

# BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

Hyderabad campus  
First Semester 2021-2022  
Course Handout

Date: 20.08.2021

**Course Number** : PHY F415  
**Course Title** : General Theory of Relativity and Cosmology  
**Instructor** : Subhash Karbelkar

**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 Waves and cosmology.

**Text Book:** An Introduction to Einstein's general relativity, James B Hartle (South east Asian edition).

## Reference Books/E materials:

- 1: A first course in general relativity, Bernard F. Schutz, Cambridge University Press, 2009
- 2: Lecture notes on General Relativity by Sean Carroll
- 3: Gravitation by Misner Thorne Wheeler, Freeman and Company, 1973.

## Course Plan:

Number of lectures	Learning Objectives	Topics to be covered	Chapter in the Text Book
4	Review of Special Relativity	Spacetime diagrams, Lorentz transformations, Invariant lengths, velocity additions.	4,5
4	Gravity as geometry	Equivalence principle, Schild's argument for curved spacetime, gravitational redshift, Newtonian gravity in spacetime terms	6
4	Description of curved spacetime	Metric, local inertial frames, length, area etc for diagonal metrics, vectors in curved spacetimes	7
2	geodesics	The geodesic equation	8
4	Vectors and tensors	Gravitation and Curvature, Christoffel symbols, non coordinate basis	20
4	Curvature of spacetime and Einstein's equation	Parallel Transport, geodesic deviation, Curvature Tensor, Einsteins equation in vacuum	21
4	Einstein field	Einstein equations motivation and	22

	equations	derivation, Newtonian limit	
3	Schwarzschild geometry	Spherically symmetric solutions, general and static. Derivation of Schwarzschild metric,	Schutz chapter Chapter 10 section 10.1 and 10.2, Chapter 11
5	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	Schutz chapter 11
4	Gravitational waves	Linearized Einstein's equations and gravitational waves	16
4	Cosmological models	Homogeneous and Isotropic Universe, Friedmann, Robertson and Walker models, Positive and Negative cosmological constants. Dark Matter , Dark Energy	18

#### Evaluation Scheme:

<b>EC No.</b>	<b>Evaluation Component</b>	<b>Duration</b>	<b>Weightage (%)</b>	<b>Date, Time</b>	<b>Nature of Component</b>
1.	Assignment Set 1		15		Open book*** Before midsem
2.	Assignment set 2		15		Open Book*** After midsem
3	Midsem	90 Min	35	22/10/2021 9.00 - 10.30AM	Open book
4	Comp. Exam	2 Hours	35	22/12 FN	Open Book

\*\*\* : Will be assigned throughout the semester as and when a coherent topic is covered. Assigned tasks with deadline before the midsem will constitute the assignment 1 and that with later deadline will be considered as assignment 2.

**Chamber Consultation Hour:** To be announced in the class.

**Notices:** Will be displayed **ONLY** 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.

(ii) prior permission from the IC

**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.