PHYS 6041, “Mathematical Methods in Physics II”,
Fall 2014 Course Information

Instructor: Daniel Phillips
Office: Clippinger Laboratory, Room 242C
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Call number: 8991
Class times: 9:15 – 10:45 am, Tuesday
Room: Clippinger Lab. Room 242C
Other reading: Mathematical Methods for Physicists: A concise introduction, Tai L. Chow (Cambridge University Press, 2000);
Office hours: 1:30 – 2:30 pm, Friday
URL: http://www.phy.ohiou.edu/~phillips/Phys6041.html

Topics to be covered

1. **Solution of differential equations by the method of series** (Sections 7.5–7.6) DEs: solution by series; Fuchs’ theorem; Wronskians and a method for finding the second solution. (1-2 weeks)

2. **Sturm-Liouville Theory** (Chapter 8) Self-adjoint ODEs; Hermitian operators; Eigenfunctions; Rayleigh-Ritz variational technique for the computation of eigenfunctions. (1-2 weeks)

3. **Green’s functions** (Chapter 10) One-dimensional problems; problems in two- and three dimensions; eigenfunction expansions. (1-2 weeks)

4. **Legendre functions** (Chapter 15) Legendre’s differential equation; the generating functional; multipoles; Legendre-function identities; orthogonality; Legendre series; associated Legendre functions; spherical harmonics. (1 week)

5. **Bessel functions** (Chapter 14) Bessel’s differential equation; the generating functional; recurrence relations; orthogonality; Bessel series; Neumann functions; Hankel functions; Modified Bessel functions; Spherical Bessel functions; Bessel series. (1 week)

6. **The Gamma function** (Chapter 13) Definitions; Stirling’s series; the Beta function; incomplete Gamma functions. (1 week)

7. **Integral equations** (Chapter 21) Introduction and classification; Integral transforms and solutions of integral equations; Neumann series; separable kernels; Hilbert-Schmidt theory. (2 weeks)

8. **Group theory** (Chapter 17; 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. (3-4 weeks)
9. **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. *(2-3 weeks)*

10. **If time permits: Calculus of variations** (Chapter 22) The Euler-Lagrange equations with one or several variables; Hamilton’s principle; Lagrange multipliers and Variation with Constraints. *(2 weeks)*

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 you find interesting. We will see how we go . . . .

**Assumed knowledge (from PHYS 5041 or elsewhere)**

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

2. **Fourier analysis** Fourier series; convergence of the series; Fourier transform; convolution theorem.

3. **Complex analysis** 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** First-order differential equations; Solving an ODE by series; Solution of partial differential equations by separation of variables.

**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 for a couple of 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)
- *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)
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 seven–ten of these, which will be due on a schedule of one every one–two weeks throughout the class. 30% of your grade will come from one in-class mid-term examination. 30% of your grade will come from one take-home final exam. The remaining 10% of your grade will be based on participation, i.e. on our interactions during class time.

At the in-class midterm exam students are expected to supply pens or pencils, scratch paper, and a calculator. This exam will be “closed book”: no books, notes, or formulas stored in electronic or written form may be consulted during it.

**Homework**

Homework assignments will generally be due at Tuesday’s class. The problem sheets will be handed out one–two weeks before they are due. The graded assignments will be returned as soon as possible.

In grading your written homework solutions I will be 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. 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.

**Learning outcomes**

After taking this course, students should have a practical command of advanced mathematical techniques for the solution of physics problems. They should:

- be able to develop expansions in orthogonal functions and apply them to physical problems;
- be able to calculate a Green’s function for a basic differential operator, and understand the use and physical interpretation of the result;
- understand the relationship between differential and integral equations;
- know the definition of a group, a group generator, and a Lie algebra;
- understand the use of group-theoretic concepts in basic quantum mechanical problems;
- be able to use ideas from the theory of probability and statistics to perform elementary data analysis tasks.

**Accommodations for students with disabilities**

If you suspect that you may need an accommodation based on the impact of a disability please contact me privately to discuss your specific needs. I will need written documentation from the Office of Student Accessibility Services in order to determine the appropriate accommodation. If you have not yet registered as a student with a disability then you should contact the Office of Student Accessibility Services.
Academic misconduct

“Academic misconduct is an A1 violation of the Ohio University Student Code of Conduct and is defined...as dishonesty or deception in fulfilling academic requirements. It includes, but is not limited to: cheating, plagiarism, un-permitted collaboration, forged attendance (when attendance is required), fabrication (e.g., use of invented information or falsification of research or other findings), using advantages not approved by the instructor (e.g., unauthorized review of a copy of an exam ahead of time), knowingly permitting another student to plagiarize or cheat from one’s work, or submitting the same assignment in different courses without consent of the instructor....

“Cheating is defined as any attempt by a student to answer questions on a test, quiz, or assignment by means other than his or her own knowledge. Examples of cheating include: using the textbook or other materials, such as a notebook, not authorized for use during an examination; observing the work of another student or allowing another student to plagiarize, copy, or observe your work; using unauthorized material during a test, notes, formula lists, notes written on clothing, etc.; taking a quiz, exam, or similar evaluation in the place of another person; providing or requesting assistance from another person in a manner prohibited by the instructor; changing material on a graded exam and then requesting a regarding of the exam; acquiring unauthorized knowledge of an examination or any part of an examination.” (From http://www.ohio.edu/communitystandards/academic/students.cfm.)

Plagiarism is the presentation of someone else's ideas or work as your own. This means you must not copy solutions to problems from those with whom you are taking the class, or from others who have taken the class before you. Plagiarism can also occur if you use a result or approach that you read about in a book and fail to properly cite that book. If you base your answer to a problem substantially on something you have read you must cite that source. In general, if you are unsure about a question of plagiarism or cheating, you are obligated to consult me on the matter before submitting the material.

If I catch you engaging in Academic Misconduct I will not warn you before penalizing you. Penalties will be applied. They shall range from zero on the particular problem on which the offence occurred to an F in the course. You may appeal any academic sanctions I impose through the grade appeal process. I may also report you to the University Judiciaries, which could choose to impose additional sanctions.

Attendance

I recognize that sometimes students must miss class for entirely legitimate reasons. These include illness, death in the immediate family, religious observance, jury duty, and involvement in University-sponsored activities. I will assist you in the management of work after you have been absent from class due to one of these reasons. You may document reasons for your absence as explained in the Undergraduate Catalog, which is available at http://catalogs.ohio.edu.

The lectures, classroom activities, and all materials associated with this class and developed by the instructor are copyrighted in the name of Daniel Phillips on August 19, 2014.