UNIVERSITY OF PUERTO RICO
RIO PIEDRAS CAMPUS
COLLEGE OF NATURAL SCIENCES
DEPARTMENT OF PHYSICS
UNDERGRADUATE PROGRAM

Title: Methods of Mathematical Physics I

Code: PHYS 4031

Number of Credits: 3

Pre-requisite: MATH 3151

Co-requisite: MATH 3152

Description

This course covers fundamental mathematical concepts applied to Physics: vector differential calculus (gradient of a scalar field, directional derivatives, divergence and curl of a vector field, transformations of gradient, divergence and curl in curvilinear coordinates); vector integral calculus (line integrals, Green's theorem on a plane, surface integrals, triple integrals, Gauss' divergence theorem, Stoke's theorem); linear algebra (linear systems of equations, linear independence, definition of a vector space); matrix algebra (inverse and determinant of a matrix, orthogonal, Hermitian and unitary matrices, eigenvalue problems, diagonalization of matrices); differential equations (first-order ordinary differential equations, separable differential equations, exact differential equations, integrating factors, Wronskian, second-order linear differential equations, homogeneous differential equations, non-homogeneous differential equations).

Objectives

After completing this course the student will be able:

- to understand the properties of differential equations in total derivatives and the general behavior of their solutions.
- to understand and manipulate the concepts of vector differential calculus, involving gradient, divergence and curl
- to apply solution methods to types of differential equations that are particularly important in physics and engineering.

Course Content

Topic	Assigned time (hours)
1. First order differential equations. Basic concepts and ideas. Separable differential equations.	3
2. Exact differential equations. Linear differential equations.	3
3. Bernoulli equation. Homogeneous linear equations of second order.	3
4. Second order homogeneous equations with constant	3

coefficients. Free oscillations of a mass-spring system.	
5. Euler-Cauchy equation. Wronskian. Nonhomogeneous equations.	3
6. Solution by undetermined coefficients and variation of parameters. Modeling: forced oscillations, electric circuits.	3
7. Higher order linear differential equations.	3
8. Homogeneous and nonhomogeneous cases.	3
9. Vector, matrices and eigenvalues. System of differential equations.	3
10. Homogeneous systems with constant coefficients. Phase plane.	3
11. Series solutions of differential equations. Power series method.	3
12. General method. Legendre's equation. Legendre Polynomials.	3
13. Frobenius method. Bessel's equation. Bessel functions.	3
14. Bessel functions of the second kind. Sturm-Liouville problems.	3
15. Orthogonal functions. Orthogonal expansions.	3
Total hours	45 contact hours

Instructional Strategies

The main instructional tool in this course is lecturing. The emphasis is to introduce the student to the importance of differential equations in physics and engineering, and why and how they appear. Pure mathematical derivations of some of the results, (e.g. the existence and uniqueness of solution) are kept to a minimum and are only used to introduce the basic concepts. Most of the lecturing time is thus dedicated to the demonstration of solving problems. Weekly homework assignments allow the student to practice problem-solving techniques discussed in class and to develop a deeper understanding of the material. Homework problems are subsequently discussed in class, where the students have the opportunity to deepen their understanding of the problems and their solution.

Minimum Require Facilities

Traditional lecture room.

Student Evaluation

Since the emphasis of this course is on problem solving techniques, the grades are mainly based on four exams where the student will work on problems similar to the ones encountered in class and in the homework problems, as well as on the performance in homework assignments.

Grading System

The overall score is determined by calculating the percentage of points obtained by the student. Grades are then assigned according to the standard curve: 100-90% = A, 89-80% = B, 79-70% = C, 69-60% = D, 59-0% = F.

Bibliography

1. Advanced Engineering Mathematics by Erwin Kreyszig, 1999, John Wiley & Sons, Inc.

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