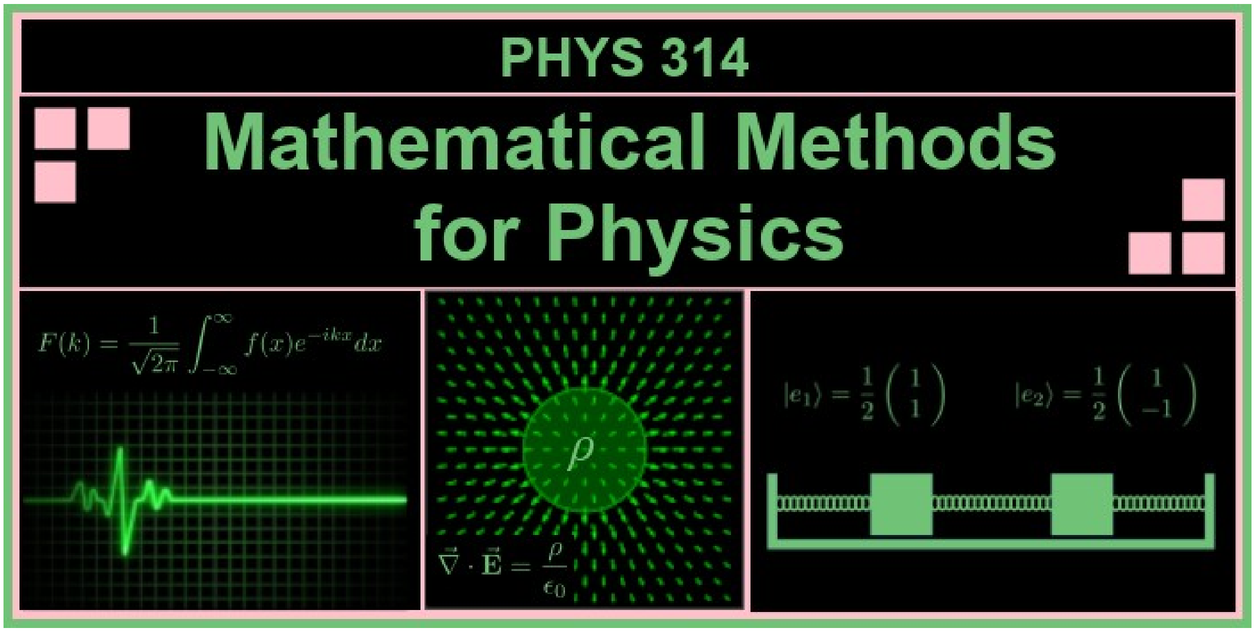

Mathematical Methods in Physics
(PHYS 314)
Fall Semester, 2025

Instructor:

Brooks Thomas
Email: thomasbd@lafayette.edu
Office: Hugel 020
Phone: (610) 330-5207

General Course Information

The common thread which unites many phenomena that we observe in nature is not *physical* — indeed, while two physical systems may give rise to very similar phenomena, the underlying physical principles which govern these systems are often very different! Rather, that common thread is *mathematical*: the equations which describe how the relevant physical quantities evolve or change in each system turn out to have a very similar mathematical form. For this reason, a working knowledge of the mathematical methods which have been developed to analyze familiar physical systems is essential when one is trying to make sense of unfamiliar ones. In this class, we will focus on the mathematical tools useful for describing and analyzing physical systems systems – tools which include power series, complex variables, linear algebra, Fourier analysis, and a variety of strategies for solving differential equations. Learning to recognize mathematical analogies between seemingly unrelated physical systems and exploit these tools in order to solve problems lies at the core of what it means to “think like a physicist.” This process can be challenging, given the degree of abstraction that it involves, but it will also be rewarding. Indeed, you can look forward to being able to do all of the following by the time this semester concludes.

- You'll be able to use **Taylor-series approximations** in order so simplify physics calculations.
- You'll be able to employ a variety of techniques in order to solve **ordinary and partial differential equations**.
- You'll be able to use **Fourier analysis** in order to analyze physical systems which give rise to waves.
- You'll learn a number of techniques for solving simple **ordinary differential equations** and be able to apply them in order to solve physics problems.
- You'll be able to use **vector operations** such as the divergence and curl to analyze physical systems involving vector fields.
- You'll be able to use **computational tools such as Python and Mathematica** in order to analyze physical systems.

