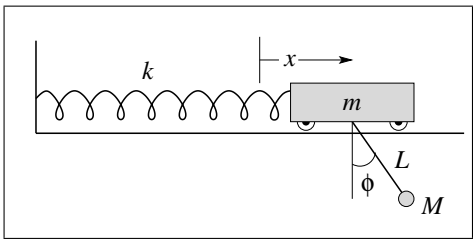
Physics 327:
Advanced Classical Mechanics
Lafayette College
Spring 2022



What this course is about

The college catalog says this: "A rigorous development of nonrelativistic mechanics: nonlinear oscillations; central-force motion, celestial mechanics, and the N-body problem; Lagrangian and Hamiltonian formulations; rotation and rigid body motion; collisions and scattering."

So, what's really going on here? At this point in your study of physics, you know that quantum mechanics, relativity, and fundamental forces (electromagnetism, weak force, strong force) are all essential to understanding of how the world works. And, yet, we plan on spending this semester analyzing classical mechanics problems using techniques which are nothing more than extensions of Newton's Laws. We will study the precession of tops, the motion of pendulums hanging from moving trains, the dynamics of pucks sliding on rotating turntables, and so on.

It is pretty obvious that you couldn't have a successful research career today doing this kind of work. So why will we spend time on it? What good is classical mechanics? Why is this course considered an essential part of a physics education? The methodologies you will learn in Physics 327—both the physical formulations and the underlying mathematics—are the foundation on which the problem solving and analysis techniques of all areas of physics are built. The formulations of classical mechanics were largely complete by the middle of the nineteenth century, but they remain essential components of advanced study in any field of twenty-first century physics.

Instructor

Prof. David Nice
Office: Hugel Science Center 030
E-mail: niced@lafayette.edu
Phone: x5204
Homepage: http://sites.lafayette.edu/niced

Course website

We will use Moodle, `http://moodle.lafayette.edu` .

Class meetings

- Monday, Wednesday 2:10-3:00, Hugel Science Center 017
- Friday 11:00-11:50, Hugel Science Center 142

Zoom link; Covid-19 logistics

All components of this course are planned to be in-person. However, should we need to have remote sessions for any purpose—class, office hours, or anything else—we will use the following Zoom link.

`https://lafayette.zoom.us/j/97762661837`

Prerequisites

The prerequisites for this course are Physics 218 and Math 264.

Office hours

Since this is a small class, rather than pre-setting office hours before the start of the semester, we will discuss what office hours will be most useful to you. It may be useful to set a weekly time for us to meet to discuss homework.

Text

The following text is required. Any format, paper or electronic, may be used.

John Taylor. *Classical Mechanics.* University Science Books. ISBN 1-891389-22-X.

Mathematica

We will make extensive use of Mathematica. Most homework assignments will include Mathematica calculations. Information about installing Mathematica on your own device is here: `https://help.lafayette.edu/mathematica/`.

Exams

There will be two midterm exams. You will have two hours for each exam. We will find a mutually acceptable time for the exam on days on or near March 2 and April 20. We will set the time/date of each exam at least two weeks in advance. We will cancel one class meeting close to each exam day.

There will be a three hour final exam at a time set by the Registrar or by mutual agreement of faculty and students.

Details of exams (e.g., whether they are open or closed book) have not yet been determined, but they will be provided well in advance of each exam.

Exam questions will resemble homework problems. Each midterm exam will be on the material covered in the preceding weeks of class (i.e., since the previous midterm exam). The final exam will cover all course material, with a slight bias towards material covered after midterm #2.

Homework

There will be weekly homework assignments. Homework papers will be due on Fridays.

If you cannot complete a homework due to illness, family emergency, or similarly compelling reason, please contact me. (Also see the section on "Dean's excuse policy" in the Student Handbook.)

You are *strongly* encouraged to work with other students on the homework. Try the problems yourself. When you get stuck, talk to someone else about them. Physics is hard. You won't get all the problems on your own. Working with others is absolutely essential in advanced physics classes.

