

PY 216 – Mathematical Methods in Physics and Engineering

Spring 2026 Syllabus

Last edited: 6th April 2026

1 Information

Credit hours: Three

Course instructor: Anthony Ashmore

Contact information: aashmore@skidmore.edu

Class location: CIS 384

Class times: Tuesday / Thursday @ 9:40-11:00 AM

Office location: CIS 380D

Office hours: Tuesday / Thursday @ 2-4 PM or by appointment (in person or on Zoom). Chat with me during or after class, or send an email, and I will get back to you as soon as possible.

Zoom link: skidmore.zoom.us/my/antash

2 Course description

“An introduction to the mathematical tools used across the physical sciences. Topics include complex numbers; power series; vectors and matrices; ordinary differential equations; functions as vectors; curve fitting; Fourier series and transforms; partial derivatives; and partial differential equations. Emphasis is on physical interpretation and using these tools to solve problems in physics. Applications include oscillations and waves, diffraction and optics, electromagnetic fields, heat flow and diffusion, and quantum mechanics.”

The mathematical techniques covered by the course will be crucial for studying advanced topics in physics at both undergraduate and graduate levels, and will be broadly useful in other quantitative subjects.

2.1 Topics covered

- **Power series:** interval of convergence; Taylor expansions; standard series for approximations.
- **Python:** Plotting, variables, logic, functions, Numpy.
- **Complex variables:** Cartesian form; basic algebra/manipulation; complex power series and disk of convergence; Euler’s formula and polar form; trigonometric and hyperbolic functions.
- **Ordinary differential equations:** First-order (separable; linear via integrating factor); second-order linear with constant coefficients; damping/forcing/resonance.

- **Vectors and matrices:** Vector spaces and inner products; orthogonality/orthonormal bases; matrices as linear maps; basic manipulation; symmetric/hermitian and orthogonal/unitary matrices; trace and determinant; eigenvalues/eigenvectors; solving linear systems.
- **Functions as vectors:** Inner products on function spaces; self-adjoint operators; orthogonal eigenfunctions; curve fitting and least squares.
- **Generalised Fourier series:** Legendre series; real and complex Fourier series; convergence and Parseval's theorem.
- **Fourier transforms:** Definition and key properties (shifts, scaling and derivatives); Dirac delta; power spectrum.
- **Partial differentiation:** Partial derivatives and total differentials; multivariable Taylor expansions; total derivatives and chain rule; exact and inexact differentials; gradient, divergence, curl.
- **Partial differential equations:** Overview of Laplace, Poisson, wave, heat and Schrödinger equations; classification and boundary conditions (elliptic, parabolic, hyperbolic); separation of variables and eigenfunction expansions; standard boundary- and initial-value problems on simple domains.

3 Tentative schedule

A tentative schedule for each week is below. Each week includes two 80-minute class meetings and one problem set; problem sets are due the following week unless otherwise noted. There is no required textbook – weekly readings are drawn from the instructor's course notes, which will be posted to theSpring before each class.

Date	Topic
20 Jan	Introduction to course
22 Jan	Power series: Definition. Convergence. Operations with series. Intro to Python. Problem Set 1 - Power series
27 Jan	Power series: Taylor expansion. Common series expansions.
29 Jan	Complex variables: Why complex numbers? Working with complex numbers. Problem Set 2 - Complex variables
3 Feb	Complex variables: The complex plane and polar coordinates. Power series.
5 Feb	Complex variables: Euler's formula and polar form. Problem Set 3 - Complex variables
10 Feb	Complex variables: Trigonometric and hyperbolic functions.

