PHYS 611 -- Mathematical Physics I -- Fall 2025

Instructor:	Chung-Sang Ng
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E-mail:	cng2@alaska.edu
Class meets:	MWF 9:15AM - 10:20AM, Reichardt 203
Office hours:	MW 10:30AM - 12:30PM, F 10:30AM - 11:30AM Reichardt 108 H 11:30AM - 12:30PM, F 2:00PM - 3:00PM Elvey 706E; or by appointment
Credits:	3 credits: 3 hours/week of lecture.
Textbook:	"Mathematical Methods for Physicists", 7th ed., by Arfken, Weber, and Harris
Prerequisites:	Graduate standing
Course Home Page:	Canvas
Zoom link	Posted on Canvas
Some videos for past classes	https://www.youtube.com/@chung-sang-ng

I. Course Description

The UAF Catalog listing for PHYS 611: "Mathematical tools and theory for classical and modern physics. Core topics: linear algebra including eigenvalues, eigenvectors and inner products in finite dimensional spaces. Infinite series. Hilbert spaces and generalized functions. Complex analysis, including Laurent series and contour methods. Applications to problems arising in physics. Selected additional topics, which may include operator and spectral theory, groups, tensor fields and hypercomplex numbers."

In terms of the content of the textbook (which you must have and bring to classes), we will try to cover most topics from Chapter 4 to 11, and 19, 20 during the fall semester, with Chapter 1 to 3 treated as background that students should review themselves. We will not cover everything in these chapters, due to the fact that we only have limited amount of time, not because other topics are not important. At the end of this syllabus is a tentative schedule which lists topics we plan to cover in more details. This is subject to change. So you should check frequently the online version of this page on Canvas.

II. Course Goals

The main goal of this course is to introduce you to some fundamental advanced mathematical methods for physics at the beginning graduate level to help students learning better in other graduate physics courses and doing research in their graduate studies. Emphasis will be on application aspects of the subject rather than proofs of theorems.

III. Student Learning Outcomes

- Know how to apply some advanced mathematical methods to solve physics problems.
- Be able to solve most PhD Mathematical Physics comprehensive exam questions in recent years.
- Can apply rigorous mathematical and logical manipulations in the study and research of physics.

IV. Textbook

You must have a copy of the textbook: "Mathematical Methods for Physicists", 7th ed., by Arfken, Weber, and Harris. It is very important that you read the Section(s) covered within each lecture and try to follow derivations before you come to that lecture. Please refer to the schedule below (subject to change) for such reading assignments. You should bring your textbook to the lectures.

You will find it extremely useful to have some mathematical references, handbooks, or tables, e.g., table of integrals. There are many options available from the Internet, but you should be cautious about the accuracy of information obtained there. One recommendation is Abramowitz and Stegun: Handbook of Mathematical Functions, which can be downloaded freely. Another one is Gradshteyn and Rhyzik. A handy collection of useful formula is the *NRL Plasma Formulary*, which you can order a free copy or download it online.

V. Instructional method and reading assignments

The course is for 3 credits, and so 3 hours per week are devoted to "lectures" in the classroom. However, since this is a graduate level course and that the topics and mathematics are quite advanced, there is not enough time to explains everything in details by lecturing. Students must help themselves by reading and studying before each class. You are expected to ask questions and contribute to discussion in class. I will not have time to go through all the text and derivations, but will try to answer questions that you found difficult. Any materials that we don't have time to go through in that class have to be left for self-study by students themselves. If you still have difficulties, you need to come to my office hours (or set up another time) and ask for additional help.

VI. Participation grade

To encourage you to finish reading assignments before classes and to practice what we are learning, 10% of the final grade is for participation. During some lectures, we will do some practice questions. You can write down your answers and derivation on pieces of paper and hand in at the end of the lecture. It is graded heavily on effort and participation instead of correctness of your answers. An absence will result in no participation grade unless it is excused based on documented reasons (e.g. research trip, sickness, or emergency). However, since I will not count the five lowest grades, those can be used for unexcused absences. If you cannot attend a class in person but can attend online, please inform me in advance so that I can turn on the Zoom room. The Zoom link for it is posted on Canvas.

