetism.

We will follow the textbook fairly closely, but I will skip some of the more advanced topics while presenting some additional information. Everyone is strongly encouraged to consult the optional textbooks and weblinks.

Don't hesitate to reach out to me (via email, in class, or at my office) if you need any additional help.

Accommodation Statement

Students are encouraged to self-disclose disabilities that have been verified by the Office of Educational Accessibility - https://www.odu.edu/accessibility - by providing Accommodation Letters to their instructors early in the semester in order to start receiving accommodations. Accommodations will not be made until the Accommodation Letters are provided to instructors each semester.

Also please take note of the following:

ODU's Office of Counseling Services (OCS , 1526 Webb University Center) is a university agency with competent, diverse, and multidisciplinary professional staff. They are committed to supporting the emotional well-being, social development, and academic progress of all students at Old Dominion University.

College life can be a wonderful time of self-discovery, but for many, it is also a time when the awareness of mental health conditions increases. OCS services are available to assist with addressing mental health concerns that a student may be experiencing. You can learn more about the broad range of confidential mental health services available on campus via our

website at http://www.odu.edu/counselingservices. All services are free to ODU students. See also https://www.odu.edu/life/health-safety/health/counseling/thrive and https://www.odu.edu/life/dean-students/student-outreach (ODU CARES).

Cultural Diversity

Old Dominion University fosters a campus community that values and supports the cultural identities of each of our members. The University also fosters an inclusive environment and provides programs that cultivate a climate of awareness, understanding, and respect of diverse individuals and groups. [Source: Adapted from https://www.odu.edu/oir]

My interpretation of the Honor Code

1) I consider it advantageous if students discuss material and content of the lectures and homework problems with each other and encourage that kind of cooperation.
   - You may pose questions about a problem to another student (as well as myself) or ask for hints.
   - You may discuss verbally the content and methods of solution of a problem.
   - If you need to use writing to explain something to another student (or vice versa), use a black/whiteboard or other clearly non-permanent means (scratch paper).
2) I consider it unethical and a violation of the honor code to simply copy another student's solution or let somebody else (including any Large Language Models – LLM -, like ChatGPT) solve the problem for you (= cheating).
   - You **have** to contribute significant work to each problem yourself.
   - **All** written submissions must be prepared by yourself.
   - If you find the solution to a problem in a book or on the web / from a LLM, you **must** quote your source(s) and reformulate the solution in your own words (using the nomenclature and symbols introduced in class). If you copy an existing solution verbatim without attribution (= plagiarism), you are violating the Honor Code.
3) You may not accept **nor give** any help during exams, including the use of weblinks, LLMs etc. However, you may ask me if anything is unclear!
4) You may not distribute, post or otherwise make public any material from this course – including (excerpts from) the textbook, my assignments and

solutions, lecture notes and formula sheets, tests and exams and items posted on my website – I retain sole copyright over any material generated by me.

PHYSICS 415/515 - Fall Semester 2025 - ODU

Schedule

This schedule shows the approximate days in the semester when we will discuss certain concepts in lecture. The details may change, but Tests, Exams and Holidays are firm.

Tentative Schedule

Date	Day	Time	Topic	Pages PRSZ	COMMENTS
26-Aug	Tue	11:00 - 12:15	Global Properties of Nuclei	1 - 18	
28-Aug	Thu	11:00 - 12:15	Liquid Drop model	19 - 23	
2-Sep	Tue	11:00 - 12:15	Decays	25 - 40	Drop/Add (full refund)
4-Sep	Thu	11:00 - 12:15	Introduction to Scattering I	41 -	
9-Sep	Tue	11:00 - 12:15	Introduction to Scattering II	- 53	Drop (50% refund)
11-Sep	Thu	11:00 - 12:15	Introduction to Scattering III	55 -63	
16-Sep	Tue	11:00 - 12:15	Nuclear Form Factors	64 - 74	
18-Sep	Thu	11:00 - 12:15	Nucleon Form Factors	75 - 82	
23-Sep	Tue	11:00 - 12:15	Nuclear Structure, Quasi-elastic Scatt.	72-74, 82-86	
25-Sep	Thu	11:00 - 12:15	Inelastic Scattering	87 -	
30-Sep	Tue	11:00 - 12:15	Deep Inelastic Scattering	- 101	
2-Oct	Thu	11:00 - 12:15	The Quark-Parton Model	103 -	
7-Oct	Tue	11:00 - 12:15	QCD	- 122	
9-Oct	Thu	11:00 - 12:15	TEST		
14-Oct	Tue		*Fall Holiday*		
16-Oct	Thu	11:00 - 12:15	Mesons	215 - 251	
21-Oct	Tue	11:00 - 12:15	Baryons	253 - 285	
23-Oct	Thu	11:00 - 12:15	Weak Interactions	139 - 165	
28-Oct	Tue	11:00 - 12:15	Neutrinos	167 - 183	
30-Oct	Thu	11:00 - 12:15	The Standard Model	185 - 211	
4-Nov	Tue		*Election Holiday - No Classes*		
6-Nov	Thu	11:00 - 12:15	The Nuclear Force	287 - 301	
11-Nov	Tue	11:00 - 12:15	The Deuteron	292 -	
13-Nov	Thu	11:00 - 12:15	The Deuteron II	- 295	Last Day to Withdraw
18-Nov	Tue	11:00 - 12:15	Light Nuclei	303 -	
20-Nov		11:00 - 12:15	Nuclear Models	- 372	
25-Nov	Tue	11:00 - 12:15	Selected Topics / TEST	-	
27-Nov	Thu		*Thanksgiving Holiday*		
2-Dec	Tue	11:00 - 12:15	Nuclear Thermodynamics	379 - 400	
4-Dec	Thu	11:00 - 12:15	Selected Topics	-	
11-Dec	Thu	12:30 - 3:30	FINAL EXAM		