# BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

*Hyderabad campus*
*Second Semester 2023-24*
<u>*Course Handout*</u>                     Date: 09-01-2024

**Course Number**     **:**    **PHY F315**
**Course Title**        **:**    **Theory of Relativity**
**Instructor**      **:**     SashideepGutti

**<u>Scope & Objective of the course:</u>**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.

**<u>Text Book</u>: 1) Introduction to Special Relativity by Robert Resnick, Wiley India Ltd.**
**2) A first course in general relativity, Bernard F. Schutz, Cambridge University Press, 2009 (South east Asian edition).**
**<u>Reference Books/E materials:</u>**
**1: An Introduction to Einstein's general relativity, James B Hartle**
**2: Gravitation and Cosmology, Steven Weinberg. Wiley India Pvt Ltd, 2008.**
**3: Lecture notes on General Relativity by Sean Carrol (available on the internet).**
**4: Gravitation by Miesner Thorne Wheeler, Freeman and Company, 1973.**
**5: 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 indicies | 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 |

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| 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 | Gravitational Waves | Linearize field equations | Schutz chapter 9 |

**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 | 11/03 - 9.30 - 11.00AM | Closed book |
| 4 | Comp. Exam | 3 Hours | 40 | 06/05 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.