

# PHYS4333: NUCLEAR & PARTICLE PHYSICS

Spring 2025

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<b><u>Instructor:</u></b>	Dr. Simeon I. Mistakidis
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<b><u>Office Hours:</u></b>	Tu: 12:00-2:30pm

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## Class Meetings:

- Lec. Nuclear & Particle Physics (Phys 4333): TuThu, 9:30-10:45am (Room 127, Physics Building)

## Required Textbooks:

- “*Nuclear and Particle Physics*”, by W.S.C. Williams, Publisher: Oxford University Press.
- “*Quarks and Leptons: An Introductory Course in Modern Particle Physics*”, by Francis Halzen, Alan D. Martin, Publisher: Wiley.

## Other useful Textbooks:

- “*The Atomic Nucleus*”, by Robley D. Evans, Publisher: McGraw-Hill.
- “*Physics of Nuclei and Particles*”, by Pierre & Eric Sheldon Marmier, Publisher: Academic Press, New York and London.
- “*Concepts of Nuclear Physics*”, by Bernard Leonard Cohen, Publisher: McGraw-Hill.
- “*Introduction to Elementary Particles*”, by David Griffiths, Publisher: Wiley-VCH.
- “*The Physics of Elementary Particles*”, by John David Jackson, Publisher: Princeton.
- “*Elementary Particles*”, by I. S. Hughes, Publisher: Cambridge University Press.
- “*The Physics of Elementary Particles*”, by H. Muirhead, Publisher: Pergamon Press.

**Course objectives/description:** Topics that will be addressed in this course, among others, revolve around: Radioactivity, Nuclear binding energy, liquid drop model,  $\alpha$ -decay,  $\beta$ -decay,  $\gamma$ -decay, quarks and color, weak interactions, strong interactions, Klein-Gordon equation, Feynman-Stückelberg interpretation, Scattering of elementary particles, Scattering amplitudes, Scattering cross-sections, Feynman diagrams, Electromagnetic field, the concept of the propagator, Dirac equation, antiparticles, the notion of spin, helicity, chirality.

This course is offered by the UMR Physics Department, Chaired by Dr. Thomas Vojta ([vojtat@mst.edu](mailto:vojtat@mst.edu)), 102 Physics, Phone: 341 - 4781 under the auspices of the College of Arts and Sciences.

## Class Material by Section:

During the semester, we will cover most of the **Chapters 1–6 & 9 from the “*Nuclear and Particle Physics*”** textbook:

- **Chapter 1–Introduction and Historical Perspective:** §1.1–§1.6
- **Chapter 2–Radioactivity:** §2.1–§2.9
- **Chapter 3–The Size and Shape of Nuclei:** §3.1–§3.4
- **Chapter 4–The Masses of Nuclei:** §4.1–§4.4
- **Chapter 5–Nuclear Instability:** §5.1–§5.4
- **Chapter 6–Alpha Decay:** §6.1–§6.6
- **Chapter 9–Forces and Interactions:** §9.10–§9.13

and **Chapters 1, & 3-6 from the “*Quarks and Leptons: An Introductory Course in Modern Particle Physics*”** textbook. Here, topics to be discussed are the following:

- **Chapter 1–A Preview of Particle Physics:** §1.1–§1.6
- **Chapter 3–Antiparticles:** §3.1–§3.5
- **Chapter 4–Electrodynamics of Spinless Particles:** §4.1–§4.5 & §4.8
- **Chapter 5–The Dirac Equation:** §5.1–§5.5
- **Chapter 6–Electrodynamics of Spin- $\frac{1}{2}$  Particles:** §6.1–§6.15

Note that the above schedule is tentative and may be adjusted according to the progress and the needs of the class.

**Prerequisites:** Physics 2305 (Introduction to Modern Physics), and Math 3304 (Elementary Differential Equations).

**Homework, extra credit assignments and Exams:** As in every Physics course, it is extremely important to solve as many as problems as possible and put your best effort to produce high-quality homework. It is also imperative to learn how to communicate your physical and mathematical reasoning. During the semester there will be **eight homework assignments** each containing around four problems that need to be submitted in a **pdf format only** in our Canvas page. **Homework exercises will be assigned every second week (usually every second Thursday), with a deadline for the online submission a week after, namely the consecutive Thursday at 12:00pm. Late homework submissions will be graded with a 10% penalization, except from cases where accommodation letters have already been provided.**

Please be aware that struggling through solving a homework problem (and beyond) is not unusual. Physics is all about **study** and **practice** and the most effective way to learn is to address your questions by reading further literature, solve problems, discuss with your instructor and with your colleagues. You might find instructive to first write down the accompanying theory and afterwards come back to the homework assignments and attempt to solve them. This way, you may be able to create your own study guide and simultaneously comprehend the material in depth. Keep in mind that in order for you to get the best grade that you can, the first step is to do every assignment to the fullest extend of your ability. However, if you still need help, I strongly encourage you to make use of my office hours.

