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 2:30 pm - 4 pm
	W 10:30 am - 12 pm
Labs:	R 1:10-4:00 pm
Room:	Hugel Science Center 042

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 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. Additionally, there will be several departmental colloquia held at various points throughout the semester that you are required to attend as part of this course. These talks will be about current research in various fields of physics and will serve to give you some insight as to what is going on in the wide, wide world of research as well as what makes a good (or bad, as the case may be) scientific presentation.

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)

Grading Grades are determined on the following basis:

Participation:	5%	Mid-term Exam I:	15%
Problem Sets:	25%	Mid-term Exam II:	15%
Labs:	15%	Final Exam:	25%

Office Hours Office hours, aka "free homework help sessions," are a chance for you to come by my office to ask questions 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.

Participation Your participation grade in this class will be based on your attendance at class meetings and departmental colloquia, your in-class contributions including discussions and asking questions, as well as office hour attendance.

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 final exam for this course. Both mid-term exams will take place during the designated week's allotted lab time and there will be no laboratory activity for those weeks. The final exam date and time will be determined by the Registrar.

Assignments

Departmental Colloquia: At the class following each departmental colloquium, we will discuss it for a few minutes to see what you (and I) found interesting and what we did/did not like. Attendance at each colloquium will count as a "problem" toward a colloquium problem set that will be weighted equally with the other problem sets you complete. It is your responsibility to inform me if you will be unable to attend a colloquium prior to the event.

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, which will count as a homework assignment for the course. More details will be provided in class.

Problem Sets: Homework will be assigned on a roughly weekly basis and will generally be due on **Wednesdays** at the start of class (**2:10 pm**). 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.

Over the course of the semester, I will allow for one "freebie" late assignment with no consequences or questions asked. If you use this option, you will have until an additional 48 hours after the assignment is due to turn it in before the late penalty is applied. Please write on the top of the assignment "*This is my freebie.*"

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.

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.

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:

- NS1: Employ the fundamental elements of the scientific method in the physical and natural world.
  (a) Identify and/or formulate a testable scientific hypothesis.
  (b) Generate and evaluate evidence necessary to test and/or revise a hypothesis.
- NS2: Create, interpret, and evaluate descriptions and representations of scientific data including graphs, tables, and/or models.
- NS3: Understand how scientific uncertainty informs the evaluation of hypotheses.

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 The 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 web site (https://registrar.lafayette.edu/wp-content/uploads/sites/193/2013/04/Federal-Credit-Hour-Policy-Web-Statement.doc) for the full policy and practice statement.

Tentative Course Schedule and Associated Readings

M	Aug. 26	Introduction and Overview	Moore C, Ch. 1
W	Aug. 28	Vectors and Velocity	Moore C, Ch. 2
R	Aug. 29	**Lab:** *Constant Volume Gas Thermometer*	
F	Aug. 30	Coordinate Transformations	Moore C, Ch. 3
M	Sept. 2	Momentum	Moore C, Ch. 4
W	Sept. 4	Interactions and Collisions	Moore C, Ch. 5
R	Sept. 5	**Lab:** *Speed of Light I: Foucault's Rotating Mirror*	
F	Sept. 6	Energy	Moore C, Ch. 6
M	Sept. 9	Galilean Relativity and the Speed of Light	Morre R, Ch. 1.1-1.6
W	Sept. 11	Spacetime Diagrams and SR Units	Moore R, Ch. 2.1-2.3
R	Sept. 12	**Lab:** *Speed of Light II: Fiber Optics*	
F	Sept. 13	Worldlines and Spacetime Diagrams	Moore R, Ch. 2.4-2.7
M	Sept. 16	Intervals and Invarients	Moore R, Ch. 3.1
W	Sept. 18	Time and the Metric Equation	Moore R, Ch. 3.1-3.3
R	Sept. 19	**Lab:** *Michelson Interferometer*	
F	Sept. 20	Geometry of Spacetime	Moore R, Ch. 3.4-3.7
M	Sept. 23	Time Dilation and the Lorentz Factor	Moore R, Ch. 4.1-4.6
W	Sept. 25	Two-Observer Diagrams	Moore R, Ch. 5.1-5.4
R	Sept. 26	**Lab: Mid-Term Exam I**	
F	Sept. 27	The Lorentz Transformation	Moore R, Ch. 5.5-5.6
M	Sept. 30	Length Contraction	Moore R, Ch. 6.1-6.4
W	Oct. 2	The Pole and Barn Paradox	Moore R, Ch. 6.5-6.6
R	Oct. 3	**Lab: make-up lecture**	
F	Oct. 4	Causality	Moore R, Ch. 7.1-7.3
M	Oct. 6	The Velocity Transform	Moore R, Ch. 7.4
W	Oct. 9	Four-Momentum	Moore R, Ch. 8.1-8.3
R	Oct. 10	**Lab:** *Muon Physics I*	
F	Oct. 11	Four-Momentum Conservation	Moore R, Ch. 8.4-8.6
M	Oct. 14	**no class** (Fall Break)	-
W	Oct. 16	Photons and Other Massless Particles	Moore R, Ch. 9.4
R	Oct. 17	**Lab:** *Muon Physics II*	
F	Oct. 18	Relativistic Collisions	Moore R, Ch. 9.1-9.3, 9.5-9.6

M	Oct. 20	General Relativity and the Equivalence Principle	-
W	Oct. 23	The Atom and its Nucleus	Krane, Ch. 12.1-12.4
R	Oct. 24	**Lab:** *Polarization of Light*	
F	Oct. 25	Nuclear Decay	Krane, Ch. 12.6-12.9
M	Oct. 27	Particle Physics: The Basic Building Blocks of Nature	Griffiths, Ch. 1.1-1.4
W	Oct. 30	The Four Fundamental Forces	Griffiths, Ch. 2.1
R	Oct. 31	**Lab: Mid-Term Exam II**	
F	Nov. 1	Matter: Quarks and Leptons	Griffiths, Ch. 1.6-1.9
M	Nov. 4	Feynman Diagrams and Interactions	Griffiths, Ch. 2.2
W	Nov. 6	Hadrons and the Strong Force	Griffiths, Ch. 2.3
R	Nov. 7	**Lab:** *Hydrogen Spectrum*	
F	Nov. 8	The Weak Force	Griffiths, Ch. 1.10, 2.4
M	Nov. 11	An Introduction to Nanoscience	Feynman article
W	Nov. 13	Crystal Structures and Morphologies	TBD
R	Nov. 14	**Lab:** *Nuclear Decay*	
F	Nov. 15	Top-Down vs. Bottom-Up Growth	TBD
M	Nov. 18	Synthesis Processes Continued	TBD
W	Nov. 20	Characterization Techniques I	TBD
R	Nov. 21	**Lab:** *Electron Charge-to-Mass Ratio I*	
F	Nov. 22	Characterization Techniques II	TBD
M	Nov. 25	Applications: Mechanical	TBD
W	Nov. 27	**no class** (Thanksgiving Break)	
F	Nov. 29	**no class** (Thanksgiving Break)	
M	Dec. 2	Applications: Electronic	TBD
R	Dec. 5	**Lab:** *Electron Charge-to-Mass Ratio II*	
W	Dec. 4	Applications: Optical	TBD
F	Dec. 6	Catch-Up/Review	

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