

# BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

Hyderabad campus  
Second Semester 2021-22  
Course Handout

Date: 15-01-2022

**Course Number** : PHY F315  
**Course Title** : Theory of Relativity  
**Instructor** : Rahul Nigam

**Scope & Objective of the course:** All of modern physics is based on theory of relativity and quantum mechanics. This course deals with all the aspects of theory of relativity. The course is designed to provide students with a working knowledge of both special and 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, wormholes as well as cosmological equations that describe the universe.

**Text Book:** Introduction to Special Relativity by Robert Resnick, Wiley India Ltd.

**Reference Books/E materials:**

- 1: An Introduction to Einstein's general relativity, James B Hartle
- 2: A first course in general relativity, Bernard F. Schutz, Cambridge University Press, 2009 (South east Asian edition).
- 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
1-8	Special Relativity	Spacetime diagrams, Lorentz transformations, Invariant lengths, velocity additions, Electricity and Magnetic fields.	RESNICK CHAPTER 1,2,3,4
9-10	Vector analysis in STR	Four vectors, four velocity, scalar products	Schutz chapter 2
11-16	Tensor Analysis in STR	Tensors, Metric, One forms, Raising and lowering the indices	Schutz chapter 3
17-19	Energy momentum tensor and perfect fluids	Fluids, Dust, Perfect fluids, Interpretation of EM tensor	Schutz chapter 4
20-23	Preface to curvature	Gravitation and Curvature, Christoffel symbols, non coordinate basis	Schutz chapter 5

24-30	Curved manifolds and differential geometry	Differentiable manifolds, Riemannian manifolds, Covariant derivative, Parallel Transport, Curvature Tensor, Bianchi Identities	Schutz chapter 6
31-34	Physics of Curved space	Differential geometry to gravity, Conserved Quantities	Schutz chapter 7
35-36	Einstein field equations	Einstein equations motivation and derivation	Schutz chapter 8
37-38	Schwarzschild solution	Spherically symmetric solutions, general and static. Derivation of Schwarzschild metric,	Schutz chapter Chapter 10 section 10.1 and 10.2, Chapter 11
39-40	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
41-42	Cosmology and Friedman equations and Big Bang	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.	Quiz I	50 Min.	15		Open book
2.	Quiz II	50 Min.	15		Open Book
3	Midsem	90 Min	30	16/03 3.30pm to 5.00pm	Open book
4	Comp. Exam	2Hours	40	23/05 FN	Close 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.

