**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 Carrol (available on the internet).**

**5: Gravitation by Miesner Thorne Wheeler, Freeman and Company, 1973.**

**6: Gravitation by T. Padmanabhan, Cambridge university Press, 2010**

**Course Plan**:

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| **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 indicies | 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:**

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| ***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.