Grading

There must be grades. Your grade will be based on:

Homework	30%
Midterm Exam #1	20%
Midterm Exam #2	20%
Final Exam	30%

Grades will be posted on Moodle. Grades may be re-scaled depending on the difficulty of exams and assignments. I will use the following numerical score when setting letter grades:

A	92.500 and higher	B−	79.500−82.499	D+	66.500−69.499
A−	89.500−92.499	C+	76.500−79.499	D	62.500−66.499
B+	86.500−89.499	C	72.500−76.499	D−	59.500−62.499
B	82.500−86.499	C−	69.500−72.499	F	59.499 and below

Course goals and topic coverage

The goal of Physics 327 is to teach the fundamental ideas of classical mechanics. This includes Newton's laws, reformulations of those laws by Lagrange and Hamilton, and the application of these laws to a variety of classical physical situations.

The list below shows the topics we will cover, along with the corresponding sections of the text and an estimate of the amount of time on each topic. The schedule will evolve as the semester progresses. Specific topic and text coverage will be given on the weekly homework assignments.

We will cover part of text §2 as warm-up for the semester, but then we skip ahead to §6. The skipped material is primarily on oscillations and waves and is covered in Physics 218. The heart of Physics 327 is in §6 to 11 of the text: our goal is to attain a through understanding of this material. We will finish off with some applications of classical physics, covered in §12 and 13 of the text.

Classical mechanics courses traditionally emphasize analytic solutions (using algebra and calculus) as opposed to numerical solutions (using computers). Indeed, one of the goals of a classical mechanics course is to hone your analytic skills. While Physics 327 will continue the traditional emphasis on analytic analysis, we will not hesitate to use numerical calculations when warranted, usually using Mathematica. Under such circumstances, the numeric techniques (and their implementation in Mathematica) will be discussed and demonstrated in class.

Topic	Text Chapter	Approximate number of classes
Newtonian mechanics review: projectiles and drag	2	3
Calculus of variations	6	3
Lagrangian mechanics	7	6
Central force problems	8	7
Non-inertial reference frames	9	5
Rigid body rotation	10	8
Nonlinear mechanics	12	5
Hamiltonian mechanics	13	3

Outcomes

After completing this course, you will be able to....

- Analyze physical situations using non-Cartesian coordinate systems.
- Understand the principles of the calculus of variations.
- Understand the derivation of Lagrange's equations.
- Use Lagrange's equations to solve mechanics problems.
- Evaluate two-body problems using the one dimensional central force formalism.
- Analyze phenomena in rotating reference frames.
- Calculate the rotational motion of three-dimensional bodies.
- Understand phenomena which arise in nonlinear mechanics.
- Understand and use generalized coordinates and the Hamiltonian formulation of mechanics.
- Use numerical tools to solve mechanics problems.

Course policies

Intellectual honesty

You are expected to abide by the principles of intellectual honesty outlined in the Lafayette Student Handbook available at `http://conduct.lafayette.edu`.

Learning is a collaborative process, I encourage you to discuss and collaborate with other students on homework. "Collaboration" does not mean "copying." You must understand and individually write out your answer to each problem.

Exams must be done on your own, using only materials specifically allowed.

Accommodation

My policy. It is important to me that you do well in this class. If you have any disabilities which you feel may interfere with your ability to succeed and prosper in this class, please contact me to discuss ways of accommodating them.

Mandatory statement for any Lafayette course with a disability policy. In compliance with Lafayette College policy and equal access laws, I am available to discuss appropriate academic accommodations that you may require as a student with a disability. Requests for academic accommodations need to be made during the first two weeks of the semester, except for unusual circumstances, so arrangements can be made. Students must register with the Office of the Dean of the College for disability verification and for determination of reasonable academic accommodations.

Mandatory privacy statement

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.

Mandatory credit hour statement

The student work in this course is in full compliance with the federal definition of a four credit hour course.