PHY-142: "Introduction to Special Relativity"

Syllabus Spring 2025

Prof. Ivan Biaggio, LL 407

MEETING TIMES

Tuesday and Thursday at 12:10pm

TOPICS

This course will be a development of the special theory of relativity that goes beyond the standard length contraction and time dilation discussion that you may have encountered already. Topics include transformation of time and space, momentum and energy, systematic use of Lorentz transformations, how physical quantities need to be modified in order to be *Lorentz invariant*, space-time intervals, proper time, four-vectors for energy velocity and momentum, how four-vectors change under Lorentz transformations, acceleration, forces, the relativistic version of "F=ma", and the meaning of mass. We will also discuss the equations that determine, for example, how time and traveled distance behave on a spaceship under constant acceleration, and explore the connection between classic electromagnetism and special relativity.

USEFUL MATERIALS

I'll have my own notes, so you don't strictly need a textbook, but there are still many resources that you will want to access. Here three textbooks, listed in order of the "depth" of their approach, from the deeper and complete one that follows the contents of this class, to simpler once that only scratch the surface.:

Hans Ohanian , "Special Relativity: A Modern Introduction"

E. F. Taylor and J. A. Wheeler, "Spacetime Physics," 2nd Edition.

Thomas A. Moore, "Six Ideas That Shaped Physics, unit R (Relativity)", 2nd Edition.

The first book (Ohanian) presents the material at the level that we will follow in this course, and covers most of the topics we will consider.

The second book (*Taylor and Wheeler*) is more discursive, presents some topics in an interesting way, and can be funny (depending on your sense of humor). It is nice to read, has very approachable introduction to the topic and good explanations, but it takes a somewhat unique approach. It is also a famous book, and its author is making it available for free online, and you can download it as a PDF file. Just google it!

The third book (*Moore*) is definitely more introductory and limited, with a strong focus on space-time diagrams. I find it insufficient, and the space-time diagrams can sometimes explain things, but can also sometimes be difficult more difficult than using good old math

There are obviously many other textbooks, and in general a lot of resources of all kinds about special relativity, but **stay away from anything that uses the concept of a velocity dependent, "relativistic mass"** (none of the above books uses it). This concept is confusing and generally a bad idea. You will understand this later, but a nice explanation of the issue starts at the very end of page 250 (continuing to the second column of page 251), of the book by Taylor and Wheeler.

LEARNING OUTCOMES

Initial Competences required for this course (what you should know already)

Before starting this course, students should be familiar with calculus, Newtonian mechanics, and electromagnetism. The course will assume the ability to work with integrals, derivatives, algebraic equations, differential equations, Maxwell's equations, and vectors.

Course contents (what I will teach in this course)

The course will develop special relativity, develop relativistic mechanics, and discuss its relationship with electromagnetism, as described in the "Topics" section, above.

Competences expected after this course (what you are expected to be able to do when done)

Students will understand how time and space when moving from one inertial frame to the other, the relationship between mass and energy, and the new mechanics and kinematics of moving bodies. They understand the nature of magnetic and electric fields, and will be able to correctly resolve and explain some famous apparent "paradoxes", and to apply four-momentum to analyze and understand the decay of photons and particles into other particles, and vice-versa.

COURSE GRADING

The final grade of the course will be determined based on homework, class participation, and exams. The relative weight of each area is given in the table below:

Homework	150	
Class participation and attendance	150	
Exams	300	(75 for each mid-term exam, and 150 from the final exam)
TOTAL	**600**	

HOMEWORK

Regular Homework (HW)

There will be a new homework assignment each week. The idea is to discuss the homework over two class meetings, and then turn in a treatment the week after. In a move to which you might not be accustomed, I will **not mark up your homework looking for mistakes**. For the purpose of grading, I will evaluate your work mainly based on the effort you put into it and the criteria listed below. You will get a very detailed, typewritten solution of the homework, and you will be responsible for studying it and comparing it with what you did, and then ask questions about it in class. In this way you will identify any mistakes you might have made.

Rules for a good homework assignment.

- Write a paragraph at the beginning of each problem to introduce your work and explain in words how you will go about solving the problem.
- Your written work must mimic what you would see in a book: Not just numbers or equations, but subtitles and full sentences that incorporate equations and numbers.
- At the end, write a conclusion that points out anything that your learned while doing the homework.