The prerequisites for this course include MATH 264 and either PHYS 133 or PHYS 152. An understanding of multi-variable calculus at the level of MATH 263, which is a prerequisite for MATH 264, is also implicitly assumed.

Components of the Course

The course will consist of class meetings, reading assignments in the text, homework problems, a set of programming activities to take place during the "Fourth Hour" for the course, two mid-term exams, and a final exam. These are described more fully below.

Class Meetings and "Fourth Hour" Activities:

Class meetings will typically be held from **1:15 AM – 2:30 PM** in Hugel 017 each Monday and Wednesday during the semester. The "Fourth Hour" associated with this class will consist of additional meetings from **1:15 AM – 2:30 PM** on certain Fridays. **Regular attendance at class meetings is expected**, but not graded. By contrast, your attendance at "Fourth-Hour" meetings does have an impact on your grade. You are expected to attend all such meetings and participate fully in the activities which take place during them. If you have a valid reason for missing a "Fourth-Hour" meeting (an illness, a family emergency, a religious holiday, participation in a College-sanctioned athletic event, etc.), it is your responsibility to inform me as far in advance as possible so that we can arrange a time for you to make up what you missed. In situations in which an Absence Verification is available, it is also your responsibility to provide me with that document. If you miss a "Fourth-Hour" meeting without a valid reason, you will receive a grade of zero for the activities which took place during that meeting. If you are physically present for only part of that meeting – e.g., you arrive more than 10 minutes late – your grade for these activities will be multiplied the fraction of the lab period for which you were present.

A schedule of topics to be covered each day in our class meeting is listed on the course web page. Much of the material covered in this course – and many of the homework problems that you'll be working through – are quite challenging. It is therefore important that you come to class prepared to ask questions and to engage in discussions. You should be aware that class meetings will involve not only my lecturing to you about the material covered in the readings (which is not necessarily the best way for me to help you learn the material), but a variety of other activities as well – the benefit you get out of which is directly proportional to the effort you put in.

Textbook:

The required textbooks for this course are

- Mary L. Boas, *Mathematical Methods in the Physical Sciences*, 3rd Ed. (Wiley, 2006).
- H. M. Schey, *Div, Grad, Curl, and All That*, 4th Ed. (W. W. Norton & Co., 2005).

I will also be posting on the course Moodle a set of lecture notes, entitled *Slightly Disturbed: A Mathematical Approach to Oscillations and Waves*, which I created for a course I taught on oscillatory and wave phenomena at Reed College a long time ago – a course which doubled as a mathematical-methods course. These notes are intended primarily as a supplementary text.

I have chosen these texts because I find them to be some of the clearest and most approachable references on mathematical methods in physics. However, there exist a great many other texts on the subject.
For this, I recommend the following:

- George B. Arfken, Hans J. Weber, and Frank E. Harris, *Mathematical Methods for Physicists*, 7th Ed. (Academic Press, 2012).
- K. F. Riley, M. B. Hobson, and S. J. Bence, *Mathematical Methods for Physics and Engineering: A Comprehensive Guide*, 3rd Ed. (2006).

Finally, since we will be using both Python and Mathematica (i.e., Wolfram Desktop) extensively in this course, you may find it useful to have a guide or tutorial for each that you can reference. A good introductory reference for Mathematica is:

- C-K. Cheung, Gerard E. Keough, Robert H. Gross, and Charles Landraitis, *Getting Started with Mathematica*, 3rd Ed. (Wiley, 2009).

A number of additional tutorials, programming guides, and other references for both Python and Mathematica are also available online. Links to some of the more useful ones for the applications we'll be dealing with in this course will be posted on the course web page.