VII. Homework

Doing homework is the most important factor in doing well in this class. There will be approximately one homework set assigned per week, usually on Fridays, and is usually due in the following Friday before class. However, you should work on your homework as early as possible before a deadline so that you can have time to ask for help during classes or in my office hours if you encounter difficulties in solving these problems. Late homework will not be accepted.

To emphasize the importance of doing homework, homework grade will count towards 30% of the total grade of the course, excluding the assignment with the lowest grade. I will grade the homework based on your effort, the method used, as well as the correctness of answers. Therefore, you should submit your partially finished work. This will help you getting partial credit, and let me identify your difficulties. Also, your work should be clean and clear enough for me to understand.

While it is good for you to have discussion with classmates or search the Internet for additional information, your submitted homework should be of your own, but not a direct copy from another source. If you finish a question with the help of another person, a solution book, or a solution you found in the Internet or passed on to you from another student, you need to cite that at the end of your answer for that question. There is no deduction of points for using help that you cited if it is not a direct copy. However there can be deduction up to the maximum points of that homework set if you used help but failed to cite. Also, you should use help only to enable you to do a problem yourselves. Keep in mind that you will be required to do similar questions on your own during exams (closed books in the exams, and also in the PhD comprehensive exam). In addition, it is

against the UAF Honor Code to misrepresent work which is not your own. Plagiarism on homework or on an exam will result in a failing grade.

Solutions to the homework problems will be available to you after the due date. Therefore, late homework will not be accepted. The homework assignments will be posted on Canvas.

VIII. Examinations

There will be an one-hour in-class midterm exam on Friday, October 17, and a two-hour final exam on Thursday December 11 from 8:00 AM to 10:00 PM. They are closed book exams with questions at a level similar to those in past PhD comprehensive exams. Calculators, computers, and communication devices are also not allowed. However, special or unusual formula or integrals essential to a particular question will be written down for that question. Midterm exam counts towards 20% of the total grade. The final exam counts towards 40% of the total grade. ***You must not miss the midterm exam and the Final Exam* (*except for documented illness or family emergency*).**

Tips for getting more points in an exam: Exam questions will be graded based on the method used, as well as the answer. Therefore, you should write down explicitly and clearly step by step how you come up with your answers. Even if you don't know how to answer a question (or parts of a question), write down everything you can think of that might help formulate an approach to answer it. If you don't know how to answer the first part of a question, you should move on to answer other parts by assuming an answer to the first part. This will help you getting partial credit.

IX. Grading

The final grade will be composed of:

Participation	10 %	Lowest grades of 5 days are dropped
Midterm exam	20 %	Mandatory
Final exam:	40 %	Mandatory
Homework	30 %	Homework set with lowest grade is dropped
Total:	100 %	

Midterm and Final exams are mandatory. The course will be graded approximately according to the following scale:

> 90 %	A
83 % -- 90 %	A-
76 % -- 83 %	B+
70 % -- 76 %	B
63 % -- 70 %	B-
56 % -- 63 %	C+
50 % -- 56 %	C
43 % -- 50 %	C-
36 % -- 43 %	D+
30 % -- 36 %	D
23 % -- 30 %	D-

< 23 %	F

Note that the passing grade for graduate students is B. Therefore, in order to pass this course, you should get most of the points in homework/participation, and to get enough points in exams.

X. Getting Help

My office hours are 10:30 AM - 11:30 AM on Mondays, Wednesdays, and Fridays. I will be at Reichardt 108 during these office hours. Canceled office hours will be announced in class or by email. If you need to see me beside these office hours, please set up a time by appointment to come to my office at Elvey 706E. These are hours set aside especially to help you - do not feel like you are imposing or cheating by coming in. If you have problems that need immediate attention, please send me an e-mail or give me a call at my office phone number.

