Fall 9-1-2021

PHSX 141N.80: Einstein's Relativity

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Physics 141N: Einstein's Relativity

Davidson Honors College
University of Montana
Fall 2021

DHC 120
MWF 12:00 – 12:50 pm
Course Number 72229

Professor: Dr. Nate McCrady
email: nate.mccrady@umontana.edu
Office Hours: by appointment, outdoors or via Zoom

Course Description

In this course, industrious students will gain deep insight into the counterintuitive nature of space and time and will acquire a greater appreciation for the power and beauty of theoretical physics. We will begin with a brief historical view of the study of motion including the works of Galileo and Newton. We will explore the necessity of introducing relativity theory to match experimental results. Einstein's special theory of relativity is introduced from a modern, geometrically oriented perspective, using spacetime diagrams throughout, and emphasizing the deep connection between time and space. We will apply the results of relativity theory to the practical real-world problems of high-energy particle physics, where the use of relativity is essential. Throughout the course, we will emphasize the logical structure of relativity to show how the unexpected and counterintuitive consequences of the theory follow directly and inevitably from the principle of relativity:

"The laws of physics are the same in all inertial reference frames."

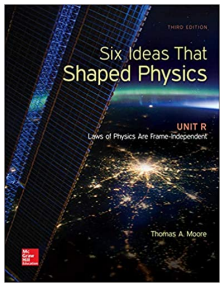
Course Objectives

My goals in this course are to…

1. Introduce students to Einstein's special theory of relativity.
2. Develop student problem solving skills in relativity.
3. Foster interest in and inspire ongoing study of physics.

Required Materials

Six Ideas That Shaped Physics,
Unit R: Laws of Physics are Frame-Independent
By Thomas Moore
Available at the UM Bookstore.
Additional reading material will be available on the course Moodle page.



iClicker or *iClicker Reef* smartphone app
Student radio frequency response remote (or app).
Available at the UM Bookstore or via online stores.

Expectations of the Professor

Physics 141 is honors course, and offers an intensive learning environment for outstanding undergraduates. This is a challenging course, and by choosing to enroll you are agreeing to work hard and remain on schedule with the readings and assignments. Students should expect daily homework assignments as they build expertise in the material. The University of Montana is one of only a small number of schools around the country offering an introductory course in relativity accessible to students who have not completed one to two years of introductory physics. By the end of the semester, you will be comfortably solving problems in relativistic dynamics and particle physics that are challenging to beginning graduate students!

This course has no prerequisites. I expect only that you have a working knowledge of algebra and trigonometry. A modest exposure to calculus is helpful, but not strictly necessary. I would recommend gaining familiarity with the Greek alphabet, as its use is ubiquitous in physics.

Time in the classroom is an essential part of this course, and it will be to your benefit to attend class. Group work on tutorial problems is an integral part of your learning experience, and you need to be present to benefit. Exams will be based on material presented in class, homework problems and reading assignments. I expect students to read the assigned material in advance of the class discussion of a topic, and to be prepared to discuss the material in class.

This course is a collaborative effort – please ask questions, offer your ideas and be prepared to participate in the discussion. Written work submitted in this course must be expressed in your own words. I specifically encourage students in this course to work together, but each student must write up her or his own response to homework problems. This step is essential to your learning – writing up the answer to a question requires you to understand the conclusion of your group, whereas transcription of the work of another does not. When in doubt, please ask me what is acceptable.

Public Health and Covid-19

As the semester begins, new cases of Covid-19, predominantly caused by the Delta variant, are increasing in Missoula County and across Montana. **The University of Montana recommends that students, faculty, and staff get the Covid-19 vaccine.** Curry Health Center offers free vaccinations for anyone, on a walk-in basis, during regular business hours. **A mask covering the nose and mouth is required for all individuals while in the classroom or laboratory.** Drinking liquids and eating food is discouraged within the classroom. Please observe physical distancing in the classroom and allow each other space. In this course, classroom windows will be open during class meetings, so please dress accordingly.

If you feel sick and/or are exhibiting Covid-19 symptoms (fever or chills, cough, shortness of breath, fatigue, muscle or body aches, headache, loss of taste or smell, sore throat, congestion or runny nose), do not come to class; contact the Curry Health Center at (406) 243-4330. If you are required to isolate or quarantine, you will receive support in this class to ensure your continued academic progress. Class attendance and seating will be recorded (as required by the University) to support contact tracing efforts, however attendance is not mandatory and is not a direct factor in your course grade.

UM policies on Covid-19 and public health are subject to modification as conditions change in the state and Missoula County. Please be flexible and understanding as we prioritize the health and safety of ourselves and of our colleagues while we learn special relativity.

Grading Policy

This course will be graded on the University's traditional letter grade system. Your grade will be based on three midterm exams (10% each), a cumulative final exam (20%), daily homework problems (40% total) and in-class "iClicker" responses (10%). I have not determined in advance how many As, Bs, etc will be assigned – I'm happy to give every student an A if they demonstrate mastery of the material. You are most definitely **NOT** competing with each other for grades! Do work together – you will learn a significant amount from your peers. Along the way I will provide regular updates regarding your grade in the course to avoid any surprises.

Each day, I will assign ~1 to 3 homework problems that will be due at the beginning of the next class. Except in the case of *prior* permission from me, late homework will be docked 20% per weekday (including homework turned in after class). Homework must be legible! If your first attempt is messy, use it as a draft to rewrite a final version for submission. If I can't read it easily, you'll get no credit! Homework problems will be graded on a four-point scale as follows:

4: a good effort with correct results *and* reasoning
3: a good effort with minor conceptual or math errors
2: a fair effort with modest conceptual errors *or* a good effort with serious conceptual errors
1: a very poor effort
0: no effort

A *good effort* involves at least *some* English explanation and use of appropriate diagrams along with any calculations. I expect you to recognize an implausible result if you get one.

Midterm exams take place during regular class time on the scheduled days. Exams will be closed book, and students will be allowed use of calculators and an equation card (to be provided by me in class). If you cannot be present on the scheduled date, tell me *before* the exam day and we can discuss arrangements. For *well-documented* compulsory absences, we will arrange a time for you to take the exam *early*.

Course Schedule & Reading Assignments

Weeks	Dates	Topic	Readings
1 – 2	Aug 30 – Sept 10	The Principle of Relativity	R1
2	Sept 13 – 17	Synchronicity	R2
3	Sept 20 – 22	The Nature of Time	R3
4 – 5	Sept 24 – Oct 1	The Metric Equation *Midterm 1: Fri, Oct 1*	R4
6	Oct 4 – 8	Proper Time	R5
7	Oct 11 – 15	Coordinate Transforms	R6
8	Oct 18 – 22	Lorentz Contraction	R7
9	Oct 25 – 29	The Cosmic Speed Limit *Midterm 2: Fri, Oct 29*	R8
10	Nov 1 – 5	Four Momentum	R9
11 – 12	Nov 8 – 19	Four Momentum Conservation	R10
13 – 14	Nov 22 – Dec 3	Particle Physics *Midterm 3: Fri, Dec 3*	R10.5
15	Dec 6 – 10	Introduction to General Relativity	
	Fri, Dec 17	Final Exam, 8:00 am – 10:00 am	