MATHEMATICAL PHYSICS II

PHYS 502

Prof. R. Gilmore
12-918 X-2779
robert.gilmore@drexel.edu

Term: Winter, 2015-2016

Course Schedule: MWF 10:00 - 10:50

Room: 12-919

Objective: To provide the basic mathematical background, both analytic and computational, required of physicists.

Texts: *Numereical Recipes* (in any language), W. H. Press, S. A. Teukolsky, W. T. Vetterling, and B. P. Flannery, Cambridge: University Press (1988) or later. *Essential Mathematical Methods* K. F. Riley and M. P. Hobson Cambridge: University Press, 2011, ISBN 978-0-521-76114-7

Additional Material: The texts do not cover all the material that will be treated in class. Addition material will be provided. This will be mounted on the course website and also provided to you by email. It is recommended that you have a folder on your computer for these files.

Grading: The course grade will based on homework assignments, an in-class midterm exam, and a final exam.

Homeworks: Homework assignments will involve a mixture of analytic and computational problems. They are due on the date stated at the top of the assignment. Late assignments will receive 50% of the possible maximum grade during the first late week, 40% during the second late week, etc. Once the problems have been done in class, late homeworks will no longer be accepted. For the computational problems, you can use any platform you desire, program in any language you like, and use any package that suites you (Matlab, Mathematica, Maple, etc.) Some of the problems will be labeled **Narrative**. For these problems you are required to provide a written statement to accompany your solution. Full sentences. Clear and lucid. The written solution must provide enough information for one of your peers (another graduate student) to reproduce your results, or for you to remember what you did a year from now. No narration = no credit.

Topics to be Covered

1. Basics
   - Intuitive arguments
   - Dimensional analysis
   - Scaling methods: Newton to RNG
   - Uses of groups in Physics
2. Linear Stuff
   - Quadratic forms
   - Choosing a basis
   - Elimination of variables
   - SVD
   - Greens functions
   - T & S matrices
   - Crossing symmetries
3. Networks
   - Fig. 16.5, pg. 624
   - Markov matrices
   - Nuclear decay schemes & Laplace transforms
   - Shannon entropy and network capacity
   - Page rank algorithm
   - Neural networks
4. Sturm Liouville Stuff
   - Equations
   - Properties
   - Solutions
   - Tabulations
   - Expansions
   - Fourier stuff: series, integrals, inverses
   - Laplace stuff: transforms and inverses
   - Convolutions
   - Convolutions of sharply peaked and rapidly oscillating functions

- Numerical implementation: FFT, aliasing

5. Variational Stuff
    - Homogeneous potentials and Euler scaling
    - Lagrange multipliers
    - Euler-Lagrange equations: ODEs
    - Euler-Lagrange equations: PDEs
    - Classical approach: separation of variables
    - Matrix variational problems
    - Transformations: PDE $\rightarrow$ matrix variational problem
    - Analytic vs. nonanalytic; Full vs. sparse matrices
    - Gaussian vs. Finite Element Method
    - C. R. Hagen's derivation of π
    - Numerical solution of PDEs
6. Probability & Statistics
    - Bradley Efron: "... thinking the unthinkable."
    - RNG & QRNG
    - A selection of probability distributions
    - Tests
    - Bayesian stuff
7. Path Integrals
    - In nuclear decays
    - In Fig. 16.5
    - In T$\rightarrow$ S crossing symmetry expansions
    - And rapidly oscillating integrals
    - Feynman and Schrödinger
8. Counting States
    - $N(k)$ in 1, 2, 3 dimensions
    - Density of states
    - Singularities at minima, saddles, Maxima
    - Morse functions, Betti numbers, van Hove theorem
    - Euler index and shape of space