Homework Assignments:

Working through problems is an essential part of this course. It gives you a chance to hone your critical-thinking and problem-solving skills while applying the concepts you'll be learning in class in new ways. For this reason, I will be assigning a number of homework problems each week which I feel provide practice with the most crucial aspects of the material we're covering in the course. A list of the problems included in each problem set will be posted on the course Moodle. Some of these problems will require nothing more than pen, paper, and a lot of careful thought; others are designed to give you some practice solving problems using computational tools like Mathematica or Python.

All homework problems are **due at 5:00 PM Eastern Time on the day indicated on the course schedule**, which is typically a Wednesday. Your work should be submitted in PDF format using the appropriate upload link on the course Moodle page. However, you do not need to typeset your homework in a fancy way. Writing your work out by hand on paper, scanning or photographing the pages, and converting the images to PDF format is perfectly acceptable. You may still turn in late homework for reduced credit (a 10% penalty will be assessed for every 24 hours it is overdue) up until the beginning of the next class meeting (typically the following Monday at 1:25 PM Eastern Time). However, because we will frequently discuss homework problems in class, late homework will not be accepted beyond that point.

I wholeheartedly encourage you to work together on homework problems with other students in the class. This can be a very productive way of expanding your own knowledge, and working with other people to solve problems is a big part of how science is really done. However, the written work that you turn in to me must be your own work: it should reflect your own understanding and should be written up independently after all discussion between you and your peers is complete.

Midterm and Final Exams**:**

There will be two mid-term exams given during the course. **The first exam will be held on Oct. 6th and the second on Nov. 10th**. These tests are designed give you the opportunity to demonstrate how well you understand the material. Mid-term exams will be given during our usual class-meeting time. In addition, there will also be a final exam at a date and time to be determined by the Registrar.

Grading

Course Grade:

Your grade in the course will be determined by the following criteria:

Homework	30%
Fourth-Hour Activities	15%
Mid-Term Exam I	17%
Mid-Term Exam II	17%
Final Exam	21%

Instructor Drop-In Hours:

My official instructor drop-in hours this semester will be held on **Wednesdays from 12:00 noon – 1:00 PM,** on **Thursdays from 11:00 AM – 12:00 noon**, and on **Fridays from 9:00 – 10:00 AM** unless otherwise noted on the course web page. These drop-in hours (sometimes called “office hours,” but in this case, that’s a misnomer, since they will not take place in my office) will be held in Hugel 125. If you and other students in the course have the same question, you are welcome – and in fact encouraged – to meet with me during my drop-in hours as a group.

The default assumption is that my drop-in hours will take place in person. However, if the need arises for you to attend drop-in hours virtually at any point during the semester (e.g., because of a winter-weather emergency or an illness), please email me in advance to schedule a virtual drop-in-hours meeting. Such meetings will take place over my drop-in-hours Zoom link, which is

- https://lafayette.zoom.us/j/89137906511

The password is provided on the course Moodle.

If you are unable to make it to these official drop-in hours either virtually or in person, you may also email me to make an appointment to meet at some other time. However, I recommend that you do this as far in advance as possible in order to ensure that we can find a time to meet.

Intellectual Honesty:

All exams in this class are closed-book. Calculators are permitted, including graphing calculators (e.g., calculators similar to the Texas Instruments TI-84), but the use of cell phones and cell-phone-based calculator-emulator apps is not permitted on exams. You will also be provided with a document containing a list of useful equations and fundamental constants at the start of each exam. However, the use of any other resources is not permitted. When studying, working in the laboratory, or working on homework problems, I encourage you to work with other students. However, you may not consult a solutions manual or any other source for answers to the problems, and the write-up that you submit to me for each problem should be your own work.

One of the goals of this class is to help you develop your own intuition about how to apply your physics knowledge in practice. For this reason, the of use tools based on generative artificial intelligence (AI) when working on homework problems and taking exams is prohibited in this class (with exceptions made for rudimentary tools associated with basic text-autocorrect or search-engine functionality). The same is true for most "Fourth-Hour" activities, though there will be certain such activities wherein we will be actively engaging with and making use of generative AI as a problem-solving tool (e.g., in vibe coding) in order to learn about its capabilities and its limitations. Further guidance will be provided at the beginning of each "Fourth-Hour" meeting with regard to the extent to which you are permitted to use of generative AI when engaging with the corresponding activities.

