Physics 327 - Advanced Mechanics
Lafayette College, Spring 2021

Professor

Zoe Boekelheide

email: `boekelhz@lafayette.edu` (the best way to reach me)

Office hours: M T W Th 11am-noon. Please drop in (remotely)!

Office hours Zoom link: `https://lafayette.zoom.us/my/boekelhz`

Class meeting times

Lecture: Tu Th 2:40-3:30pm and F 1:10-2:00pm

4th hour: F 2:10-3:00pm (immediately after lecture)

Physics 327 is scheduled as an IN-PERSON class meeting in HUGEL 115

However, class may need to be held remotely at times. Class will go remote under the following circumstances:

- The College is in Operation Level 3 or 4
- Discretion of the instructor (including for snow days)
- Multiple students or myself needing to quarantine

In addition, if an individual student cannot attend class in-person temporarily, the student can Zoom into class. We may need to play around with the technologies to make this work, but we will try!

Here is the class Zoom link for when any of these circumstances occur: `https://lafayette.zoom.us/j/91375424290?pwd=azBuUk0wRVFYU2hncUpsRUhOY1ZPUT09`

About this course

Physics 327 is an advanced course in classical mechanics. Our starting point will be your strong base in introductory Newtonian mechanics, particularly in Cartesian coordinates. We will expand on this and add the Lagrangian and Hamiltonian formulations of Newtonian mechanics to our repertoire, as well as other coordinate systems. We will apply these tools to a range of interesting mechanics problems. Along the way, we will learn some mathematical machinery to help us solve complicated problems both analytically and computationally. As you know, classical mechanics has its limitations among the very small and the very fast, but it is nevertheless a very successful model and is still the most relevant model for much of the world as we experience it.

Prerequisites

Physics 218 and Math 264 are prerequisties for this course. Either may be waived with permission from the instructor.

Expectations and workload

The student work in this course is in full compliance with the federal definition of a four credit hour course. The federal course credit rule requires a total of 180 hours (12 hours/week) of student work over an approximately 15-week semester for a full unit (four credit hour) course. See the Registrar's Office web site for the full policy and practice statement (`https://registrar.lafayette.edu/wp-content/uploads/sites/193/2013/04/Federal-Credit-Hour-Policy-Web-Statement.doc`).

You should therefore expect to spend about 12 hours/week on this course: 3 hours in lecture, 1 hour in our 4th hour section, and an additional 8 hours spread throughout the week on homework and studying.

Course materials

For this course, you are required to obtain the following textbook: John R. Taylor, Classical Mechanics.

You also need access to Mathematica, which you should be able to get through Lafayette. Please let me know if you need help with this.

Course website and communications

I will use Moodle to post class handouts, homework assignments, etc.: `http://moodle.lafayette.edu`.

I will use Lafayette's Google Groups to send email to the class if necessary (e.g. any notifications of remote meetings, homework clarifications, etc.) so please check your Lafayette email regularly.

Learning Outcomes

By the end of this semester...

- Analyze physical situations using non-Cartesian coordinate systems.
- Understand and apply the principles of the calculus of variations.
- Understand the derivation of Lagranges equations.
- Use Lagranges 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 and use generalized coordinates and the Hamiltonian formulation of mechanics.
- Use numerical tools to solve mechanics problems

Grades

Grades on various assignments serve multiple purposes:

- To provide feedback on your performance on given assessments (e.g. exams, assignments). Your performance on such assessments should reflect your understanding of the material, i.e. the degree to which you have met learning outcomes.
- To provide more immediate incentives for certain behaviors which are beneficial to your learning (e.g. studying or completing homework) or to the class as a whole (e.g. participating in class).

Thus, your final course grade should reflect a combination of how well you understand the material and how well you complete required tasks. Your final course grade does NOT indicate your value as a person, and also does not determine your future success in physics or in life.

