

University of Puerto Rico, Río Piedras Campus
Faculty of Natural Sciences, Department
of Physics, Graduate Programme

Title: Methods of Theoretical Physics I

Code: PHYS 6401

Number of Credits: 3

Number of Hours 3 hours of in-person, classroom lecture per week

Prerequisites: Permission of the Graduate Committee

Effective date of the syllabus First Semester, 2024-2025 academic year

Instructor Lutful Bari Bhuiyan

Office Natural Sciences II, C-350

Class period: Tuesdays and Thursdays, 8:30 am -9:50 am Room C-312

Office hours: Mondays and Wednesdays, 8 am – 1 pm, 2 pm – 3.30 pm

Fridays 8 am – 12 noon, 2 pm – 3.30 pm

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Description

Vector analysis. Curvilinear coordinates and tensor differential operators. Infinite series: Taylor expansion, power series. Functions of a complex variable. Conformal mapping. Calculus of residues. Special functions: Bessel functions, Legendre functions, Hermite functions, and Laguerre functions. Spherical harmonics. Application of Green's functions to electrostatic boundary problems.

Objectives

After the completion of this course the student will learn the basic concepts and techniques of calculation in several branches of mathematics relevant to theoretical physics. And the required mathematical background to understand and perform calculations in classical mechanics, quantum mechanics and classical electrodynamics.

Course Content

Week 1,2:

- Vector analysis
 - Brief review of basic concepts, definitions
 - Rotation of coordinate axes
 - Vector calculus, differential vector operators, Gauss' Divergence Theorem, Stokes' Theorem, potential theory
 - Curvilinear coordinates, tensor analysis

Week 3

- Infinite series
 - Various convergence tests
 - Power series, Taylor's expansion

Week 4, 5

- Functions of a complex variable
 - Basic concepts, complex algebra
 - Analyticity of a complex function, Cauchy-Riemann conditions
 - Cauchy's integral Theorem, Cauchy's integral formulae

Week 6,7,8:

- Functions of a complex variable (contd)
 - Complex Taylor series, analytic continuation
 - Laurent series, singularities
 - Conformal mapping
 - Calculus of residues

Week 9,10,11:

Residue theorem and the Evaluation of real integrals using the Residue Theorem.

Week 12,13,14:

- Special functions
 - Legendre polynomials, Associated Legendre polynomials
 - Spherical harmonics
 - Bessel functions of the First and Second Kinds, Neuman functions, Hankel functions, Hermite functions
 - Gamma and Beta functions, analyticity of Gamma functions

Week 15, 16:

- Fourier Series and Integrals
 - Properties, applications of Fourier series, Dirichlet conditions
 - Complex Fourier series
 - Development of the Fourier Integral
 - Fourier transforms

Green's functions, applications to electrodynamics and wave theory.

Instructional Strategy (Modalidad)

The main instructional tool in this class is lecturing. **The *modalidad* of the course is in-person, classroom lecture.**

The content of the course will be offered in the form of virtual lectures with emphasis in examples of applications to different branches of physics. The students are trained to apply theoretical techniques to simple physical situations and setting up the problem mathematically, which is then solved using the methods learned. A fair part of the lecturing effort is thus dedicated to the demonstration of solution of problems taken, for example, classical mechanics, electromagnetism, quantum mechanics.

Student Evaluation

- Will be based on four exams each of which will have the same weight as follows: Exam 1: Week 4, Exam 2: Week 8, Exam 3: Week 12, Exam 4: period of final exams. At least two of the exams will have take home components that need to be handed in within a specified period. The exams will constitute 75% of the total Grade, while the remaining 25% will be based on a numerical project.
- Problems in the exams will be based on the material covered in the class, examples worked out in class, suggested problems, and exercises given throughout the course.

Grading System

The student completing the course work will be graded according to the standard scale A to F.

Text

Mathematical Methods for Physicists, G. Arfken and H. Weber, Sixth edition, Elsevier (Academic Press), 2005. ISBN 0-12-0597876-0, 0-12-0888584-0

Bibliography

Mathematical Methods in the Physical Sciences, Mary L. Boas, Second edition, John Wiley, 1983, ISBN 0-471-04409-1

Mathematical Methods for Physics, H. W. Wyld, Benjamin/Cummings, 1976, ISBN 0-8053-9856-2, 0-8053-9857-0

Complex Variables, Stephen D. Fisher, Second edition, Dover, 1999, ISBN 0-486-40679-

Additional learning resources <https://www.khanacademy.org> , Wikipedia

Rights of Students with Disabilities

UPR complies with all federal and state laws and regulations regarding discrimination, including the Americans with Disabilities Act 1990 (ADA) and the Commonwealth of Puerto Rico Law 51. Students receiving services through Rehabilitaci3n Vocacional must contact the professor at the beginning of the semester in order to plan for a reasonable accommodation and any required support equipment according to the recommendations given by the Oficina de Asuntos para las Personas con Impedimentos (OAPI) of the Dean of Students. Likewise, students with special needs that require some type of accommodation must contact the professor.

Acomodo Razonable

La Universidad de Puerto Rico cumple con todas las leyes federales, estatales y reglamentos concernientes a discriminaci3n, incluyendo "The American Disabilities Act" (Ley ADA) y la Ley 51 del Estado Libre Asociado de Puerto Rico. Los estudiantes que reciban servicios de rehabilitaci3n vocacional deben comunicarse con el (la) profesor(a) al principio del semestre para planificar el acomodo razonable y equipo de apoyo necesario conforme a las recomendaciones de la Oficina de Asuntos para las Personas con Impedimento (OAPI) del Decanato de Estudiantes. Una solicitud de acomodo razonable no exime al estudiante de cumplir con los requisitos academicos del curso.

Academic Integrity

La Universidad de Puerto Rico promueve los m1s altos est1ndares de Integridad acad3mica y cient3fica. El Art3culo 6.2 del Reglamento General de estudiantes de la UPR (Certificaci3n N1m. 13, 2009-2010, de la Junta de S3ndicos) establece que "la deshonestidad acad3mica incluye, pero no se limita a: acciones fraudulentas, la obtenci3n de notas o grados acad3micos vall1ndose de falsas o fraudulentas simulaciones, copiar total o parcialmente la labor acad3mica de otra persona, plagiar total o parcialmente el trabajo de otra persona copiar total o parcialmente las respuestas de otra persona o las preguntas de un examen, haciendo o consiguiendo que otra tome en su nombre cualquier prueba o examen oral o escrito, as3 como la ayuda o facilitaci3n para que otra persona incurra en la referida conducta". Cualquiera de estas acciones estar1 sujeta a sanciones disciplinarias en conformidad con el procedimiento disciplinario establecido en el Reglamento general de Estudiantes de la UPR vigente.

Disciplinary Action in case of academic dishonesty

Grade D will be given.

Hostigamiento

La Universidad de Puerto Rico prohíbe el discrimen par razón de sexo y género en todas sus modalidades, incluyendo el hostigamiento sexual. Según la Política institucional contra el Hostigamiento Sexual en la Universidad de Puerto Rico, Certificación Núm. 130, 2014-2015 de la Junta de Gobierno, si un estudiante está siendo o fue afectado por conductas relacionadas a hostigamiento sexual, puede acudir ante la Oficina de la Procuraduría Estudiantil, el Decanato de Estudiantes o la Coordinadora de Cumplimiento con Título IX para orientación y/o presentar una queja.