Irregular, longer homework assignments

These are additional homework assignments that follow another format and explore a given topic at length. We will discus them over several weeks and you add to your solution bit by bit. By allowing for multiple discussions in class and more development, these extra assignments will provide a different way to explore a topic. The aim is not even necessarily to complete them in full, it is to discuss them and then analyze solutions to understand what is going on.

CLASS PARTICIPATION AND ATTENDANCE

Class discussions are important. The aim is that students come to class prepared and contribute to the conversation in class with questions or comments based on past and present class material or any readings. Coming to class prepared means having read and studied the class notes or other material (such as homework solutions), and being ready to discuss them and to ask questions. It doesn't necessarily mean having understood everything already. Also, I'd like to stress that class meetings will work best when the teaching is driven by questions from students, and therefore I'll be expecting them.

EXAMS

Exams are closed book, but a summary sheet with the most important facts and expressions will be provided, and you can add some small notes for yourself on it. You don't need to memorize any formula.

Mid-Term Hour Tests

There will be two hour tests that will take place in class around the usual mid-term period. No make-up tests will be given. If a student misses a test and has a justification, the grade of the final exam will be substituted for the missed test.

Final Exam

There will be one comprehensive final exam.

READING ASSIGNMENTS AND HOW TO USE THEM

I will provide written weekly summaries of what I do in class, and suggest some additional reading. Scrupulously follow the reading assignments, and don't be a minimalist. You will do best if you read ***more*** than just what I suggest.

ACADEMIC INTEGRITY

All members of the Lehigh community have a responsibility to maintain academic integrity [https://provost.lehigh.edu/academic-integrity]. Resources and details of expectations at Lehigh are available on the Provost's website. It is expected that all students will abide by these standards throughout the course (e.g., homework, quizzes, papers, exams, projects, etc.). Academic integrity case studies will be discussed on the first day of class, and students are encouraged to ask questions for further clarity throughout the semester. Violations of academic integrity standards will not be tolerated and will be handled according to the guidelines in the University's Student Conduct System.

The university has put together a set of eight vignettes [https://www.lehigh.edu/lts/official/Academic_Integrity_Vignettes.pdf] that focus on issues of academic integrity and that are based on actual cases that have come before the University's Committee on Discipline

ACCOMMODATIONS FOR STUDENTS WITH DISABILITIES

Lehigh University is committed to maintaining an equitable and inclusive community and welcomes students with disabilities into all of the University's educational programs. In order to receive consideration for reasonable accommodations, a student with a disability must contact Disability Support Services (DSS), provide documentation, and participate in an interactive review process. If the documentation supports a request for reasonable accommodations, DSS will provide students with a Letter of Accommodations. Students who are approved for accommodations at Lehigh should share this letter and discuss their accommodations and learning needs with instructors as early in the semester as possible. For more information or to request services, please contact Disability Support Services in person in Williams Hall, Suite 301, via phone at 610-758-4152, via email at indss@lehigh.edu, or at https://studentaffairs.lehigh.edu/disabilities.

THE PRINCIPLES OF OUR EQUITABLE COMMUNITY

Lehigh University endorses the Principles of Our Equitable Community [https://www2.lehigh.edu/diversity-inclusion-equity/principles-equitable-community]. We expect each member of this class to acknowledge and practice these Principles. Respect for each other and for differing viewpoints is a vital component of the learning environment inside and outside the classroom.

LEHIGH UNIVERSITY POLICY ON HARASSMENT AND NON-DISCRIMINATION

Lehigh University upholds the Principles of Our Equitable Community and is committed to an educational, working, co-curricular, social, and living environment for faculty, staff, and students. The University does not discriminate in its admissions practices, employment practices, or educational programs or activities on the basis of age, color, disability, ethnicity, familial status, gender expression, gender identity, genetic information, marital status, national origin (including shared ancestry), pregnancy or related conditions, race, religion, sex, sexual orientation, and veteran or military status. Harassment or discrimination is unacceptable behavior and will not be tolerated. The University strongly encourages (and, depending upon the circumstances, may require) students, faculty, or staff who experience or witness harassment or discrimination, or have information about harassment or discrimination in University programs or activities, to immediately report such conduct.

If you have questions about Lehigh's Policy on Harassment and Non-Discrimination [https://policy.lehigh.edu/policy-harassment-and-non-discrimination] or need to report harassment or discrimination, contact the Equal Opportunity Compliance Coordinator (Alumni Memorial Building / 610 758 3535 / eocc@lehigh.edu)