Your final course grade will be determined as follows:

Homework:	35% total
Written component:	(20%)
Oral component:	(15%)
Project	5%
Exam #1	20%
Exam #2	20%
Exam #3	20%

Detailed description of course components

Homeworks

There will be weekly homework assignments. These homeworks are critical to your learning in this course. If this is your first 300-level physics course, the problems you will encounter may be different or more challenging than problems you have encountered in previous courses. This is a good thing! Because of the importance of the homework assignments to this course, the homework grade is given a large amount of the available points in this course, and I am scaffolding the homework to make sure that you have an opportunity to revise your work, correct any errors, and fill any gaps in understanding.

Homework presentations: We will use the 4th hour to collaboratively review homework problem solutions. Thus, you should come to the 4th hour prepared to present your solution or attempted solution to any of the problems due. I will be particularly interested to hear where you think the potential pitfalls are in a particular problem, so it's okay if you don't finish a problem, as long as you can identify the sticking points. Students will be randomly selected to present their solution or attempted solution to the homework problems at the board. Please do not look up solutions to homework problems - it's okay if you don't have the full solution to a problem during 4th hour! The grade on the homework presentations is not based on solution correctness, but participation and effort. I expect that the students in this class will be supportive of and kind to each other so that this can be a fun and interesting exercise, and not too stressful.

Written homework: After the 4th hour, you will have a chance to revise your solutions. Then you will turn them in to me to be graded. With this scaffolding, you should have ample opportunity to correct any errors and the homework you turn in should be of excellent quality.

Here are some guidelines for what your homework should look like when you turn it in:

- Each problem should start on a new page. This is more for you than for me - it will make it much easier for you if you need to go back and change something on a long problem solution.
- Write out the problem (or an abbreviated version containing all relevant information).
- Draw and use pictures/diagrams generously.
- Clearly work out the problem, commenting your work as you go. Problem sets should never contain just math; use words to describe what you are doing and to reference where an equation came from and why it is relevant.
- $\boxed{\text{Box}}$ your final solution. This makes it easier to grade and also tells me that you know what the problem was asking for. You may wish to underline, star, or otherwise highlight other major milestones as you do the problem.
- Comment on the significance of your answer. (Does it make sense? Is it what you expected? Why or why not? If it is a complicated algebraic expression, are there special cases you can consider for a "sanity check"?)
- You should acknowledge everyone you have collaborated with on the assignment. This includes any other fellow students, faculty, etc. (anyone who you consulted or worked with).
- Scan your work or take photos (in good lighting!) to turn in to Gradescope.

I will grade homework problems as follows: Everyone starts with an 8.5/10 on each problem, and points are added for aspects of your homework that I think are excellent (for example, excellent diagrams or explanations) or subtracted for mistakes, omissions, or sloppiness.

Exams

There will be two exams and a final:

- *Exam #1* will be on Friday, March 19. It will be a 110 minute exam beginning in class and extending until 3:00pm (through the 4th hour).
- *Exam #2* will be on Friday, April 23. It will be a 110 minute exam beginning in class and extending until 3:00pm (through the 4th hour).
- *Exam #3* will be a three hour exam during finals week at a time determined by the Registrar.

Exam problems will be similar to problems worked on homework and discussed in class. Exam problems will be designed to be completed within the time period provided, and will be designed to test understanding of concepts and competence in skills learned in the preceding weeks. *Exams may include use of computer/Mathematica to solve some problems. If this is the case, I will notify you in advance.*

Project

The last week or so of the semester will be devoted to an informal project. This will be similar to a homework, but with one big problem rather than ~ 10 smaller problems. Different students will work on different problems, and present them at the end of the semester.

Intellectual honesty

You are expected to abide by the principles of intellectual honesty outlined in the Lafayette Student Handbook (available from `http://studentlife.lafayette.edu`). Here are some guidelines specific to this course.

Homework - collaboration

Learning is a collaborative process. Discussion and collaboration on homework in this course is encouraged. "Collaboration" does not mean "copying." You must understand and individually write out your answer to each problem. For computational problems, start from the beginning and create your own computation/simulation file, do not use a classmate's file. Acknowledge your collaborators on your homework paper.

