Centre for High Energy Physics
Faculty of Science
University of the Punjab, Lahore
Course Outline

Program	BSCP	**Course Code**	CPHY 372	**Credit Hours**	3
Course Title	**Mathematical Method for Physics II**				

Course Introduction

The sophisticated mathematical methods utilized in physics and other scientific fields are thoroughly explored in the Mathematical Methods course. It covers Sturm-Liouville Systems, Green Functions, special functions, power series techniques, and partial differential equations. The convergence of solutions, variable separation in coordinate systems, and equations regulating physical processes are all topics covered in this course. Additionally, it explores the subtleties of the Bessel, Modified Bessel, Spherical Bessel, Legendre, and Associate Legendre functions, Hermit and Laguerre functions, Chebyshev Polynomials, Hypergeometric functions, Gamma, and beta functions, as well as Hermit and Laguerre. To provide students a thorough knowledge of both mathematical techniques and real-world physics applications, the course also goes deeply into the characteristics of Hermitian Operators and Green Functions.

Learning Outcomes

The course introduces the subject of Mathematical Methods at graduate level. Its objectives are as following.

1. Studying the partial differential equations of physics.
2. Studying complex differential equations.
3. Studying special functions.
4. Studying the Sturm-Liouville systems and the theory of green functions.

Course Content

Week 1	Common partial differential equations in Physics
	Cartesian, cylindrical, and spherical coordinate systems
Week 2	Conversions of Cartesian, cylindrical and spherical coordinate systems
	Variable separation in Cartesian coordinates system
Week 3	Variable separation in cylindrical coordinates system
	Variable separation in spherical coordinates system
Week 4	Power Series Method
	Power series solution of standard SOLDE (Bessel and Legendre DE's);
Week 5	Power series solution of standard SOLDE (Hermit and Laguerre DE's);
	Power series solution of standard SOLDE (Chebyshev and Hypergeometric DE's);
Week 6	Convergence of solutions; Special cases of polynomial solutions
	Special functions: Bessel function; Modified Bessel function; Spherical Bessel functions;
Week 7	Legendre function; Associate Legendre function

	Study of the various Properties of these special functions including Generating functions, Recurrence relations, Orthonormalization, Asymptotic forms, and related properties.
Week 8	(Problem Solving)
	(Problem Solving)
Week 9	(Problem Solving)
	(Problem Solving)
Week 10	Hermit functions, Laguerre functions
	Chebyshev Polynomials, Hypergeometric functions,
Week 11	Gamma and beta functions
	The Sturm-Liouville Systems: Self-adjoint ODEs;
Week 12	Sturm Liouville DE's and systems; Applications of properties of Sturm Liouville Systems
	Hermitian Operators; Properties of Hermitian operators
Week 13	Green Functions: Green's functions in one dimension
	(Problem Solving)
Week 14	Green's functions for second-order linear differential operators
	(Problem Solving)
Week 15	Eigen function expansion of Green's functions
	(Problem Solving)
Week 16	Green functions in 3 dimensions.
	(Problem Solving)

Textbooks and Reading Material

1. Foundations of Mathematical Physics, Sadri Hassani, *Allyn and Bacon* (1999).
2. Mathematical Methods for Physics (4^{th}edition), G. Arfken, *Academic Press, NY* (1995).
3. Advanced Engineering Mathematics (8^{th}Edition), E. Keyszig, *J. Wiley* (2001)
4. An Introductory Course in Differential Equations, K.L. Mir, *IlmiKitabKhana*(1999).
5. Mathematical Physics, E. Butkov, *Addison-Wesley* (1973).

Teaching Learning Strategies

The instructor is required to make use of Mathematica/Maple/Python to teach the concepts through visualization/antimutation and symbolic/numerical calculations. The students are required to solve a large portion of related exercises/questions/problems of the main textbooks.

Assignments: Types and Number with Calendar

At least two assignments and two quizzes. A course project may also be assigned.

Assessment

Sr. No.	Elements	Weightage	Details

1.	Midterm Assessment	35%	Written Assessment at the mid-point of the semester.
2.	Formative Assessment	25%	Continuous assessment includes Classroom participation, assignments, presentations, viva voce, attitude and behavior, hands-on-activities, short tests, projects, practical, reflections, readings, quizzes etc.
3.	Final Assessment	40%	Written Examination at the end of the semester. At least fifty percent of the question paper would involve new problems related to the concepts learned in the course. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.