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PHSX 141N.80: Einstein's Relativity - Honors

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Physics 141: Einstein's Relativity

Davidson Honors College
University of Montana
Spring 2014

DHC 120
MWF 12:10 – 1:00 pm
Course Number 31124

Professor: Dr. Nate McCrady
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Office: 122 CH Clapp Building
Office Hours: Tu/Th 3-4 pm, Fri 1-2 pm, and by appointment
Course website: `cas.umt.edu/physics/physics141/`

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 known 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,
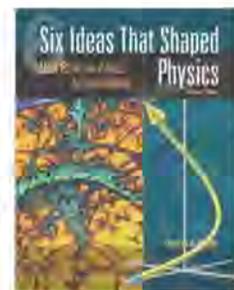*Unit R: Laws of Physics are Frame-Independent*
By Thomas Moore
Available from amazon.com (and elsewhere) for about $40.
Additional reading material will be available on the course website.

iClicker
Student radio frequency response remote.
Available at the UM Bookstore for about $30.

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 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 on 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.

And of course, while in class, please turn off your phones and other electronic gadgets. (Laptops may be used for note taking if you so desire, but please stay home if you need to surf the web.)

Pedagogical Philosophy of the Professor
My primary goal in teaching this course is to provide students opportunities to explore the profound and unexpected consequences of Einstein's two simple postulates that establish the special theory of relativity.

Research in how people learn indicates that the knowledge of an expert in a topic is organized around core concepts. In order to help you begin to develop expertise in the topics of special relativity, this course is organized around several core concepts. These concepts are outlined on the class schedule in this syllabus. Each concept is associated with a number of specific learning goals, a complete list of which I will provide for your use as a study aid. Each learning goal is stated from the student's perspective. If you can achieve these specific goals, you will succeed in this course – and be on your way towards expertise in 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 (25%), daily homework problems (35% 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 ~1-3 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 day (specifically 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 in class. If you cannot be present, 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*.

Academic Conduct
Plagiarism, cheating and other violations of the student conduct code will be taken seriously. A student in violation of the code will be assigned an F grade for the work in question and referred to the Office of the Vice President for Student Affairs for possible University sanctions. An excerpt from the UM *Student Conduct Code*:

> Academic misconduct is defined as all forms of academic dishonesty, including but not limited to:
>
> **1. Plagiarism:** Representing another person's words, ideas, data, or materials as one's own.
>
> **2. Misconduct during an examination or academic exercise:** Copying from another student's paper, consulting unauthorized material, giving information to another student or collaborating with one or more students without authorization, or otherwise failing to abide by the University or instructor's rules governing the examination or academic exercise without the instructor's permission.
>
> **3. Unauthorized possession of examination or other course materials:** Acquiring or possessing an examination or other course materials without authorization by the instructor.
>
> **4. Tampering with course materials:** Destroying, hiding, or otherwise tampering with source materials, library materials, laboratory materials, computer system equipment or programs, or other course materials.

Course Schedule & Reading Assignments

Weeks	Dates	Topic	Readings
1	Jan 27 – 31	The Principle of Relativity	R1
2	Feb 3 – 7	Synchronicity	R2
3	Feb 10 – 15	The Nature of Time	R3
4 – 5	Feb 18 – 28	The Metric Equation	R4
6	Mar 3 – 7	Proper Time	R5
7	Mar 10 – 14	Coordinate Transforms	R6
8	Mar 17 – 21	Lorentz Contraction	R7
9	Mar 24 – 28	The Cosmic Speed Limit	R8
10	Apr 7 – 11	Four Momentum	R9
11 – 12	Apr 14 – 21	Four Momentum Conservation	R10
12 – 13	Apr 23 – May 2	Particle Physics	R10.5
14	May 5 – 9	General Relativity	TBA