As always, you are expected to abide by the principles of intellectual honesty and academic integrity outlined in the Lafayette Student Handbook, which can be found at

- https://conduct.lafayette.edu/student-handbook/

Other Useful Information

Student Academic Resources Site:

This is a centralized website for Lafayette students which contains resources related to college-transition support, accessibility services, tutoring, health and well-being, advising and registration, technology help, library services, student funds, and more. A link to the site is provided below

https://spaces.lafayette.edu/enrol/index.php?id=1276

You are encouraged to self-enroll in this site and to bookmark it for future reference.

Accessibility Services:

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. If you are requesting accommodations, you must register with the Accessibility Services Office (administered by the Academic Resource Hub) for disability verification and for the determination of reasonable academic accommodations. Accessibility Services will then provide me with a document which outlines what those accommodations are. I cannot provide accommodations until I receive such a letter. Requests for academic accommodations must be made within the first two weeks of the semester, except in unusual circumstances, so that suitable arrangements can be made in a timely manner.

Informal Surveys:

As the semester progresses, I want to hear from you how you feel the course is going, what you like, what you don't like, what your concerns are, and how you think the course could be improved. Therefore, throughout the semester, you'll have the opportunity to fill out short surveys and informal evaluations so I can get your feedback.

Course Communication:

This syllabus, a list of assigned readings and problem sets, and other course materials will be posted on the course web page, which can be found at

- https://workbench.lafayette.edu/~thomasbd/Phys314-MathematicalMethods-Fall-2025/Phys314-MathematicalMethods-Fall-2025.html

In addition to the course web page, there is also a Moodle page for this course which I will frequently use in distributing course materials, communicating with the class, etc. The Moodle page can be found at

- https://moodle.lafayette.edu/course/view.php?id=30634

Occasionally, it may be necessary for me to communicate additional information (scheduling changes, clarifications about homework problems, etc.) to the class as a whole. When I do so, I will use your official Lafayette email addresses for all course-related correspondence, so make sure to **check your Lafayette email regularly**.

Health Protocols:

At the moment, masking is not required during class meetings, during the "Fourth Hour," or during my office hours under normal circumstances, though I encourage you to wear a mask if it makes you feel more comfortable. However, this policy may change at any point during the semester is circumstances change. In any event, if you are experiencing symptoms (cough, chills, fever, sore throat, etc.) typically associated with communicable respiratory illnesses, you are required to wear a mask while your symptoms persist, even if those symptoms are mild. If you do not feel well enough to attend class meeting, inform me of the situation by email and do not come to class. You are of course also required to abide by all campus-wide health protocols established by Lafayette College while they remain in effect.

Contingency Procedures for Virtual Class Meetings:

The default expectation is that all class meetings this semester will be held in person in Hugel 017. However, under certain circumstances (e.g., the campus closes due to a winter-weather emergency) we may temporarily be compelled to move those meetings online. If this should occur, the Zoom link that we will use for these class meetings is

- https://lafayette.zoom.us/j/82298962066

The password is provided on the course Moodle. I will notify all members of the class by email as far in advance as possible if we need to switch to a virtual classroom environment at any point during the semester. The assumption is that if this should even happen, we will return to an in-person learning environment as soon as circumstances permit.

If we are ever temporarily forced to move to a virtual format, I would like us to be able to simulate the atmosphere of a physical classroom to whatever extent we can. For this reason, I would like to ask that you have your camera on during any virtual class meetings we end up having and to use the "gallery view" option on Zoom so that we can all see each other and respond to each other's visual cues. I will do the same. That said, if there are extenuating circumstances which would make having your camera on an issue for you, please reach out to me and we will work out an equitable solution. Please mute yourself when you are not speaking in order to reduce background noise. Please raise your actual hand in order to take part in the discussion. If I do not see your actual hand, please raise your "digital hand."

Privacy Statement Concerning Course Materials and 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. Permission will be granted only when sanctioned as an academic accommodation in an official letter from the Accessibility Services Office. If you have any questions about proper usage of course materials please ask me. Please also be in contact with me if you have any concerns with being recorded during the course.

