

MATH 121A: MATHEMATICAL TOOLS FOR THE PHYSICAL SCIENCES

Fall 2025

Instructor:	Michael Ragone (<i>he/him</i>)	Time:	MWF 2:00-2:59 PM
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Course Pages: All course information will be accessible on our bCourses (Canvas) website. If you have not been added, please let me know!

Office Hours: Mondays 3:15-4:15 and Tuesdays 12-1, Evans 1071 (*or by email appointment*).

References: We have one main reference for this course:

- Boas, *Mathematical Methods in the Physical Sciences*, Third Edition.

Any edition of this text is acceptable. While not required, I will provide some suggested alternative texts, especially for topics which are not thoroughly discussed in Boas. All have freely available digital copies:

- Margalit and Rabinoff, [This wonderful linear algebra online text](#).
- Axler, *Linear Algebra Done Right*
- [This online digital signal processing book](#).
- Dyke, *An Introduction to Laplace Transforms and Fourier Series*.
- Romik, *Topics in Complex Analysis*. PDF is freely available through the [publisher's website](#).
- Hunter and Nachtergaele, *Applied Analysis*. PDF is available online [here](#). This is a much more mathematically advanced book, but its treatment of Hilbert spaces is excellent.

If you have any issues obtaining access to these texts, please send me an email. I will also mention that many of our topics are covered in the wonderful videos of Youtuber 3Blue1Brown.

Prerequisites: Math 53, 54.

Tentative Course Outline:

- Series and Linear Algebra
- Complex Variables and Analytic Functions
- Hilbert spaces
- Integral Transforms
- Calculus of Variations

Grading Policy: Midterm 1 (20%), Midterm 2 (20%), Midterm 3 (20%), Final (25%), Homework (15%).

The lowest midterm score may be replaced by your final score, if it helps. There will be no make-up exams. For each midterm, you will be allowed 1 standard (8.5×11 inch) two-sided cheat sheet, and for the final, you will be allowed 3 standard two-sided cheat sheets.

- Midterm 1 (Friday, 09/26). Series and linear algebra (Lectures 1-10)
- Midterm 2 (Monday, 10/27). Complex analysis and a little bit of optimization (Lectures 11-24)

- Midterm 3 (Wednesday, 12/03). Hilbert spaces, integral transforms, and calculus of variations (Lectures 25-37).
- **Final** (Thursday, Dec 18, 3:00PM - 6:00PM). Cumulative final, meaning all content is fair game.

Homework:

- Homework is to be submitted through gradescope by 11:59 PM on the due date on the attached schedule. Extensions will *not* be accepted unless you have my written prior approval. Please email or talk to me before at least 5:00 PM on the due date if you have unusual circumstances.
- The bottom two homeworks will be dropped.
- Homeworks must be written up and submitted individually.
- Collaboration is a central part of science and is encouraged. But you must appropriately acknowledge your collaborators: for each problem, you must list any coauthors (including GenAI, see Statement below).
- Be careful that you *try* on the homeworks. The only true way to learn mathematics is by practice—do not rob yourself of that practice!

Academic Honesty: Lack of knowledge of the academic honesty policy is not a reasonable explanation for a violation.

Generative Artificial Intelligence (GenAI) Statement: Generative Artificial Intelligence systems, like ChatGPT and Gemini, can be useful (albeit [ethically murky](#)) tools when used thoughtfully. I like to think of them as very talented parrots, trained by piles upon piles of human conversation: they are masters of jumbled regurgitation. Here are some examples of good use cases for GenAI:

- GenAI can be a very powerful search engine, helping you find real resources for niche material.
 - “Can you give me some resources to learn more about Fourier series in an intuitive way?”
- GenAI can help you find closely related concepts to supplement your ongoing learning.
 - “What do contour integrals have to do with electrical engineering?”

At its current state, GenAI seems to lack higher level cognition. Moreover a regurgitator is only as good as its training, which inevitably contains variable amounts of garbage (c'mon, you've been on the internet).

- GenAI is highly prone to hallucinating facts and presenting “strings of text” as logic.
- Using it as a tutor, a fact checker, or your primary source of ideas is unwise (and unfair to yourself).
- *Remember:* you are here to invest in your own minds. You will not learn without practice!

