PHYS/MATH 612 -- Mathematical Physics II -- Spring 2018

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Class meets:	MWF 10:30 AM - 11:30 AM, Reichardt 207
Office hours:	MWF 9:25 AM - 10:25 AM 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, Phys/Math 611
Course Home Page:	http://www.gi.alaska.edu/~chungsangng/phys612/phys612.html

I. Course Description

The UAF Catalog listing for PHYS 612: "Continuation of Mathematical Physics I; mathematical tools and theory for classical and modern physics. Core topics: classical solutions to the principal linear partial differential equations of electromagnetism, classical and quantum mechanics. Boundary value problems and Sturm-Liouville theory. Green's functions and eigenfunction expansions. Integral transforms. Orthogonal polynomials and special functions. Applications to problems arising in physics. Selected additional topics, which may include integral equations and Hilbert-Schmidt theory, perturbation methods and probability theory."

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 13 to 23 during the spring semester. 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: http://www.gi.alaska.edu/~chungsangng/phys612/phys612.html

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.

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 Blackboard.

VIII. Examinations

There will be an one-hour in-class midterm exam on Monday, March 5, and a two-hour final exam on Wednesday May 2 from 10:15 AM to 12:15 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, while Participation and Homework are optional in the sense that grades for each of them will be counted only if it can increase your total grade. If either one or both of

them would decrease your total grade, it will be replaced by the average grade of both exams. 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 9:25 AM - 10:25 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: http://www.gi.alaska.edu/~chungsangng/phys612/phys612.html . 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 Blackboard 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	Main Topics	Homework

		(Reading Assignment)		due
1/17	W	13.1	Gamma Function/Definitions, Properties	
1/19	F	13.2-13.3	Digamma and Polygamma Functions/The Beta Function	
1/22	M	13.4-13.5	Stirling's Series/Riemann Zeta Function	
1/24	W	13.6	Other Related Functions	HW #1
1/26	F	14.1	Bessel Functions of the First Kind	
1/29	M	14.2/14.3	Orthogonality/Neumann Functions, Bessel Functions of the Second Kind	
1/31	W	14.4/14.5	Hankel Functions/Modified Bessel Functions	HW #2
2/2	F	14.6/14.7	Asymptotic Expansions/Spherical Bessel Functions	
2/5	M	12.1	Orthogonal Polynomials	
2/7	W	15.1-2	Legendre Polynomials/Orthogonality	HW #3
2/9	F	15.3	Physical Interpretation of Generating Function	
2/12	M	15.4	Associated Legendre Equation	
2/14	W	15.5/15.6	Spherical Harmonics/Legendre Functions of the Second Kind	HW #4
2/16	F	19.1	Fourier Series/General Properties	
2/19	M	19.2-19.3	Applications of Fourier Series/Gibbs Phenomenon	
2/21	W	20.1-20.2	Integral Transforms/Fourier Transform	HW #5
2/23	F	20.3-20.4	Properties of Fourier Transforms/Fourier Convolution Theorem	
2/26	M	20.5-20.6	Signal-Processing Applications/Discrete Fourier Transform	
2/28	W	20.7-20.8	Laplace Transforms/Properties of Laplace Transforms	HW #6
3/2	F	20.9-20.10	Laplace Convolution Theorem/Inverse Laplace Transform	
3/5	M		Mid-term exam	
3/7	W	21.1-21.2	Integral Equations/Some Special Methods	HW #7
3/9	F	21.3-21.4	Neumann Series/Hilbert-Schmidt Theory	
3/19	M	22.1	Calculus of Variations/Euler Equation	
3/21	W	22.2	More General Variations	HW #8
3/23	F	22.3/22.4	Constrained Minima/Maxima/Variation with Constraints	
3/26	M	16.1	Angular Momentum Operators	

3/28	W	16.2	Angular Momentum Coupling	HW #9
3/30	F	16.3	Spherical Tensors	
4/2	M	16.4	Vector Spherical Harmonics	
4/4	W	17.1-17.2	Introduction to Group Theory/Representation of Groups	HW #10
4/6	F	17.3-17.4	Symmetry and Physics/Discrete Groups	
4/9	M	17.5-17.6	Direct Products/Symmetric Group	
4/11	W	17.7-17.8	Continuous Groups/Lorentz Group	HW #11
4/13	F	17.9-17.10	Lorentz Covariance of Maxwellâ€™s Equations/Space Groups	
4/16	M	18.1-18.2	Hermite Functions/Applications of Hermite Functions	
4/18	W	18.3-18.4	Laguerre Functions/Chebyshev Polynomials	HW #12
4/23	M	23.1-23.2	Probability: Definitions, Simple Properties/Random Variables	
4/25	W	23.3-23.4	Binomial Distribution/Poisson Distribution	
4/27	F	23.5-23.6	Gauss' Normal Distribution/Transformations of Random Variables	HW #13
5/30	M	23.7	Statistics	
5/2	W		Final (10:15 AM to 12:15 PM)	
5/7	M		This is absolutely the last day for submitting your report to me, as well as discussing with me about your grades.	
5/9	W		Final grades will be submitted by noon. They will also be posted on Blackboard.	