

SYLLABUS

Meeting Times

Lectures: MWF 2:10-3:00 pm
Room: Hugel Science Center 017

Office Hours: M 9:00 am - 10:30 am
T 1:30 pm - 3:30 pm
R 9:30 am - 11:00 am

**office hours will be in Hugel 023*

Contact Information

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Course Overview This is the first course in Lafayette's introductory Physics sequence. The goal of this course is to expose you to some of the exciting developments in contemporary physics and to give you a sense of some of the fundamental questions to which we are still seeing answers. We will survey some of the bizarre and often non-intuitive picture of the natural world that emerges in situations far removed from our everyday experiences including phenomena that emerge at distances at or smaller than the size of an atom, at temperatures millions of times hotter than the sun, or at speeds approaching the speed of light.

We will begin by building a foundation by covering several key concepts from classical physics before moving on to Einstein's theory of relativity and its weird and seemingly paradoxical implications. We will follow this with a foray into particle physics and the Standard Model in order to describe nature in terms of its most basic building blocks. We will end with an exploration of how physics manifests on the nanoscale and why exploiting those phenomena enable us to create the myriad devices and technologies we use everyday.

Learning Outcomes By the end of this course, you will be able to

- understand the fundamental principles of Einstein's special theory of relativity and apply the mathematical tools necessary to solve quantitative problems analyzing the motion of objects in spacetime.
- be familiar with the particles of the Standard Model, their properties, and how they interact.
- identify how and why nanoscience differs from classical physics and explain the array of experimental tools that can be used to create and characterize nanoscale materials.
- identify what physical phenomena become important at different distance and energy scales.
- understand how symmetry informs our understanding of nature and be able to apply symmetry principles and conservation laws in order to solve problems.
- be able to perform experimental measurements relevant for testing a hypothesis and to evaluate whether your data supports, motivates the revision of, or refutes that hypothesis.

Co-requisite MATH 161 or permission of instructor

Course Text

Six Ideas That Shaped Physics: Unit R - Laws of Physics are Frame-Independent, 3rd ed.
Thomas A. Moore (McGraw-Hill Education, 2017)

Supplementary texts (relevant excerpts will be posted on Moodle):

Six Ideas That Shaped Physics: Unit C - Conservation Laws Constrain Interactions, 2nd ed.
Thomas A. Moore (McGraw-Hill Education, 2003)

Modern Physics, 3rd ed. Kenneth Krane (Wiley, 2012)

Introduction to Elementary Particles, 2nd ed. David Griffiths (Wiley, 2008)

Course Policies Attendance is mandatory and I encourage you to read the relevant sections of the text *before* class so that the material is not completely unfamiliar to you when we start discussing it together. Your participation grade in this class will be based on your attendance at class meetings and your in-class contributions including problem-solving and discussions.

Grading Grades are determined on the following basis:

Participation:	5%	Laboratory:	15%	Midterm Exam I:	15%
Physics Fridays:	5%	Problem Sets:	25%	Midterm Exam II:	15%
				Final Exam:	20%

Labs The laboratory is an essential part of this course. There you will see and experiment with a variety of important physics concepts and learn how to approach, analyze, and communicate details of an experiment and your confidence in your results. Physics is an experimental science and it takes careful, quantitative experiments to prove (or disprove) theories. Not only will labs give you a chance to test and develop your understanding of some of what we discuss in class, but you will also be introduced to additional concepts that we will not be able to cover in lecture. Further details will be provided by your laboratory instructor.

Exams There will be two midterm examinations as well as a comprehensive final exam for this course. Both midterm exams will take place during the designated week's allotted lab time.

Physics Fridays On most Fridays throughout the semester, we will start off class with a 5-10 minute presentation and discussion on an interesting topic in Physics. This could be a person, an experiment, etc. - whatever interests you! Each member of the class will be responsible for one presentation over the course of the semester. More details will be provided in class and on Moodle.

Assignments Homework will be assigned on a roughly weekly basis and will generally be due on **Fridays** at the start of class. Late assignments will be docked an additional 25% for each 24 hour period after the due date, unless you have received an exemption from me ahead of time or provide me with a Dean's Excuse. Please plan to manage your time accordingly.

