Topics in Mathematical Physics (PHYS 320) Spring 2009 v3.5

In this course we review, learn, and practice a number of mathematical tools which have practical use for physicists. The idea is that these tools will be of use, not only in your remaining studies at Hamilton, but also in graduate school. A "pedestrian guide" to the mathematics, the course focuses on the implementation of the methods and applications rather than proofs and placing the results in context within mathematics. So, even if you have had a course in one or more of the topics, the emphasis and even some of the methods will be new. I also hope that you master much of the material so that you can easily use in research, further studies, or elsewhere in life.

For the most part I assume that you have had linear algebra such as Math 224. To ease the transition for those of you for whom this material is rusty, I will hand out a review at the beginning of the semester. Boas has a good bit on linear algebra as well - see chapter 3 sections 6 - 11.

Contact Info:

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My office hours will be 1:30-5 on Monday. Thursday morning is also normally a good time to find me. If I am not in my office try the "QG theory space", G064, or the intro labs. However, I encourage you to stop by anytime.

Course Info:

The Phys 320 web site is
http://www.hamilton.edu/academics/physics/Physics/Courses/Physics320/phys320.html

Course objectives:

- To learn and become proficient at solving mathematical problems in contemporary physics. My expectation is that you will become fluent in the methods that you have used before (e.g. vector analysis, the simple harmonic oscillator equation) and familiar with a number of new methods (e.g. special functions, Laplace transforms, groups). In addition you will acquire a much broader mathematical base from which to draw in the future - mathematical methods for which you have "active familiarity").
- To learn *how* to *learn* new mathematical methods for use in physics.

Course Structure:

The course will be in lecture/discussion format punctuated by short presentations. I strongly encourage you to ask questions and make observations when these occur to you. Much of the class time will be spent making connections to physics. Discussion is welcome!

The format will be somewhat unusual in that you may first encounter the material in your reading and in a small number of problems. In class we will focus on filling out understanding, answering questions, embellishing the material, and working through more examples.

Textbooks:

We will mainly draw from Mary Boas, *Mathematical Methods in the Physical Sciences*. There are a number of other texts which we will also refer to including: Potter and Goldberg (henceforth "PG"), *Mathematical Methods* (in common room); Wong, *Introduction to Mathematical Physics*; Arfken and Weber, *Essential Mathematical Methods for Physicists* (known as "Baby Arfken"); Arfken, *Mathematical Methods for Physicists* (QA37.2.A74 1970) (I think I have this checked out.). These are listed in order of increasing difficulty; Arfken is a graduate level-text.

Homework - Solutions - Quizzes:

- *Daily Solutions*: There will be 2-3 problems due every class. These will be relatively quick exercises on the reading. When you come to class hand in a copy and keep the original for discussion. On these problems, I encourage you to work together. I look these over, write comments as necessary, and return them to you. Complete "Daily Solutions", even if they contain some errors, receive full credit.

- *Quiz Problem Sets (QPS)*: At suitable intervals (roughly every two weeks) we will have a quiz. They are like problem sets in that they will be open textbook and notes. However, unlike traditional problem sets these must be entirely your own work. They will be typically handed out on a Friday and be due the following Monday.

- *Solutions* to the daily problems will be either discussed or distributed during class. The QPS will have full written solutions posted and/or distributed after your solutions are returned.

Grades: Your semester grade will be determined by the following scheme:

Daily solutions	25%
Quiz Problem Sets	50%
Final	25%

Topics:

The information you have been waiting for! We may not (un)cover all of these...

- **Vector Calculus and Dirac Notation**: vector review, Dirac notation (QM) curvilinear coordinates, partial differentiation, multidimensional integration, integral theorems
- **Methods of solving Ordinary Diff. Equ's (ODEs)**: first order, second order with constant coefficients, series method.
- **Sturm-Liouville Theory**:
- **Special Functions**: Legendre, Hermite, Bessels, Error, Dirac δ- functions
- **Fourier Series**: a theorem, computation of coefficients
- **Integral Transforms**: Laplace and Fourier
- **Partial Diff Equ's (PDEs)**: waves, diffusion, Schrödinger, Laplace, separation of variables
- **Groups**: (Jones) intro, examples, rotations in 3-space, representations, applications
- **Techniques of Complex Analysis**: complex number review, analytic functions, integration, integral theorems
- **Tensors**: (Notes) definition and applications