Homework - resources You may use classmates, my office hours, the textbook, and our 4th hour as resources. Do not seek out solutions to homework problems on the internet; for this class, I consider this to be a breach of intellectual honesty. Finding solutions to homework problems on sites such as (but not limited to) Chegg or Bartleby is not allowed, nor is consulting an instructor's solution manual or notes from students from previous semesters. *Rationale:* Some students believe that looking up solutions to homework problems when they get stuck helps their learning because they get immediate feedback. I will argue that the negatives of this approach outweigh any benefits. Here are some of the negatives:

- Creates a false sense of security that won't be there during exams.
- Can replace other healthy learning behaviors, such as: reading through the text for missing concepts or similar examples; asking a friend; asking a professor; taking a break and coming back to the question later; having a "Eureka" moment in the shower. These are all healthy learning behaviors, and doing less of them is a negative.
- Can lead to a culture where it feels like everyone knows the answer all the time and being unsure is not normal (I assure you that being unsure is normal).

In the context of our 4th hour, this means you may show up to our 4th hour with some incomplete or incorrect answers to our challenging problems, and we will work them out together.

Exams

Exams must be done on your own, using only materials specifically allowed. Access to a smartphone or any electronic device besides your calculator is not allowed (with an exception in the case of a Mathematica exam problem).

Inclusion statement

In Physics 327, all students are welcome. Students and professors bring diverse identities to class, and it is my intention that all students feel included in the intellectual community of the classroom. Unfortunately, the history of science is full of exclusion, so it's important to be explicit about inclusion.

Please contact me if you feel your identity is not being honored in class, if you have a preferred name or pronouns that I am not aware of, you observe religious holidays which conflict with coursework, or if there is something else that I can or need to address. I am still learning, too, and your feedback is important to me.

Accommodation

It is important to me that nothing impedes your ability to do well in this course. 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 Moodle 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.

Schedule for Lafayette Spring 2021 PHYS327 course

*subject to change

Wk	Lec	Date	Topic	Textbook Sections
1	1	9-Feb	Intro; Newton's Laws	1
	2	11-Feb	Projectiles and Drag	2
	3	12-Feb	Projectiles and Drag	2
2	4	16-Feb	Projectiles and Drag	2
	5	18-Feb	Calculus of Variations	6
	6	19-Feb	Calculus of Variations	6
3	7	23-Feb	Calculus of Variations	6
	8	25-Feb	Lagrangian Mechanics	7
	9	26-Feb	Lagrangian Mechanics	7
4	10	2-Mar	Lagrangian Mechanics	7
	11	4-Mar	Lagrangian Mechanics	7
	12	5-Mar	Lagrangian Mechanics	7
5	13	9-Mar	Lagrangian Mechanics	7
	14	11-Mar	Central force problems	8
	15	12-Mar	Central force problems	8
6	16	16-Mar	Central force problems	
	17	18-Mar	Central force problems	8
	18	19-Mar	**Exam 1**	8
7	19	23-Mar	Central force problems	8
	20	25-Mar	Central force problems	8
	21	26-Mar	Central force problems	8
8		30-Mar	**Spring break**	9
	22	1-Apr	Non-inertial reference frames	
	23	2-Apr	Non-inertial reference frames	9
9	24	6-Apr	Non-inertial reference frames	9
	25	8-Apr	Non-inertial reference frames	9
	26	9-Apr	Non-inertial reference frames	9
10	27	13-Apr	Rigid body rotation	10
	28	15-Apr	Rigid body rotation	10
	29	16-Apr	Rigid body rotation	10
11	30	20-Apr	Rigid body rotation	10
	31	22-Apr	Rigid body rotation	10
	32	23-Apr	**Exam 2**	10
12	33	27-Apr	Rigid body rotation	10
	34	29-Apr	Rigid body rotation	10
	35	30-Apr	Hamiltonian mechanics	13
13	36	4-May	Hamiltonian mechanics	13
	37	6-May	Hamiltonian mechanics	13
	38	7-May	Hamiltonian mechanics	13
14	39	11-May	Hamiltonian mechanics	13
	40	13-May	Work on projects	
	41	14-May	Project presentations	
15	42	18-May	Review	
		20-May		
		21-May		
		TBD	**Final exam**	