A few notes about assigned problem sets:

- It is to your advantage to do the assigned homework. I have chosen the problems to help *you* learn the material. Physics can be a complicated thing, but repeatedly working with it (and at it) is essential in order to gain physical intuition and get comfortable with the mathematical theory.
- Feel free to use computational aids for some of the mathematics if you prefer, but note that there is some advantage to working things out by hand. Not being able to solve problems "by inspection" could end up hurting you on an exam where you may not be permitted to use computational tools and, frequently, there are mathematical tricks you can use to easily simplify a problem that you will not appreciate if you ask a program to do the work.
- I encourage you to work on these problem sets collaboratively, though I do expect you to take 10-15 minutes to give a problem "the old college try" on your own so you enter into discussion with others having some ideas to contribute. You will make your life easier as well as improve your understanding if you work with others (either by explaining it or having it explained to you). I expect solutions to be written up individually (or, if your handwriting is illegible, typed), and all collaboration should be properly acknowledged.
- I expect your problem sets to be clearly and logically organized. This means that:
 - Each problem should start on a **new** page.
 - Write out the problem (or an abbreviated version containing all relevant information). Draw a picture/diagram if useful.
 - Clearly work out the problem, commenting your work as you go. Problem sets should never contain just the math; use words to describe what you are doing and to reference where in the text an equation came from and why it is relevant.
 - Remember to keep track of units (by writing them out with all your calculations)! Do the units work out as you expect they ought to at the end of a problem? Dimensional analysis is the easiest check to ensure you have tackled the problem correctly.
 - Box your final solutions or major milestones as you do the problem. This makes it easier to grade and also for you to follow your own work when you look it over.
 - Comment on the significance of your answer. (Does it make sense? Is it what you expected? Why or why not?)
 - Attach a cover page to your problem set. This can be the problem sheet or something else, but it should have your name and a clear acknowledgement of all those you have collaborated with on the assignment. This includes fellow students, faculty, etc. (anyone who you consulted or worked with).
 - Please see me if you have any questions about this! I know it seems a bit ridiculous listed out like this, but I promise that it will serve you well in the long run. Writing in science is different from the traditional humanities paper, but the point is the same: to clearly and effectively communicate something. This will help you to accomplish that.

Office Hours Office hours, aka "free homework help sessions," are a chance for you to come by my office to ask questions or chat about any aspect of the course. You should feel free to stop by anytime; if I am available I will be happy to chat, but you are guaranteed to find me during the listed office hours (except under extraordinary circumstances). If you are unable to drop by during the listed times, please talk to me about setting up an appointment for a different time.

Academic Honesty I expect that you will abide by the "Principles of Intellectual Honesty" appearing in the Lafayette College Student Handbook. Posting homework or exam questions to an external site without my permission is a violation of the Academic Honesty Policy. The Physics department also has an Academic Honesty policy for rules regarding collaboration with others. This document is available on the Moodle page for this class. Please feel free to ask if you have any questions about this policy.

Accommodations In accordance with Lafayette College policy, reasonable academic accommodation and support services are available to students who have a documented disability. It is your responsibility to provide me with the appropriate paperwork from the Accessibility Services Office. More information is available at <https://hub.lafayette.edu/>.

Gender Inclusion This is a gender-inclusive classroom. I have been provided with a class roster and your legal names. I will gladly honor any requests to be addressed by a different name or pronoun than appears on the class. Please make me aware of any preferences.

Proper Usage of Course Materials & Classroom Recordings At Lafayette College, all course materials are proprietary and for class purposes only. This includes posted recordings of lectures, worksheets, discussion prompts, and other course items. Reposting such materials or distributing them through any means is prohibited. Such materials should not be reposted or distributed through any means. You must request my permission prior to creating your own recordings of class materials, and any recordings are not to be shared or posted online even when permission is granted to record. If you have any questions about proper usage of course materials please ask me.

COVID-19 Mask Policy Wearing a mask is known to reduce the transmission of SARS-CoV-2, the virus responsible for COVID-19. Regardless of your vaccination status, to protect the health of our class, the College policy is that masks must be worn during all indoor class sessions. Masks should be worn properly over the nose and mouth and secured on the chin. Food and drink must also be eaten outside of the classroom. Students who show up to class without a mask will be asked to return to class wearing one in order to protect the health of our classroom community. In the event that you do not have access to a mask to wear during the class session, please let me know and I will make sure that you will be able to obtain one.

Common Course of Study Outcomes Statement This course (and particularly the lab component) will promote the following outcomes for Natural Sciences (NS) within the Lafayette Common Course of Study:

- NS 1: Employ the fundamental elements of the scientific method in the physical and natural world by identifying and evaluating a testable scientific hypothesis.
- NS2: Create and evaluate descriptions and representations of scientific data via equations, graphs, tables, and/or models.

Moodle Privacy Statement Please note that Moodle contains student information that is protected by the Family Educational Right to Privacy Act (FERPA). Disclosure to unauthorized parties violates federal privacy laws. Courses using Moodle will make student information visible to other students in this class. Please remember that this information is protected by these federal privacy laws and must not be shared with anyone outside the class. Questions can be referred to the Registrar's Office.

Federal Credit Hour Compliance Statement Student work in this course is in full compliance with the federal definition of a four credit hour course. Please see the Registrar's Office website (<https://registrar.lafayette.edu/wp-content/uploads/sites/193/2013/04/Federal-Credit-Hour-Policy-Web-Statement.doc>) for the full policy statement.

