

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

Hyderabad campus

2022-23

Course Handout

Date: 20.8.2022

Course Number : PHY F415
Course Title : General Theory of Relativity and Cosmology
Instructor : Sashideep Gutti

Scope & Objective of the course: The course is designed to provide students with a working knowledge of General theory of relativity. The necessary mathematical background required to understand the geometric aspects of relativity are developed in the course. As part of the applications of general relativity, the course includes detailed analysis of black holes, Gravitational Wave equations.

Text Book: A first course in general relativity, Bernard F. Schutz, Cambridge University Press, 2009 (South east Asian edition).

Reference Books/E materials:

- 1: An Introduction to Einstein's general relativity, James B Hartle
- 2: General Relativity: An Introduction for Physicists. M.P Hobson, G. Efstathiou and N. Lasenby, Cambridge University Press. 2006.
- 3: Gravitation and Cosmology, Steven Weinberg, Wiley India Pvt Ltd, 2008.
- 4: Lecture notes on General Relativity by Sean Carroll (available on the internet).
- 5: Gravitation by Misner Thorne Wheeler, Freeman and Company, 1973.
- 6: Gravitation by T. Padmanabhan, Cambridge university Press, 2010

Course Plan:

Lecture Number	Learning Objectives	Topics to be covered	Reference Chapter/ Section
1-7	Special Relativity	Spacetime diagrams, Lorentz transformations, Invariant lengths, velocity additions.	SCHUTZ CHAPTER 1. HOBSON CHAPTER 1
8-10	Manifolds, Coordinates	Curves, Surfaces, Geometry on Manifolds, Lengths, Volumes	Schutz chapter 2, Hobson chapter 2
11-15	Tensor Analysis	Tensors, Metric, One forms, Raising and lowering the indices	Schutz , Hobson, chapter 3,4

16-17	Energy momentum tensor and perfect fluids	Fluids, Dust, Perfect fluids, Interpretation of EM tensor	Schutz chapter 4, Hobson chapter 6
18-19	Preface to curvature	Gravitation and Curvature, Christoffel symbols, non coordinate basis	Schutz chapter 5
20-22	Curved manifolds and differential geometry	Differentiable manifolds, Riemannian manifolds, Covariant derivative, Parallel Transport, Curvature Tensor, Bianchi Identities	Schutz chapter 6
23-25	Physics of Curved space	Differential geometry to gravity, Conserved Quantities	Schutz chapter 7
26-27	Einstein field equations	Einstein equations motivation and derivation	Schutz chapter 8
28	Schwarzschild solution	Spherically symmetric solutions, general and static. Derivation of Schwarzschild metric,	Schutz chapter Chapter 10 section 10.1 and 10.2, Chapter 11
19-35	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, Formation of black holes, Kerr blackhole and charged black hole.	Schutz chapter 11
36-40	Gravitational Waves	Homogeneous and Isotropic Universe, Friedmann equations, Positive and Negative cosmological constants. Dark Matter , Dark Energy	Schutz chapter 12

Evaluation Scheme:

EC No.	Evaluation Component	Duration	Weightage (%)	Date, Time	Remarks
1.	Assignment 1		15		Open book
2.	Assignment 2		15		Open Book
3	Midsem	90 Min	30		Open book
4	Comp. Exam	3Hours	40		Open Book

Chamber Consultation Hour: To be announced.

Notices: Will be displayed in CMS.

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

of evidential documents.

(i) Debilitating illness.

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.