12 Feb	1st-order ODEs: Motivation and terminology. General vs particular solutions. Initial and boundary conditions. Separation of variables. Problem Set 4 - 1st-order ODEs
17 Feb	1st-order ODEs: Integrating factor. Linear differential operators. Homogeneous vs inhomogeneous.
19 Feb	2nd-order ODEs: Solution by auxiliary equation. Exponential and oscillating solutions. Inhomogeneous ODEs. Problem Set 5 - 2nd-order ODEs
24 Feb	2nd-order ODEs: Inhomogeneous ODEs.
26 Feb	2nd-order ODEs: Overdamped, underdamped, critically damped. Driven oscillator motion. Problem Set 6 - 2nd-order ODEs; Review for Evaluation 1
3 Mar	<i>Evaluation 1: Power series, complex variables, 1st-order ODEs</i>
5 Mar	Vectors and matrices: Vectors and vector spaces. Dot product as inner product. Orthogonality/orthonormal bases. Problem Set 7 - Vectors and matrices
10 Mar	No class – Spring Vacation
12 Mar	No class – Spring Vacation
17 Mar	Vectors and matrices: Matrices. Matrix operations.
19 Mar	Vectors and matrices: Matrix multiplication. Problem Set 8 - Vectors and matrices
24 Mar	Vectors and matrices: Trace, determinant, inverse. Solving linear systems.
26 Mar	Vectors and matrices: Special matrices. Eigenvalues and eigenvectors. Problem Set 9 - Generalised Fourier series
31 Mar	Generalised Fourier series: Vector spaces of functions. Inner products. Orthonormal functions.
2 Apr	Generalised Fourier series: Fourier–Legendre series. Convergence. Problem Set 10 - Fourier transforms
7 Apr	Generalised Fourier series: Complex Fourier series. Real Fourier series.
9 Apr	Fourier transforms: Motivation and definition. Examples. Problem Set 11 - Partial derivatives; Review for Evaluation 2
14 Apr	Fourier transforms: Dirac delta function. Orthonormal basis functions. Power spectrum and Parseval’s theorem.
16 Apr	<i>Evaluation 2: 2nd-order ODEs, vectors and matrices, generalised Fourier series</i> Problem Set 12 - PDEs: Laplace, heat

21 Apr	Partial derivatives: Multivariable functions. Motivation and definition. Taylor series for multivariable functions.
23 Apr	PDEs: Introduction and motivation. Classification and boundary conditions. Separation of variables and eigenfunction expansions. Laplace equation.
Problem Set 13 - PDEs: Wave, Schrödinger; Review for Final Exam	
28 Apr	PDEs: Heat equation. Wave equation. Schrödinger equation.
1-3 May	Study Days (optional open review sessions)
4 May	Final Exam @ 6:00-9:00 PM, Monday of Finals Week in CIS 384

4 Learning goals

Students who pass this course will be able to:

- Identify information needed to answer a scientific question.
- Create and interpret graphs and diagrams.
- Translate between physical and mathematical representations of a system.
- Organize, analyse and interpret data using appropriate software.
- Work in groups in a productive and collaborative manner.
- Use appropriate format for problem solutions, presentations, and papers.
- Communicate thought processes through problem solving and/or derivations.

5 Course requirements

- PY 140 – Introductory Physics II with Laboratory: Electrodynamics
- MA 113 – Calculus II

6 Course materials

Course materials, including class notes and problem sets, will be uploaded to theSpring. We will cover topics in a slightly different order from the optional texts, so I will point you to the relevant chapters if you wish to have an alternative explanation of a concept, or you're looking for more problems to solve.

6.1 Required texts

- “PY 216 – Mathematical Methods in Physics and Engineering”, A. Ashmore – uploaded to theSpring.

6.2 Optional texts

- “Mathematical Methods for Physics and Engineering”, Riley, Hobson, Bence.
- “Mathematical Methods in the Physical Sciences”, Boas.
- “Mathematical Methods for Physicists”, Arfken, Weber, Harris.
- “Physical Mathematics”, Cahill.

