IIT Mandi
Proposal for a New Course

Course number : PH 528
Course Name : Introduction to General Relativity
Credit Distribution : (3-0-0-3)
Intended for : I-Ph.D., M.Sc., B.Tech 3rd and 4th Year.
Prerequisite : Mathematical Physics (PH511), Classical Physics (PH 512), Electromagnetic Theory (PH 521).
Mutual Exclusion : None

1. Preamble:

General Relativity is one of the main pillars of modern physics. Einstein's discovery of General Relativity revolutionized our understanding of gravity and the universe. Since then, there has been enormous progress in both theoretical and observational fronts. General Relativity is foundational to fields such as cosmology, astrophysics, black hole physics and the physics of gravitational waves. In this course, we introduce students to the theory and applications of General Relativity.

2. Course Modules with quantitative lecture hours:

Special Relativity: Principles of special relativity – Lorentz transformations, Covariant and contravariant vectors, Relativistic Mechanics. **(4 Hours)**

Tensor Algebra and Tensor Calculus: Manifolds and metric, Introduction to tensors – Transformation of coordinates, Lie derivatives – covariant differentiation – Christoffel symbols, The Riemann and Ricci tensors – The Bianchi identities, Geodesics, Isometries – The Killing equation and conserved quantities. **(9 Hours)**

General Relativity: The equivalence principle – The principle of general covariance, The stress-energy tensor, Einstein equations, The equation of geodesic deviation, linearized gravity and idea of gravitational waves. **(9 Hours)**

Schwarzschild solution and Black holes: The Schwarzchild solution, Motion of particles in the Schwarzschild metric – Precession of the perihelion – Bending of light, Black holes – event horizon and singularity, The Kruskal extension – Penrose diagrams. **(10 hours)**

Cosmology: Homogeneity and isotropy – The FRW metric, Friedmann equations – Solutions with different types of matter, Cosmological redshift – standard candles, Dark matter and dark energy, Thermal history of the universe, Horizon problem and Inflation. **(10 hours)**

3. Text books:

1. J. B. Hartle, Gravity: An Introduction to Einstein's General Relativity, Pearson Education, India, 2003
2. B. F. Schutz, A First Course in General Relativity, 2nd Edition, Cambridge University Press, United Kingdom, 2009

4. References:

1. S. Carroll, Spacetime and Geometry, Addison Wesley, USA, 2004)
2. Barbara Ryden, Introduction to Cosmology, 2nd Edition, Addison-Wesley, USA, 2016

5. Similarity with the existing courses:

(Similarity content is declared as per the number of lecture hours on similar topics)

S. No.		Course Code	Similarity Content	Approx. % of Content
1.	Electromagnetic Theory	PH 521	4 lectures	10%

6. Justification of new course proposal if cumulative similarity content is >30%: NA

Approvals: