BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE-PILANI, HYDERABAD CAMPUS
SECOND SEMESTER 2019-2020

06-01-2020

Course Handout

Course No. : PHY F431
Course Title : Geometrical Methods in Physics
Instructor-in-Charge : Sashideep Gutti

Course Description : The course begins with defining manifold. This is followed by defining geometric objects called tensors (scalars, vectors and higher order tensors). The differential forms are defined with lot of examples from physics. Lie group theory is discussed in a geometric way. Idea of metric and Riemannian geometry is the discussed. Aspects of topology and the relevance to physics is then discussed. The idea of integration on a manifold is covered, and derivation of Gauss's theorem and Stokes theorem are done using integrals of differential forms. Fiber Bundles and the idea of a connection is discussed along with the interpretation of magnetic vector potential using the new language. The application of the above topics to Classical Mechanics, Electrodynamics, Gravitation, Quantum mechanics, Quantum Field Theory is discussed.

Scope & Objectives : This is a course in which a geometrical understanding is obtained for various ideas in physics like quantum mechanics, gravitation, classical mechanics and quantum field theory. The course helps in an intuitive and exact interpretation of many results and concepts in physics. A lot of ambiguity that exists in defining quantities in physics is eliminated due to the precise geometric way these quantities are interpreted. A student aspiring to understand physics in a geometric and intuitive way will find this course highly beneficial because of the fundamental interpretations presented in of the course.

Learning Objectives: 1) Manifolds 2) Scalars, Vectors, General Tensors. 3) One forms as gradients, n forms, exterior algebra 4) Lie derivatives 5) Lie group theory and Symmetries 6) Differential Forms 6) Topology, Cohomology 7) Fiber Bundles and Connections 8) Applications in Physics.

Text Book: Geometrical Methods of Mathematical Physics, Bernard Schutz, Cambridge University Press, 1979

Reference Books:
1. Gauge Fields, Knots and Gravity, John Baez and Javier P Munian, World Scientific. 1994.

2. Topology, Differential Geometry and Group Theory for Physicists, by Sunil Mukhi and N Mukunda, Wiley Eastern Limited, 1990.

Course Plan:

Lecture No.	Learning Objectives	Topics to be covered	Chapter in the Text Book
1-2	Manifolds , curves, functions on manifolds	Definitions, examples of manifolds. Spacetime as manifold	2.1-2.5
3-7	Vectors, tensors, fibers	Definitions and Interpretation . Physical Objects as tensors. Metric Tensor, Inertia Tensor, Stress tensor, Energy Momentum Tensor, Riemann Tensor	2.5-2.11
8-12	Integral Curves, Lie Brackets, One Forms	Lie Brackets, Applications	2.12-2.31
13-20	Lie Derivatives and Lie Groups	Lie Derivative, Symmetries, Killing Vectors, Lie Algebras, Lie Groups	3.1-3.18
21-26	Differential Forms	Algebra and Integral Calculus of forms, Volume and Integration on Manifolds, Differential Calculus of forms	4.1-4.13
27-33	Exterior Differentiation	Closed and Exact forms, Stoke's theorem, Gauss Theorem, Conservation Laws.	4.14-4.29
34-36	Homotopy	Loops and Homotopies, Fundamental Groups, Higher Homotopy Groups, Arahanov Bohm Effect, Ampre's law, Gauss theorem.	2.1-2.3 Sunil Mukhi Lecture Notes
37-41	Applications to Physics	Hamiltonian dynamics using Geometry, Thermodynamics, Derivation of maxwell's equation using guage principle, Yang-Mills theory using symmetries, Connection two forms and curvatures.	Chapter 5,Schutz
42	Unsolved issues in physics		

Evaluation:

EC No.	Evaluation Component.	Duration.	Weigh tage	Date, Time & Venue.	Nature of Component.
1	Mid-semester test	90 min.	30%	4/3 3.30 - 5.00 PM	Closed Book
2	Assignments		25%		Open Book
3	Comprehensive Examination	3 Hours.	45%	08/05 AN	Open Book

Chamber Consultation Hour: To be announced in the class.

Notices: Notices concerning the course will be put up on the **PHYSICS** notice board.

Make-up Policy: Make-up for the tests will be granted only for genuine cases of health problems or urgency for going out of town.

Academic Honesty and Integrity Policy: Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

Instructor-in-charge