6.3 Software

- We will have a short introduction to Python as a tool for plotting. The easiest way to get started with Python is via [Google Colab](#). Google Colab is a cloud-based Jupyter notebook environment that allows you to write and execute Python code directly in your browser without needing any local setup. It also provides free access to computing resources including GPUs. You will need a Google account in order to use Colab.
- We will also sometimes use Mathematica or Wolfram Alpha when useful. You can find instructions for installing this for free via Skidmore’s institutional license here: <https://flipphillips.com/mathematica/>.
- At times, we may use LLM-based AI tools. You do not need to purchase a subscription for these – you can likely get by with the free versions. I’d encourage you to register for free accounts with both [ChatGPT](#) and [Claude](#), this way, if you hit the usage limits of your free account with one of them, you can switch to the other.

7 Class expectations

Estimated workload This class is a **three-credit** course. Each hour of class time should be accompanied by two hours of work outside of class. You should expect to spend roughly **six hours** each week reviewing the course notes and completing the weekly problem set. There will be two in-class evaluations – problem sets set the week before an evaluation will often include review questions to prepare for the evaluation.

Collaborative work I encourage students to work together on course material and problem sets, and to attend Peer Academic Coaching sessions and talk to me as often as possible. At the same time, it is crucial that all work you hand in is your own. For example, you should feel free to discuss

ideas, methods and approaches for solving a problem with classmates (or me), but you should then solve the problem yourself.

General advice This course will equip you with the mathematical tools needed to understand and predict the behaviour of physical systems. There is often no rigid procedure which will tell you exactly how to solve a problem. Instead, it will need some amount of understanding, insight and even creativity – all of these will grow with experience and practice.

This is very similar to learning a new language or to play a musical instrument. You start with the building blocks and internalise the basics. More complicated things – like constructing sentences or writing new music – come from combining the building blocks in ways that will become automatic with time and practice. Physics is a game whose rules you can learn; the more time you spend practising and thinking about this game, the better you will become at it. Practice will ensure that the basics of problem solving become automatic, leaving you to focus on the concepts instead. **Do as many problems as you have time to do.** There are plenty of extra example problems in the course notes and in the recommended textbooks.

Some suggestions for success:

- Physics cannot be learned solely by reading notes or memorising formulas. Instead, it is best learned via [deliberate practice](#), that is, by solving many problems, receiving feedback and then thinking about why your approach was correct or incorrect. In addition to the weekly problem sets and in-class exercises, you should also be solving end-of-chapter exercises from the course text.
- Ask questions freely and often. You should be actively trying to probe the limits of your understanding.
- Accept mistakes as part of the process. Learning physics is an iterative process. Mistakes are an inevitable and essential part of this, and serve to highlight gaps in our understanding.
- Discuss with others and listen to their perspectives. Physics is a collaborative science that has emerged from thousands of years of debate and experiment. You should expect to describe and explain concepts to peers in your own words, and to back this up with the relevant physics or mathematics.

8 Community norms

In this course we are learning together, and the way we interact matters. Physics can be challenging, and part of the goal is to build an environment where everyone feels comfortable contributing, asking questions and learning from mistakes. To that end, I ask that we all keep the following in mind:¹

¹Adapted from Prof. Evan Halstead.

- **Ask questions freely.** If something is unclear to you, it is very likely unclear to someone else too. Questions are how we learn.
- **Expect and value mistakes.** Nobody gets everything right on the first try. Errors are part of the learning process, and they often point the way to deeper understanding.
- **Listen respectfully.** Pay attention to what others are saying, and treat different perspectives as opportunities to learn.
- **Share the floor.** Be mindful of how much you are speaking relative to others, and make space so that everyone can participate.
- **Take responsibility for your words.** Good intentions matter, but so does impact. If you say something that causes harm or offence, a simple acknowledgement and apology can go a long way.
- **Speak from your own perspective.** Avoid assuming that others have had the same experiences as you.
- **Correct without blame.** If you or others are misinformed, treat it as an opportunity to set the record straight rather than to assign fault.

Our collective goal is to create a class environment that is open, respectful, and focused on helping each other succeed in learning physics.