Accommodations: UC Berkeley is committed to creating a learning environment that meets the needs of its diverse student body including students with disabilities. If you anticipate or experience any barriers to learning in this course, please feel welcome to discuss your concerns with me.

If you have a disability, or think you may have a disability, you can work with the Disabled Students' Program (DSP) to request an official accommodation. The Disabled Students' Program (DSP) is the campus office responsible for authorizing disability-related academic accommodations, in cooperation with the students themselves and their instructors. You can find more information about DSP, including contact information and the application process on [this website](#). If you have already been approved for accommodations through DSP, please meet with me so we can develop an implementation plan together.

Schedule: Below is our *tentative* class schedule. I strongly encourage you to do the readings before class so you may get more out of the lecture. The lecture content may vary. Here's the system:

- (no letters) = Boas
- MR = Margalit and Rabinoff (with link)
- R = Romik
- HN = Hunter Nachtergaele

Don't expect to fully cover each section—we will only be taking the highlights.

Note also that there are several Review/Problem session days. Depending on our pace, these may serve as “buffer” days for overflowing content, or as proper review and problem session days.

#	Date	Topic	Homework	Readings
1	W 08/27	Series and convergence I		1.1
2	F 08/29	Series and convergence II		1.5-1.9
	M 09/01	Labor day, no class		
3	W 09/03	Power series, Taylor series I	HW 1 due	1.10-1.14
4	F 09/05	Power series, Taylor series II		1.10-1.14
5	M 09/08	Systems of linear equations		MR, Ch. 1
6	W 09/10	Vector spaces and bases	HW 2 due	MR, Ch. 2
7	F 09/12	Linear maps and matrices		MR, Ch. 3
8	M 09/15	Diagonalization and Eigenstuff		MR, Ch. 5
9	W 09/17	Hilbert spaces and the spectral theorem I	HW 3 due	MR, Ch. 5
10	F 09/19	Hilbert spaces and the spectral theorem II		MR, Ch. 5
11	M 09/22	Partial differentiation, gradients and optimization		4.1-4.9
12	W 09/24	Optimization, Lagrange multipliers	HW 4 due	4.9-4.10
	F 09/26	Midterm 1		
13	M 09/29	Complex Numbers		2.1-2.5
14	W 10/01	Geometric and Exponential series	HW 5 due	2.6-2.11
15	F 10/03	Powers, roots, logarithm, trig		2.11-2.15
16	M 10/06	Complex differentiation, Cauchy-Riemann equations		14.1-14.2
17	W 10/08	Contour integration	HW 6 due	14.3
18	F 10/10	Cauchy's integral formula and consequences		14.3, R 1.9
19	M 10/13	Theorems galore		R 1.9
20	W 10/15	Zeros, poles, and the residue theorem	HW 7 due	14.5-14.6, R 1.10
21	F 10/17	Laurent series		14.4

#	Date	Topic	Homework	Readings
22	M 10/20	Applications of residue calculus I		14.7
23	W 10/22	Applications of residue calculus II	HW 8 due	14.7
24	F 10/24	Review/Problem session		
	M 10/27	Midterm 2	HW 9 due	
25	W 10/29	Intro to Fourier series, heat equation		HN 7
26	F 10/31	Hilbert spaces return I		HN 6
27	M 11/03	Hilbert spaces return II		HN 6
28	W 11/05	Fourier series	HW 10 due	7.2, HN 7
29	F 11/07	Fourier series and spectral theory		7.11, 7.12, HN 7
30	M 11/10	Fourier transform on $\mathbb{R}$		7.11, 7.12
31	W 11/12	Convolution	HW 11 due	8.10, 8.11
32	F 11/14	Convolution and the Dirac Delta		8.11
32	M 11/17	Green's functions		8.12
33	W 11/19	Laplace transform	HW 12 due	8.8
34	F 11/21	Calculus of Variations		9.1-9.2
35	M 11/24	Euler-Lagrange		9.2-9.5
	W 11/26	Thanksgiving, no class		
	F 11/28	Thanksgiving, no class		
36	M 12/01	Review/Problem session		
	W 12/03	Midterm 3	HW 13 due	
37	F 12/05	Review/Problem session		