

FALL 2016

Physics 466: Methods of Theoretical Physics I

Tu Th 12:30-1:45 pm, Rm. 184

Instructor: S. PRASAD, Rm 1119, 277-5876, sprasad@unm.edu

The purpose of the course is to introduce you to the basic mathematical concepts and techniques that provide part of the essential mathematical underpinnings of graduate-level physics, astronomy, and optics courses. The course is designed to articulate well with our graduate electrodynamics course (Physics 511), for which it is a mathematical prerequisite. Mathematical concepts will be developed in physically relevant settings. Proving of abstract theorems will be kept to a minimum, while, by contrast, physical applications and approximations will be stressed. Some use will be made of numerical methods, at the level of MATLAB/MAPLE/MATHEMATICA, for more realistic implementations of mathematical ideas than possible with purely analytical methods.

I will begin with a review of important fundamental mathematical concepts that you should have seen in some detail at the junior undergraduate level, specifically linear (matrix) algebra, Fourier analysis, and vector analysis. But if for some reason you did not, then you should still benefit adequately from the review that will set the stage for more advanced concepts and methods like complex analysis, partial differential equations (PDEs), and the widely occurring special functions of physics. We shall return to further elucidation of linear algebra in the context of PDEs.

The main text for the class will be *Mathematical Methods for Physicists* by G. Arfken, H. Weber, and F. Harris, 7th ed. (Elsevier, 2013). The more advanced book, *Physical Mathematics*, by Prof. K. Cahill, one of our own, will serve as an excellent supporting text. It is full of rare gems of concepts and tools, including some sophisticated ones, that theoretical physicists use, but its coverage is not always accessible to advanced undergraduate and beginning graduate students. Other supplementary texts include N. Lebedev, *Special Functions and Their Applications* (Dover, 1972); and G. Carrier, M. Krook, and G. Pearson, *Functions of a Complex Variable* (McGraw Hill, 1966). While highly dated, they are still eminently relevant. Physical applications will be drawn from the texts used for our graduate courses in classical mechanics, quantum mechanics, and electrodynamics.

Lecture Notes

I will post my lecture notes on my course page at physics.unm.edu/Courses/Prasad/Fa16/P466. The username and passwd are phys466 and MathMethods, respectively. Homework assignments and solution sets will also be posted there, as will the various exams and their solutions (after the exams have been given of course) and any notes from the problem sessions.

1-Hour Problems Course (Physics 468)

To help you with problem-solving skills, understanding, and occasionally to go deeper into a particular concept than possible during the regular lectures, a 1-hour problems course has been instituted. I will have you work in small groups on pre-announced problems. As you must know, solving problems is an essential aspect of learning physics. The class has been rescheduled to meet every Friday at 2:15 pm in Rm 184. You are strongly encouraged to register for this course.

Grading

The grading in the course will be based on your performance in homework (HW) assignments (25%), two mid-term (MT) exams (40%), and a final exam (35%). In all, there will be 9 - 10 HW assignments with 4-5 problems each. Each exam will be a closedbook exam. MT Exam I is tentatively scheduled for Th, Sep 22; MT Exam II for Th, Oct 27; and the Finals on Thursday, Dec 15.

Grader: Yaser Silani; email: yasersilani@unm.edu;

Office Hrs: Instructor's: M W 1:00 - 3:00 pm or by appointment
Grader's: To be determined

Schedule of Topics

- I. Review of Matrix Algebra, Fourier Analysis, Vector Analysis* (5 lectures)
Eigenvalues, eigenvectors, and diagonalization of square matrices
Unitary, normal, Hermitian, positive definite matrices
Rectangular matrices, rank, and singular-value decomposition
Fourier series, discrete and continuous Fourier transforms
Review of vector algebra and calculus
- II. Complex Analysis* (8 lectures)
Analytic functions, Cauchy's integral theorem, formula
Taylor and Laurent expansions, convergence, asymptotic series
Analytic continuation
Singularities, poles and branch points, Riemann sheets
Contour integration, calculus of residues, asymptotic methods
Causality of linear response, Kramers-Kronig dispersion relations
- III. Partial Differential Equations & Special Functions* (15 lectures)
PDEs of physics, including Laplace, diffusion, wave, and Helmholtz equations
Separation of variables
Bessel functions (including spherical)
Legendre functions, polynomials
Spherical harmonics and angular momentum operators
Transform methods - Laplace and Fourier
Nonhomogeneous equation - Green's function
Sturm-Liouville theory - eigenfunctions and eigenvalues
General theory of orthogonal functions
Applications drawn from electrostatics, QM, heat flow, diffusion
Introduction to linear vector and function spaces

In an effort to meet obligations under Title IX, UNM faculty, Teaching Assistants, and Graduate Assistants are considered "responsible employees" by the Department of Education

(see pg 15 - <http://www2.ed.gov/about/offices/list/ocr/docs/qa-201404-title-ix.pdf>).

This designation requires that any report of gender discrimination which includes sexual harassment, sexual misconduct and sexual violence made to a faculty member, TA, or GA must be reported to the Title IX Coordinator at the Office of Equal Opportunity (oeo.unm.edu). For more information on the campus policy regarding sexual misconduct, see: <https://policy.unm.edu/university-policies/2000/2740.html>