9 Grading scheme

Your final grade will be determined by combining your scores on regular problem sets, in-class evaluations and a final exam. The proportion ascribed to each is as follows:

Assessment	Grade fraction
Homework	60%
In-class evaluations	20%
Final Exam	20%

9.1 Problem sets

Problem sets will be posted on [theSpring](#). There will be one problem set per week of the course. They will have a mix of straightforward applications of class material together with a few problems designed to stimulate discussion and test your understanding. You can submit your answers by uploading them to theSpring.

I encourage you to attend the [Peer Academic Coaching](#) sessions for Physics. These will be in CIS 382 from 7-9 PM on Sundays to Thursdays.

Late work If you know your work will be late due to an excused reason, let me know as soon as possible. If work is late without notifying me in advance or a documented excuse, your score will be reduced by 10% for that problem set. If your work is submitted after the solutions have been released, your score will be capped at 60/100.

Corrections policy You can get back 1/3 of the points you missed if you turn in corrections. To qualify for these points, for each question: you need to explain why your answer was incorrect; you need to provide the correct solution; you need to provide a similar question and solve it. Corrections will be accepted for two weeks from the day you received your graded solutions.

AI use and acknowledgement AI tools may be used when solving problem sets within the guidelines set out by the AI policy below. However, if you use an AI tool while preparing your answers, you must acknowledge its use. An acceptable form of citation is to include a brief statement at the bottom of your work indicating which tool was used and how it contributed to your process (e.g., “I used ChatGPT to check my algebra” or “I asked Claude to explain why there is an i in the Fourier transform”). When possible, please also include a link to your AI conversation when submitting your work on theSpring.² Failure to cite AI use will be treated in the same way as submitting work copied from a fellow student. See the academic integrity and AI policies below for further details.

9.2 Evaluations

There will be two in-class evaluations which will examine the topics covered to date. Evaluations will include both conceptual questions and problem solving. You are allowed a calculator for evaluations.

Missed evaluations If you need to miss an evaluation for a verified, excused reason, please notify me at least one week ahead of time so that we can arrange an alternative time for you to take the evaluation. If you miss an evaluation for a verifiable emergency, please notify me as soon as possible and we will arrange an alternative time for you to take the evaluation. Failure to take an evaluation without notifying me in advance or a verifiable emergency will result in a score of zero for that evaluation.

Corrections policy You can get back 1/3 of the points you missed if you turn in corrections. To qualify for these points, for each question: you need to explain why your answer was incorrect; you need to provide the correct solution; you need to provide a similar question and solve it. Corrections will be accepted for two weeks from the day you received your graded solutions.

Conflicts Finals must be taken during the scheduled time slot unless you have a valid conflict. A student is deemed to have a conflict when they have two exams scheduled for the *same time period*

²Please ask me how to do this if you are not sure.

or when they have three finals scheduled for the *same day*. If you have a conflict and you want to request rescheduling of the final, you must contact me at least three weeks before the date of the final.

10 Attendance

Participating in discussions and collaborative problem solving is crucial for learning and understanding physics. It is expected that students will attend all class sessions.

Wellness policy Attendance must be balanced with the health and well-being of all Skidmore students. As such, I ask that you miss class only when necessary, and that you let me know ahead of time. If you miss a class, it is your responsibility to catch up with the material covered and any assignments. If you are unwell and would like to attend class remotely, please let me know so that I can set up a Zoom session. The Zoom link will be on the course website on theSpring.

Missed classes Students who miss more than a third of the class sessions without documented excuses may expect to be barred from final examination. In such cases, the course grade will be recorded as F.

Incompletes If you find yourself falling behind, please come and talk to me as soon as possible. Under some circumstances, I will be willing to grant a grade of **Incomplete** if you believe that you will be able to finish the work eventually.

11 Academic integrity policy

Students are expected to follow the [Skidmore Honor Code](#) to its full extent,

“I hereby accept membership in the Skidmore College community and, with full realization of the responsibilities inherent in membership, do agree to adhere to honesty and integrity in all relationships, to be considerate of the rights of others, and to abide by the College regulations.”

and to make the following attestation on examinations,

“I have not witnessed any wrongdoing, nor have I personally violated any conditions of the Skidmore College Honor Code, while taking this examination.”