Tentative Course Schedule and Associated Readings

M	Aug. 30	Introduction and Overview	Moore C, Ch. 1
W	Sept. 1	Vectors and Velocity	Moore C, Ch. 2
R	Sept. 2	Lab: <i>Absolute Zero</i>	
F	Sept. 3	Coordinate Transformations	Moore C, Ch. 3
M	Sept. 6	Momentum	Moore C, Ch. 4
W	Sept. 8	Interactions and Collisions	Moore C, Ch. 5
R	Sept. 9	Lab: <i>Speed of Light: Foucault's Rotating Mirror</i>	
F	Sept. 10	Energy	Moore C, Ch. 6
M	Sept. 13	SR Units	Moore R, Ch. 1.1-1.6, 2.1-2.2
W	Sept. 15	Speed of Light & Measuring Time	Moore R, Ch. 2.1-2.3
R	Sept. 16	Lab: <i>Speed of Light: Fiber Optics</i>	
F	Sept. 17	Worldlines and Spacetime Diagrams	Moore R, Ch. 2.4-2.7
M	Sept. 20	Determining Distance & Time in Spacetime	Moore R, Ch. 2.4-2.7
W	Sept. 22	Intervals and Invariants	Moore R, Ch. 3.1
R	Sept. 23	Lab: <i>Michelson Interferometer</i>	
F	Sept. 24	Three Kinds of Time	Moore R, Ch. 3.1
M	Sept. 27	Time and the Metric Equation	Moore R, Ch. 3.1-3.3
W	Sept. 29	Geometry of Spacetime	Moore R, Ch. 3.4-3.7
R	Sept. 30	Lab: <i>Muon I</i>	
F	Oct. 1	Time Dilation	Moore R, Ch. 4.1-4.6
M	Oct. 4	Relating the Different Kinds of Time	Moore R, Ch. 4.1-4.6
W	Oct. 6	Catch-Up	
R	Oct. 7	Lab: Exam I	
F	Oct. 8	Two-Observer Diagrams	Moore R, Ch. 5.1-5.4
M	Oct. 11	Fall Break	
W	Oct. 13	Two-Observer Diagrams continued	Moore R, Ch. 5.1-5.4
R	Oct. 14	Lab: <i>Muon II</i>	
F	Oct. 15	Lorentz Transformation	Moore R, Ch. 5.5-5.6
M	Oct. 18	Length Contraction	Moore R, Ch. 6.1-6.4
W	Oct. 20	Pole and Barn Paradox	Moore R, Ch. 6.5-6.6
R	Oct. 21	Lab: <i>Charge-to-Mass Ratio of the Electron</i>	
F	Oct. 22	Causality	Moore R, Ch. 7.1-7.3

M	Oct. 25	Einstein Velocity Transformation	Moore R, Ch. 7.4
W	Oct. 27	Relativistic Momentum	Moore R, Ch. 8.1-8.3
R	Oct. 28	Lab: <i>Polarization of Light</i>	
F	Oct. 29	Relativistic Energy	Moore R, Ch. 8.4-8.6
M	Nov. 1	Conservation of Relativistic Momentum	Moore R, Ch. 9.2-9.4
W	Nov. 3	Relativistic Collisions	Moore R, Ch. 9.1-9.3, 9.5-9.6
R	Nov. 4	Lab: <i>Hydrogen Spectrum</i>	
F	Nov. 5	General Relativity and the Equivalence Principle	
M	Nov. 8	The Atom and its Nucleus	Krane, Ch. 12.1-12.4
W	Nov. 10	Nuclear Decay	Krane, Ch. 12.6-12.9
R	Nov. 11	Lab: Exam II	
F	Nov. 12	Particle Physics & the Four Fundamental Forces	Griffiths, Ch. 1.1-1.4, 2.1
M	Nov. 15	Matter: Quarks and Leptons	Griffiths, Ch. 1.6-1.9
W	Nov. 17	Matter: Quarks and Leptons continued	Griffiths, Ch. 1.6-1.9
R	Nov. 18	Lab: <i>Nuclear Decay</i>	
F	Nov. 19	Feynman Diagrams and Interactions	Griffiths, Ch. 2.2
M	Nov. 22	Feynman Diagrams and Interactions continued	Griffiths, Ch. 2.2
W	Nov. 24	Thanksgiving Break	
R	Nov. 25	Thanksgiving Break	
F	Nov. 26	Thanksgiving Break	
M	Nov. 29	Introduction to Nanoscience	Feynman article
W	Dec. 1	Crystal Structures and Morphologies	
R	Dec. 2	Lab: <i>Quantum Dots</i>	
F	Dec. 3	Nanostructure Synthesis: Top-Down vs. Bottom-Up	
M	Dec. 6	Characterization Techniques	
W	Dec. 8	Optical, Electrical, & Mechanical Applications	
R	Dec. 9	Lab: <i>Scanning Electron Microscopy</i>	
F	Dec. 10	Catch-Up and Review	

FINAL EXAM (comprehensive): date and time TBD by the Registrar