Moreover, **extra credit assignments** will be available for interested students. These extra assignments are by no means mandatory and will refer to a relatively involved calculation in the context of the course. Besides your own better understanding and development, they can be used to replace solely one of the midterm exams (Exam 1 or 2, see also below). In case that you are interested in such an assignment you will need to ask the instructor before February 15, 2025.

There will be **two midterm exams**, i.e. Exam 1 and Exam 2, and **one cumulative final exam**. For their schedule, please consult the below given “Important Dates” section. Before **the exams**, I will run review sessions one for each exam according to:

Review session # 1 for Exam 1 .....	Date TBA
Review session # 2 for Exam 2 .....	Date TBA
Review session # 3 for Final .....	Date TBA

In all review sessions, we will solve practice problems, and homework questions upon interest. **Note that all students must take the regular exam!** Only **qualified** students can take an official make-up exam.

**Make-Up Exam Policy.** Make-ups for mid-semester exams are scheduled on the day preceding the exam. You may request a make-up exam if you have a documented and valid reason for missing an exam preferably at least a week before the official mid-semester exam.

**Exam/Class Conflict:** If you have two exams scheduled during the same time period, or a class during our scheduled exam, you are eligible for a make-up exam. You must notify Dr. Simeon Mistakidis per email at least two weeks before the scheduled exam.

**Religious Observance:** In the case of absence from an exam due to religious observance, please make sure that you provided the specified notification at the beginning of the semester.

**Medical Reasons:** If you will be absent from an exam due to medical reasons, you should notify Dr. Simeon Mistakidis at least one week in advance of the exam. If you have a medical emergency, you should inform Dr. Simeon Mistakidis as soon as possible.

**Note that there is no re-taking of exams in this course.** If you are sick and take the exam anyway, you cannot re-take the exam later for a better grade. Regardless of the situation, if you do not feel you can take the exam on the scheduled date please notify Dr. Simeon Mistakidis by email immediately. Once you take the exam, there is nothing that can be done to change the grade. Additionally, make-up exams will not be given to accommodate travel plans.

**Grading Policy and Exams:** Your final grade in this course is calculated according to:

Homework .....	100 points
Exam 1 .....	100 points
Exam 2 .....	100 points
Final Exam .....	200 points
<b>Total .....</b>	<b>500 points</b>

**Course Letter-grade Scale:**

A	B	C	D	F
450-500	400-450	350-400	300-350	< 300

**Important Dates:**

Exam 1 .....	Thursday, February 27, (Room 127, 9:30-10:30am)
Exam 2 .....	Thursday, April 10, (Room 127, 9:30-10:30am)
Holiday - Martin Luther King Jr. Recognition .....	Monday, January 20
Spring Recess .....	Thursday 8:00am-Monday 8:00am, March 13-17
Spring Break .....	Sunday 8:00am-Monday 8:00am, March 23-31
Last day of classes .....	Friday, May 9
Final Exam .....	Tuesday, May 13, 7:30am-9:30am (Location: TBA)

Please also use the following link for updates regarding the final exam dates: <https://registrar.mst.edu/media/administrative/registrar/documents/calendars/2025/SP25final examschedule.pdf#241028035718> and also visit the registrar's office webpage to review important dates for the 2025 Spring semester via <https://registrar.mst.edu/media/administrative/registrar/documents/calendars/2024/AcademicCalendarAY2024-2025.pdf>

**ChatGPT and Online Resources:**

Exploiting ChatGPT or any other related Artificial Intelligence toolkits for preparing homework and in general assignments **is highly discouraged** and in case of usage **it should be disclosed**, otherwise the homework will remain ungraded. Within the semester an Artificial Intelligence detector will be used randomly for several homeworks. The students may use Artificial Intelligence tools **solely as search engines** if they do not want to use standard internet search tools.

**Exams and Class Policies:**

- Exams are primarily based on the material we cover in class and homework exercises.
- No formula sheets, class notes and calculators are allowed during midterm and final exams.
- Please go through the cheating and plagiarism procedures by clicking [Honor-Code](#) but also [Student Academic Regulations](#).
- Learning and memorizing formulas takes time. Do not postpone this until the last minute.

