Physics 616, Fall 2009 Course Information

Instructor:	Daniel Phillips
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Email:	phillips@phy.ohiou.edu
Class times:	9:10–10 am Tuesday and 9:10–11 am Thursday
Text:	*Mathematical Methods for Physicists*, G. B. Arfken and H. J. Weber, 6th edition (Elsevier, 2005)
Other reading:	*Mathematical Methods for Physicists: A concise introduction*, Tai L. Chow (Cambridge University Press, 2000) *Mathematical Methods in the Physical Sciences*, Mary L. Boas, 3rd Edition, (Wiley, 2006)
Office Hours:	By appointment
URL:	http://www.phy.ohiou.edu/˜phillips/Phys616.html

Topics to be covered

1. **Sturm-Liouville Theory** (Chapter 10 and Section 17.8) Review of series solution of ODEs; Self-adjoint ODEs; Hermitian operators; Eigenfunctions; Green's functions and their eigenfunction expansion; Rayleigh-Ritz variational technique for the computation of eigenfunctions.

2. **Legendre functions** (Chapter 12) Legendre's differential equation; the generating functional; multipoles; Legendre-function identities; orthogonality; associated Legendre functions.

3. **Bessel functions** (Chapter 11) Bessel's differential equation; the generating functional; recurrence relations; orthogonality; Neumann and Hankel functions; Spherical Bessel functions.

4. **The Gamma function** (Chapter 8) Definition; Stirling's series; the Beta function; incomplete Gamma functions.

5. **Integral equations** (Chapter 16) Introduction and classifcation; Integral transforms and solutions of integral equations; Neumann series; separable kernels; Hilbert-Schmidt theory.

6. **Group theory** (Chow, Chapter 12) Introduction to group theory; Group multiplication tables; Isomorphic groups; Generators of continuous groups; Orbital angular momentum; Angular momentum coupling; SU(2) and SU(3); Homogenous Lorentz group;

7. **Probability theory** (Boas, Chapter 15) Basics of probability; Probability theorems; Combinatorics; Random Variables; The binomial, normal, and Poisson distributions; Statistics and experimental measurements; Likelihood; Bayes' theorem.

This list of topics to be covered is *tentative*. It is subject to change. In particular, I want to modify what we cover, and the level at which we cover it, according to what the students taking the course (and the instructor teaching the course!) find interesting. The initial plan is to spend about 1 week on each of the first five topics and then $\sim$ two weeks on each of the last two. We will see how we go . . . .

Assumed knowledge (from PHYS 615 or elsewhere)

1. **Series** (Chapter 5) Definition of convergence; geometric series; comparison tests; improving convergence; absolutely-convergent series; series of functions; Taylor series; power series.

2. **Fourier analysis** (Chapters 14 and 15) Fourier series; convergence of the series; Fourier transform; convolution theorem.

3. **Complex analysis** (Chapters 6 and 7) Complex variables; differentiability and the Cauchy-Riemann conditions; analyticity; branch points; Taylor expansion for complex function; Laurent expansion; complex integration; Cauchy's theorem; residue theorem; principal-value integral; definite integrals.

4. **Differential Equations** (Chapter 9) First-order differential equations; Solving an ODE by series; the method of Frobenius; Wronskians; Fuchs' theorem; Finding a second solution; Solution of partial differential equations by separation of variables.

5. **Calculus of variations** (Chapter 17) The Euler-Lagrange equations with one or several variables; Hamilton's principle; Lagrange multipliers and Variation with Constraints.

Additional reading

The textbook by Arfken and Weber will be my main source of material for this course. However, I will use the Chow and Boas books in the last two sections. If you wish to purchase either of them they are nice books. If you do not wish to purchase them I will provide photocopies of the relevant portions. Other nice books in this area which I may draw from at various times are:

- *A guided tour of Mathematical Methods for the Physics Sciences*, Roel Snieder (Cambridge, 2001)
- *Mathematics for Physicists*, Susan M. Lea (Thomson, 2004)
- *Group theory and its application to physical problems*, M. Hammermesh (Dover, 1989)
- *Lie Groups for Pedestrians*, Harry J. Lipkin (Dover, 2002)
- *Elementary theory of angular momentum*, M. E. Rose (Dover, 1995)
- *Data Analysis: A Bayesian Tutorial*, D. S. Sivia (Oxford, 1996)
- *Probability theory: The Logic of Science*, E. T. Jaynes (Cambridge, 2003)

It is probably worthwhile for you to borrow (either from Alden Library or through OhioLink) at least one of the books on this list that deals with Group Theory and at least one of them that deals with Probability and Statistics.

Assessment

30% of your grade will come from your work on Homework assignments. There will be five of these, which will be due on a schedule of one every one–two weeks throughout the course. 10% of your grade will come from “participation”. A significant fraction of the participation grade will be based on your presentation of the solution of one–two homework problems to the class. The homework problems you present are to be chosen by arrangement between you and me. 30% of your grade will come from one in-class mid-term examination. That will take place at 10 am on Thursday, October 15. 30% of your grade will come from one take-home final exam, which will be available at 10 am on Thursday, November 19, and must be handed in 24 hours after that.

Homework

The problem sheets will be handed out at least one week before they are due. The graded assignments will be returned as soon as possible. Particular homework questions will be discussed in class. Over the course of the quarter each student is expected to present the solution to (at least) one homework problem on the board during these sessions.

In grading homework I will be mainly looking to see if you understand how to solve the problems. Therefore partial credit will be given for incomplete solutions, and, conversely, the correct answer without adequate explanation will actually yield very little credit. All steps used in reaching the solution must be properly explained and justified. In particular, the mathematical reasoning should be quite rigorous. For instance, when theorems discussed in class are employed the conditions for their applicability should be explicitly verified. Furthermore, the solution should be able to be read as a coherent discussion in English of the problem. I.e., explanatory sentences should be inserted into the mathematical reasoning.

Plagiarism (i.e. copying each other’s solutions) will not be tolerated. However, I think it is a good idea for you to discuss together how to solve the problems. Operationally, this means that you are welcome to talk together about the homework assignments, but then you should each go off and generate your own solutions to be handed in.

Attendance policy

Attendance will not be taken. However, regardless of whether you were there or not, you will be responsible for knowing all of the material that has been presented in class, and you are expected to be aware of any announcements made in class.