I have set up a home page for the course on Canvas. I may put additional materials that may be helpful to you later. So, please come back often, especially to check any changes in the schedule. The UAF Canvas site for this course will be made available to students, but will not be used to provide communication about this course. I might post grades there but those might not be updated very frequently.

XI. Disabilities Services

The Physics Department will work with the Office of Disabilities Services (http://www.uaf.edu/disability/) to provide reasonable accommodation to students with disabilities.

XII. Tentative Schedule

Below is a tentative schedule (subject to change):

Date	Day	Text (Reading Assignment)	Main Topics	Homework due
8/25	M	Ch1-3	Review of Mathematical Preliminaries	
8/27	W	11.1-2	Complex Variables and Functions/Cauchy-Riemann Conditions	
8/29	F	11.3	Cauchy's Integral Theorem	
9/3	W	11.4	Cauchy's Integral Formula	
9/5	F	11.5	Laurent Expansion	HW #1
9/8	M	11.6	Singularities	
9/10	W	11.7	Calculus of Residues	
9/12	F	11.8	Evaluation of Definite Integrals	HW #2
9/15	M	11.9-10	Evaluation of Sums/Conformal Mapping	
9/17	W	19.1	Fourier Series/General Properties	
9/19	F	19.2-19.3	Applications of Fourier Series/Gibbs Phenomenon	HW #3
9/22	M	20.1-20.2	Integral Transforms/Fourier Transform	
9/24	W	20.3-20.4	Properties of Fourier Transforms/Fourier Convolution Theorem	

9/26	F	20.5-20.6	Signal-Processing Applications/Discrete Fourier Transform	HW #4
9/29	M	20.7-20.8	Laplace Transforms/Properties of Laplace Transforms	
10/1	W	20.9-20.10	Laplace Convolution Theorem/Inverse Laplace Transform	
10/3	F	4.1-2	Tensor Analysis/Pseudotensors, Dual Tensors	HW #5
10/6	M	4.3	Tensors in General Coordinates	
10/8	W	4.4	Jacobians	
10/10	F	5.1	Vectors in Function Spaces	HW #6
10/13	M	5.2	Gram-Schmidt Orthogonalization	
10/15	W	5.3	Operators	
10/17	F		Mid-term exam	HW #7
10/20	M	5.4-5	Self-Adjoint Operators/Unitary Operators	
10/22	W	5.6-8	Transformations of Operators/Invariants	
10/24	F	6.1-2	Eigenvalue Equations/Matrix Eigenvalue Problems	HW #8
10/27	M	6.3-4	Hermitian Eigenvalue Problems/Hermitian Matrix Diagonalization	
10/29	W	6.5	Normal Matrices	
10/31	F	7.1-2	Ordinary Differential Equations/First-Order Equations	HW #9
11/3	M	7.3-4	ODEs with Constant Coefficients/Second-Order Linear ODEs	
11/5	W	7.5	Series Solutions - Frobenius' Method	
11/7	F	7.6	Other Solutions	HW #10
11/10	M	7.7-8	Inhomogeneous Linear ODEs/Nonlinear Differential Equations	
11/12	W	8.1-2	Sturm-Liouville Theory/Hermitian Operators	
11/14	F	8.3-5	ODE Eigenvalue Problems/Variation Method	HW #11
11/17	M	9.1-2	Partial Differential Equations/First-Order Equations	
11/19	W	9.3	Second-Order Equations	
11/21	F	9.4	Separation of Variables	
11/24	M	9.5-6	Laplace and Poisson Equations/Wave Equation	HW #12
12/1	M	9.7-8	Heat-Flow, or Diffusion PDE	
12/3	W	10.1	Green's Functions/One-Dimensional Problems	
12/5	F	10.2	Problems in Two and Three Dimensions	
12/11	R		Final (8:00 AM to 10:00 AM)	
12/15	M		This is absolutely the last day for submitting your work to me, as well as discussing with me about your grades.	
12/17	W		Final grades will be submitted by noon.	