**Students with special accommodations:** The University provides disability-related support services to qualified students. If you have a disability or if you anticipate or experience physical, academic, and/or digital barriers due to a disability, please contact Student Accessibility and Testing at (573) 341-6655, email [dss@mst.edu](mailto:dss@mst.edu), or visit [Student Accessibility and Testing](#) for more information.

**Help Resources:** The best way to get help is to attend our classes or to exploit the office hours to resolve open questions. However, there are other resources available too. The Learning Enhancement Across Disciplines (LEAD) program runs Learning Centers and Tutoring which provide efficient means to improve your understanding and increase your mastery of the material you are studying. Discipline-based faculty and undergrad peer instructors operate open-environment learning centers in nearly every foundational course as well as many upper-level courses. You can find the schedule for LEAD learning assistance at [LEAD schedule](#). The Student Success Center (SSC) supports student development through peer Academic Mentoring focusing primarily on STEM courses, peer-to-peer soft skill coaching

which can also act as an accountability buddy, and campus programming – all while providing free coffee and hot beverages! All undergraduate students are encouraged to utilize the SSC's free services to get timely support and to enhance their S&T Miner Experience. Contact information at [success@mst.edu](mailto:success@mst.edu) OR 573-341-7590. To see the course offerings and times for SSC Academic Mentoring, visit [SSC mentoring](#). Finally, all enrolled S&T undergraduate students can receive complimentary FREE tutoring assistance from peers who have successfully completed the course, available round the clock. You have the option to connect via the Knack platform online or in person on campus. For more information please visit [Knack mentoring](#).

**Diversity and Inclusion:** I am fully committed to an academic environment that is free of bias against any group and I firmly believe in the value of diversity in people and ideas. My ultimate goal is to establish that this class is a welcoming environment to every-one regardless of gender identity, sexual orientation, race, ethnicity, or religious identity. The University and I do not tolerate discrimination. Please feel comfortable coming to me or an administration if at any point you ever feel uncomfortable for any reason. It is important to know that Missouri S&T is committed to the safety and well-being of our campus community, and to creating an environment free from discrimination and harassment. The University prohibits discrimination and harassment on the basis of race, color, national origin, ancestry, religion, sex, pregnancy, sexual orientation, gender identity, gender expression, age, disability, protected veteran status, and any other status protected by applicable state or federal law. As used in this policy, the word "sex" is also inclusive of the term "gender." Additionally, US Federal Law Title IX states that no member of the university community shall, on the basis of sex, be excluded from participation in, or be denied benefits of, or be subjected to discrimination under any education program or activity. Sexual harassment violations of this law include quid pro quo, hostile environment, sexual assault, dating/domestic violence, and stalking. The U.S. Department of Education has stated the prohibition on discrimination on the basis of sex includes sexual orientation and gender identity. Students who are experiencing pregnancy or pregnancy-related conditions, including the birthing parent and non-birthing parent, have rights protected under Title IX. Students should contact the Office of Equity and Title IX to learn more about their rights and pregnancy-related assistance/accommodations provided by the University to ensure equitable access to University educational programs and activities. In accordance with the University of Missouri's Collected Rules and Regulations, all faculty and staff are required to report any information concerning discrimination disclosed through communication including, but not limited to, direct conversation, email, social media, classroom papers and homework exercises to the Equity Officer/Title IX Coordinator.

For more information regarding support for those that have been impacted or to report an incident of discrimination or harassment as defined by [Chapter 600](#) of the University's Collected Rules and Regulations, visit the Office of Equity and Title IX or visit their website at [Equity and Title IX](#). **Office of Equity and Title IX Equity Officer and Title IX Coordinator: Dr. Paul Hirtz Phone: (573) 341-7734, Location: 900 Innovation Drive, Suite 500, E-mail: [equity@mst.edu](mailto:equity@mst.edu)**

**Student support and well-being:** Student Support and Community Standards is your guide during your time at S&T. You or a friend may need help navigating their student experience, facing a barrier, or experiencing a challenge. Student Support has a dedicated team and numerous resources such as [UCARE](#), housed within the Division of Student Success, and the [Student Emergency Fund](#), that aim to help you navigate the S&T experience and support your success. This includes support to address barriers related to academic, personal, emotional, medical, financial, or any other needs. All students can learn and grow from challenges or setbacks, they are stepping stones to success and we are here to help.

## **Respiratory Illnesses including COVID-19 Compliance, Classroom, and Campus Safety:**

The University is committed to protecting the health and safety of the campus community. Taking preventative steps, as well as monitoring your health and staying home if you are feeling unwell, will help protect the entire campus community. You can have a look at the University's Health services in <https://studenthealth.mst.edu>.