BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

SECOND SEMESTER 2019-20

Course Handout *Date: 06.01.2020*

Course Number : PHY F315
Course Title : Theory of Relativity
Instructor : S Bhattacharya

Scope & Objective of the course: The theory of Relativity reveals a fundamental aspect of nature. This course is intended to serve as an introduction to this fascinating subject. Since Special Theory of Relativity is essential for understanding much of modern physics, the first half of the course focuses on it in detail and also on its applications in theories of Physics. The second half of the course is designed to provide the students with a basic knowledge of General Theory of Relativity. The mathematical background required for understanding the geometric aspects of relativity are developed in the course. A few of the applications of GR, The course also includes a very brief introduction to black holes and gravitational waves.

Text Books: Introduction to Special Relativity by Robert Resnick, Wiley India Ltd., General Theory of Relativity, P A M Dirac

Reference Books/E materials:

1: A first course in general relativity, Bernard F. Schutz, Cambridge University Press, 2009 (South east Asian edition).
2: An Introduction to Einstein's general relativity, James B Hartle
3: Gravitation and Cosmology, Steven Weinberg. Wiley India Pvt Ltd, 2008.
4: Lecture notes on General Relativity by Sean Carrol (available on the internet).
6: Classical Theory of Fields, L. Landau & E. Lifshitz
7: Introduction to Electrodynamics, D. J. Griffiths
8. Quantum Field Theory in a nutshell, A. Zee
9. Introducing Einstein's Relativity, R. D'Inverno

Learning Outcomes:

Course Plan:

Lecture Number	Learning Objectives	Topics to be covered	Chapter in the Text Book
1-7	Special Relativity	Spacetime diagrams, Lorentz transformations, Invariant lengths, velocity additions, Electricity and Magnetic fields.	RESNICK CHAPTER 1,2,3,4
8-10	Vector analysis in STR	Four vectors, four velocity, scalar products, spacetime diagrams	Resnick, Schutz chapter 2, Griffiths
11-14	Tensor Analysis in STR	Tensors, Metric, One forms, Raising and lowering the indices, Minkowski	Schutz chapter 3

		metric	
15-16	Relativistic mechanics	Modification of Force law and expression for energy, Derivation of E=mc^2	Resnick, Griffiths
17-19	Field Theories in Special Theory of Relativity	Construction of field theories with Lorentz symmetry, scalar, vector and tensor fields, Examples: Klein-Gordon theory, Electrodynamics, a theory of 'spin 2' waves. Introduction to energy-momentum tensor	Griffiths (last two chapters), Schutz chapter 4, Weinberg, Zee
20-26	Curved manifolds and differential geometry	Differentiable manifolds, Riemannian manifolds, Covariant derivative, Parallel Transport, Curvature Tensor, Bianchi Identities	Dirac, Landau-Lifshitz
27-28	Einstein field equations	Einstein equations motivation and derivation	Dirac
29-30	Schwarzschild solution	Spherically symmetric solutions, general and static. Derivation of Schwarzschild metric,	Dirac, Schutz
31-38	Black Holes and Schwarzschild geometry	Motion of geodesics in spherically symmetric spacetimes, Behavior of coordinates near event horizon, Region inside the black hole, Coordinate systems: Eddington-Finkelstein coordinates and Kruskal and Penrose diagrams	Dirac, Caroll, D'Inverno
39-40	Gravitational waves	Weak Gravitational waves in almost-Minkowski space-time, connection to 'spin-2' waves, which has already been discussed	Dirac, Schutz, Weinberg

Evaluation Scheme:

EC No.	***Evaluation Component***	***Duration***	***Weightage (%)***	***Date, Time***	***Remarks***
1.	Quiz	50 Min.	30		closed book
2.	Midsem	90 Min.	30	5/3 3.30 - 5.00 PM	Open Book
3	Comp. Exam	3Hours	40	11/05 FN	Closed Book

Chamber Consultation Hour: To be announced.

Notices: Notices and solutions of tests & Final Comprehensive Examination will be displayed only on the **Physics** notice board.

Make-up Policy: It is applicable to the following two cases and it is permissible on production of evidential documents.

(i) Debilitating illness.

(ii) Out of station with prior permission from the Institute

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.