Any and all violations of the Academic Honor Code will be reported, with an appropriate penalty recommended following the [Definitions and Guidelines for Penalties](#) and [Sanctions and Further Impact](#) guidelines.

12 AI policy

AI and LLM tools, such as ChatGPT, Claude AI or Gemini, may be used when completing assignments and studying for this course. The course policy below has been adapted from David Joyner’s at Georgia Tech³. It aims to balance the educational benefits of AI tools with the importance of academic integrity and individual learning.

We treat AI tools in the same way we treat collaboration with peers: just as you are encouraged to talk about your ideas and work with other people, both inside and outside the class, you are also free to do so with AI assistants. However, as stated in the Academic Integrity Handbook, “if your work has benefited from the ideas, information, or words of other people and sources, it is your most serious responsibility as a student, colleague, and friend to acknowledge all partnerships in the learning process”. Just as you should not copy work from another person, you should not copy directly from an AI assistant. All work that you submit must be your own. You should never include in your assignment anything that was not written directly by you without proper citation, making sure to “distinguish carefully between our own information and perspectives and the help we have received from other sources”. Including anything you did not write in your assignment without proper citation will be treated as an academic misconduct case.

If you cannot explain or reproduce a calculation, argument, or solution that resulted from a conversation with an AI assistant, it is likely you are copying rather than collaborating. One of the central goals of this course is for you to build your own understanding of physics concepts and problem-solving methods. If you rely on AI to generate work that you cannot independently reconstruct or justify – whether that means carrying out the algebra again, re-deriving a result from first principles, or articulating why a particular approach is valid – you have not actually learned the material. In practice, this means that you should be able to explain any step that appears in your submitted work. If you cannot do so without returning to the AI output, then you have crossed the line from acceptable collaboration into academic misconduct. In such cases, **I reserve the right to amend scores on problem sets or other submitted work, including lowering or assigning a score of zero, if it becomes clear that the work submitted was not your own.**

If you are unsure where the line is between *collaborating* with AI and *copying* from AI, we recommend the following heuristics:

- Never copy from your conversation with an AI assistant. You can copy your own work into your conversation, but do not copy anything from the conversation back into your assignment. Instead, use your interaction with the AI assistant as a learning experience, then let your work reflect your improved understanding.
- Use AI for brainstorming, clarification or to get unstuck, not for producing final work. It should be used to enhance your understanding, not to bypass the learning process.

³Available here: <https://bit.ly/3AQAMPC>.

- Avoid writing down solutions or completing assignments with the AI tool open on your device at the same time. Instead, use your conversation with the AI as a learning experience, then close the interaction down, complete your assignment, and let your assignment reflect your revised knowledge.

Deviating from these “rules of thumb” does not automatically qualify as academic misconduct; however, following these heuristics essentially guarantees your collaboration will not cross the line into misconduct. If you are unsure about appropriate AI use for a specific task, consult with the instructor.

13 Accommodations for students with disabilities

Skidmore College is committed to supporting the learning needs of all students in our diverse community. If you have a documented barrier to learning or think you may have a disability, please consult with Meg Hegener, Director of Accessibility Services (mhegener@skidmore.edu). Accommodations are approved by the coordinator following a review of students’ documentation. If you are approved for academic accommodations, please provide your letter of accommodations to me early in the semester or as soon as you are approved so that we can proactively coordinate implementation. Academic accommodations based on disability cannot be granted by individual faculty. For further information, please call (518) 580-8150 to contact The Learning Commons in Starbuck Center.

14 Conscientious religious observance policy

Skidmore College acknowledges that our community is one of many faiths with a diverse range of practices and observances important to each tradition. In order to fulfil our mission to educate a diverse population of talented students and our commitment to inclusion regardless of religious and spiritual tradition, we seek to practice an equitable and consistent approach in providing religious accommodations. If religious observance requires absence from class or you anticipate a conflict with assignments or due dates, please notify your instructor **prior** to the absence or conflict so that accommodations can be arranged. Although not required, please provide notification about a pending religious holiday at the start of the semester or at least one week before the holiday. As an option, you may use the form available at skidmore.edu/religious-life/calendar.php (or [here](#)).