Online discussions in Moodle occurring during synchronous class sessions should also remain private and not be shared outside of the course. Courses using Moodle will make student information visible to other students in this class. Student information in courses is protected by the Family Educational Right to Privacy Act (FERPA). Disclosure of student information to unauthorized parties violates federal privacy laws and it 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. The full policy and practice statement can be found on the Registrar's Office website at

- https://registrar.lafayette.edu/wp-content/uploads/sites/193/2022/07/Federal-Credit-Hour-Policy-Web-Statement.pdf

Winter-Weather Emergencies:

You should assume that class meetings will occur as usual, despite any weather-related issues (including power outages), even if campus offices open late or close early. In the rare event that class must be canceled, I will notify the class by email, and by leaving a voicemail message on my office phone, the number for which is (610) 330-5207.

In Closing

If you have any questions about this syllabus, or about any aspect of the course, please don't hesitate to contact me. We have a fascinating and rewarding semester ahead of us. True, the material we will be covering is challenging and quite abstract; however, it is also immensely rewarding. Indeed, the mathematical and computational skills you'll be practicing and honing in the process will serve you well in any field of physics – and in many fields outside of physics as well.

Course Schedule

The full, up-to-date schedule for the course, including due date for all assignments is available on the course web page.

Week	Topics and Readings	Due Dates
Week 1 8/25 – 8/29	**Power Series** Boas 1.1 – 1.15; Thomas 2.1 – 2.3, 2.6 – 2.7	
Week 2 9/1 – 9/7	**Complex Variables** Boas: 2.1 – 2.16; Thomas: 3.1 – 3.5	HW1 (Due 9/3)
Week 3 9/8 – 9/12	**Special Functions** Boas: 11.1 – 11.11, 8.1 – 8.2; Thomas: 4.1 – 4.2	HW2 (Due 9/10)
Week 4 9/15 – 9/19	**Ordinary Differential Equations** Boas: 8.3 – 8.7; Thomas: 4.3 – 4.4, 5.1 – 5.4	HW3 (Due 9/17)
Week 5 9/22 – 9/26	**Laplace Transforms and Green's Functions** Boas: 8.8 – 8.9, 8.11 – 8.12; Thomas: 8.1 – 8.5	
Week 6 9/29 – 10/3	**Systems of Differential Equations** Boas: 3.1 – 3.10; Thomas: 9.1 – 9.8	HW 4 (Due 10/1)
Week 7 10/6 – 10/10	**Vector Spaces and Linear Algebra** Boas: 3.14, 12.6	Midterm I (10/6)
Week 8 10/13 – 10/17	**Eigenvectors, Eigenvalues, and Normal Modes** Boas: 3.10 – 3.12; Thomas: 9.9 – 9.10	HW 5 (Due 10/15)
Week 9 10/20 – 10/24	**Vector Fields and Vector Calculus** Boas 6.1 – 6.9; Schey: p. 52 – 91, p. 115 – 121	HW 6 (Due 10/22)
Week 10 10/27 – 10/31	**The Fundamental Theorems of Vector Calculus** Boas: 6.10 – 6.11; Schey: p. 11 – 41, p. 91 – 104	HW7 (Due 10/29)
Week 11 11/3 – 11/7	**Fourier Analysis** Boas: 7.1 – 7.7, 7.12; Thomas: 7.1 – 7.7	HW 8 (Due 11/5)
Week 12 11/10 – 11/14	**Partial Differential Equations** Boas: 13.1 – 13.2	Midterm II (11/10)
Week 13 11/17 – 11/21	**Waves and the Wave Equation** Boas: 13.3 – 13.4	HW 9 (Due 11/19)
Week 14 11/24 – 11/28	**Thanksgiving Break** (No Classes)	
Week 15 12/1 – 12/5	**Orthogonal Functions in 3D** Boas: 13.5, 13.7 – 13.8; Schey. p. 124 – 131	HW 10 (Due 12/3)
Final Exam Week		Final (TBA)