**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 Carrol**

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

**Course Plan**:

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| --- | --- | --- | --- |
| **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 intertial 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 equations | Einstein equations motivation and derivation, Newtonian limit | 22 |
| 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:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***EC No.*** | ***Evaluation Component*** | *Duration* | *Weightage* ***(%)*** | ***Date, Time*** | ***Nature of Component*** |
| 1. | Assignment Set 1 |  | 15 |  | Open book\*\*\*  Before midsem |
| 2. | Assignement 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.