STUDENT PROTECTIONS AND SERVICES STATEMENT:

Every qualified student is welcome in my classroom. As needed, I am happy to work with you, disability services, veterans' services, rural student services, etc. to find reasonable accommodations. Students at this university are protected against sexual harassment and discrimination (Title IX), and minors have additional protections. For more information on your rights as a student and the resources available to you to resolve problems, please go the following site: www.uaf.edu/handbook/.

UA is an AA/EO employer and educational institution and prohibits illegal discrimination against any individual: https://alaska.edu/nondiscrimination/.

Your instructor follows the University of Alaska Fairbanks Incomplete Grade Policy: "The letter "I" (Incomplete) is a temporary grade used to indicate that the student has satisfactorily completed (C or better) the majority of work in a course but for personal reasons beyond the student's control, such as sickness, has not been able to complete the course during the regular semester. Negligence or indifference are not acceptable reasons for an "I" grade."

Effective communication: Students who have difficulties with oral presentations and/or writing are strongly encouraged to get help from the UAF Department of Communication's Speaking Center (907-474-5470, speak@uaf.edu) and the UAF English's Department's Writing Center (907-474-5314, Gruening 8th floor), and/or CTC's Learning Center (604 Barnette Street, 907-455- 2860).

Syllabus Addendum (Revised 8/22/2022)

COVID-19 statement: Students should keep up-to-date on the university's policies, practices, and mandates related to COVID-19 by regularly checking this website: https://sites.google.com/alaska.edu/coronavirus/uaf?authuser=0
Further, students are expected to adhere to the university's policies, practices, and mandates and are subject to disciplinary actions if they do not comply.

Student protections statement: UAF embraces and grows a culture of respect, diversity, inclusion, and caring. Students at this university are protected against sexual harassment and discrimination (Title IX). Faculty members are designated as responsible employees which means they are required to report sexual misconduct. Graduate teaching assistants do not share the same reporting obligations. For more information on your rights as a student and the resources available to you to resolve problems, please go to the following site: https://catalog.uaf.edu/academics-regulations/students-rights-responsibilities/.

Disability services statement: I will work with the Office of Disability Services to provide reasonable accommodation to students with disabilities.

ASUAF advocacy statement: The Associated Students of the University of Alaska Fairbanks, the student government of UAF, offers advocacy services to students who feel they are facing issues with staff, faculty, and/or other students specifically if these issues are hindering the ability of the student to succeed in their academics or go about their lives at the university. Students who wish to utilize these services can contact the Student Advocacy Director by visiting the ASUAF office or emailing asuaf.office@alaska.edu.

Student Academic Support:

- Speaking Center (907-474-5470, uaf-speakingcenter@alaska.edu, Gruening 507)
- Writing Center (907-474-5314, uaf-writing-center@alaska.edu, Gruening 8th floor)
- UAF Math Services, uaf-traccloud@alaska.edu, Chapman Building (for math fee paying students only)
- Developmental Math Lab, Gruening 406
- The Debbie Moses Learning Center at CTC (907-455-2860, 604 Barnette St, Room 120, https://www.ctc.uaf.edu/student-services/student-success-center/)
- For more information and resources, please see the Academic Advising Resource List (https://www.uaf.edu/advising/lr/SKM_364e19011717281.pdf)

Student Resources:

- Disability Services (907-474-5655, uaf-disability-services@alaska.edu, Whitaker 208)
- Student Health & Counseling **[6 free counseling sessions]** (907-474-7043, https://www.uaf.edu/chc/appointments.php, Gruening 215)
- Center for Student Rights and Responsibilities (907-474-7317, uaf-studentrights@alaska.edu, Eielson 110)
- Associated Students of the University of Alaska Fairbanks (ASUAF) or ASUAF Student Government (907-474-7355, asuaf.office@alaska.edu, Wood Center 119)