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

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## Course Information

- Professor Dr. Andrew Ware
- Office: CHCB 130 (S 412 o Thursdays)
- Email: [andrew.ware@umontana.edu](mailto:andrew.ware@umontana.edu)
- Lectures MWF 12:00 p – 12:5 p in DHC 118
- Office Hours: MW – PM & TR 1 – 1 AM by appointment
- Course web page [umonline.umn.edu](http://umonline.umn.edu) (Moodle)

## Course Overview

This course develops one of the most profound concepts in physics, the principle of relativity, and follows it to its surprising and counterintuitive insights into nature of space and time. Students in this course 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."*

## Learning Objectives

My goals in this course are:

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

## Required Materials

*Six Ideas That Shaped Physics*

*Unit R: Laws of Physics Are Frame-Independent*

B Thomas Moore

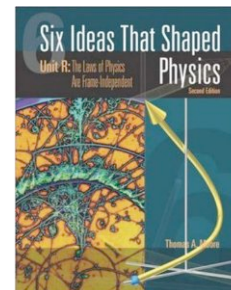
Available at the UM Bookstore for about \$50

Additional reading material will be available on the course Moodle page.

*iClicker*

Radio frequency response remote.

Available at the UM Bookstore for about \$40.



## Expectations of the Professor

Physics 141N is an 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 handful 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 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.)

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

*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 Guidelines and Policies

### Student Conduct Code

The Student Conduct Code at the University of Montana embodies and promotes honesty, integrity, accountability, rights, and responsibilities associated with constructive citizenship in our academic community. This Code describes expected standards of behavior for all students, including academic conduct and general conduct, and it outlines students' rights, responsibilities, and the campus processes for adjudicating alleged violations. [Full student conduct code:](http://www.umt.edu/vpsa/policies/student_conduct.php)  
[http://www.umt.edu/vpsa/policies/student\\_conduct.php](http://www.umt.edu/vpsa/policies/student_conduct.php)

### Course Withdrawal

Students may use Cyberbear to drop courses through the first 11 instructional days of the semester. Beginning the 16<sup>th</sup> instructional day of the semester through the 45<sup>th</sup> instructional day, students use paper forms to drop, add and make changes of section, grading option or credit. PHSX 141 can only be taken as traditional letter grade course.

### Disability Modifications

The University of Montana assures equal access to instruction through collaboration between students with disabilities, instructors and [Disability Services for Students](#) If you think you may have a disability adversely affecting your academic performance, and you have not already registered with Disability Services, please contact Disability Services in Lommasson Center 154 or call 406-243.2243. I will work with you and Disability Services to provide an appropriate modification.

## Course Schedule Reading Assignments

| Weeks   | Dates             | Topic   | Readings |
|---------|-------------------|---|----------|
| 1       | Aug 29 – Sept 2   | The Principle of Relativity                             | R1       |
| 2       | Sept – 9          | Synchronicity   | R2       |
| 3       | Sept 12 – 16      | The Nature of Time                                      | R3       |
| – 5     | Sept 19 – Sept 30 | The Metric Equation<br><i>Midterm 1: Fri, Sep 30</i>    | R4       |
| 6       | Oct 3 – 7         | Proper Time   | R5       |
| 7       | Oct 10 – 14       | Coordinate Transforms                                   | R6       |
| 8       | Oct 17 – 21       | Lorentz Contraction                                     | R7       |
| 9       | Oct 24 – 28       | The Cosmic Speed Limit<br><i>Midterm 2: Fri, Oct 28</i> | R8       |
| 10      | Oct 31 – Nov 4    | Four Momentum   | R9       |
| 11 – 12 | Nov 7 – 17        | Four Momentum Conservation                              | R10      |
| 13 – 14 | Nov 21 – Dec 2    | Particle Physics<br><i>Midterm 3: Fri, Dec 2</i>        | R10.5    |
| 15 – 16 | Dec 5 – 12        | General Relativity                                      |          |
|         | Thu, Dec 15       | Final Exam, 10:10 am – 12:10 pm                         |          |