Accommodations for your absence should not reduce the overall expectations of a course nor unduly burden you for requesting accommodation. Students shall not suffer academic, athletic, or employment penalties because of the conscientious observance of any religious day or days. Faculty must permit students to take a make-up examination without any penalty if they have to miss an examination due to religious observances. Similarly, faculty must permit students to submit missed assignments by an agreed upon due date, without penalty.

If a student, supervisor, coach, or faculty member feels the policy is being violated, they should contact the Dean of Faculty Office at 518-580-5705 (Palamountain 416), the Dean of Students Office at 518-580-5760 (Case Center 313), or Human Resources at 518-580-5800 (Barrett Center first floor). The full policy can be found at skidmore.edu/religious-life/calendar.php.

15 Diversity and inclusion

Skidmore College is committed to fostering a diverse and inclusive community in which members develop their abilities to live in a complex and interconnected world. Consistent with our educational mission, we recognize ourselves as a community that respects individual identities based on varying sociocultural characteristics such as race, ethnicity, gender identity and expression, sexual orientation, national origin, first language, religious and spiritual tradition, age, ability, socio-economic status and learning style. We strive to create a socially just world that honours the dignity and worth of each individual, and we seek to build a community centred on mutual respect and openness to ideas – one in which individuals value cultural and intellectual diversity and share the responsibility for creating a welcoming, safe and inclusive environment. We recognize that our community is most inclusive when all members participate to their full capacity in the spirited and sometimes challenging conversations that are at the centre of the college’s educational mission.

16 Recording of class sessions

To ensure the free and open discussion of ideas, students may *not* record or stream classroom lectures, discussions, or activities unless explicit permission is granted by the instructor or, with the instructor’s involvement, through the academic accommodation process. This recording policy extends to audio and video recording and streaming, photography, and transcription of audio through generative AI or other tools.

Students with approved accommodations that permit the recording of class meetings should submit an accommodation letter from Accessibility Services before recording commences. For all students, permission to record is conditioned on the requirement that recordings will be used exclusively for educational purposes, such as for assistance with notetaking. Consistent with Skidmore’s commitment to academic freedom, freedom of speech, and respectful dialogue, recordings may not be used in any way that denigrates and/or decontextualizes the instructor or any student whose remarks are recorded. Any information contained in the recording may not be posted, published, or quoted, and all recordings must be erased at the end of the semester. Violation of these expectations will be reported to Student Conduct and may result in a grade penalty at the instructor’s discretion.

17 Sexual and gender-based misconduct: Title IX statement

Skidmore College considers sexual and gender-based misconduct to be one of the most serious violations of the values and standards of the College. Unwelcome sexual contact of any form is a violation of students' personal integrity and their right to a safe environment and therefore violates Skidmore's values. Sexual and gender-based misconduct is also prohibited by federal and state regulations. Skidmore College faculty are committed to supporting our students and upholding gender equity laws as outlined by Title IX. If a student chooses to confide in a member of Skidmore's faculty or staff regarding an issue of sexual or gender-based misconduct, that faculty or staff member is obligated to tell Skidmore's Title IX Coordinator or Title IX Deputy Coordinator. The Title IX Coordinator or Deputy Coordinator will assist the student in connecting with all possible resources for support and options for reporting both on and off campus. Identities and details will be shared only with those who need to know to support the student and to address the situation through the college's processes. If the student wishes to confide in a confidential resource, the Counseling Center Staff, Health Services, and Victim Advocates (anonymous) are all options available.

More information can be found at the Sexual and Gender-Based Misconduct [website](#) or by contacting the Title IX Coordinator, Joel Aure (jaure@skidmore.edu), 518-580-5708.