



Indian Institute of Information Technology, Allahabad

Department of Applied Sciences

Syllabus

Name of the Course : General Relativity

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Component	Unit	Topics for Coverage
Component 1	1	The spacetime interval, the metric, Lorentz transformations, spacetime diagrams, vectors, the tangent space, dual vectors, tensors, tensor products, the Levi-Civita tensor, differential forms, Hodge duality, energy momentum tensor, perfect fluids, energy-momentum conservation
	2	Maps, continuity, the chain rule, open sets, charts and atlases, manifolds examples of charts, differentiation, vectors as derivatives, coordinate bases, the tensor transformation law, canonical form of the metric, Riemann normal coordinates, tensor densities, volume forms and integration
	3	Covariant derivatives and connections, connection coefficients, transformation properties, the Christoffel connection, structures on manifolds, parallel transport, the parallel propagator, geodesics affine parameters, the exponential map, the Riemann curvature tensor, symmetries of the Riemann tensor, the Bianchi identity, Ricci and Einstein tensors, Weyl tensor, simple examples, geodesic deviation, tetrads and non-coordinate bases, the spin connection, Maurer-Cartan structure equations, fiber bundles and gauge transformations.
Component 2	4	The Principle of Equivalence, gravitational redshift, gravitation as spacetime curvature, the Newtonian limit, physics in curved spacetime, Einstein's equations, the Hilbert action, the energy-momentum tensor again, the Energy Conditions, alternative theories, the initial value problem, gauge invariance and harmonic gauge, domains of dependence, causality.
	5	Pullbacks and push forwards, diffeomorphisms, integral curves, Lie derivatives, the energy-momentum tensor one more time, isometries and Killing vectors.
	6	The weak-field limit defined, gauge transformations, linearized Einstein equations, gravitational plane waves, transverse traceless gauge, polarizations.
	7	The Schwarzschild metric, Birkhoff's theorem, geodesics of Schwarzschild spacetime, perihelion precession, the event horizon, black holes, Kruskal coordinates, Penrose diagrams, conformal infinity, no hair, charged black holes, cosmic censorship, rotating black holes, the Penrose process, black hole thermodynamics.
	8	Homogeneity and isotropy, the Robertson-Walker metric, forms of energy and momentum, Friedmann equations, cosmological parameters, evolution of the scale factor, redshift, Hubble's law.

Text Book: General Relativity by R. M. Wald.

References:

1. Spacetime and Geometry: An introduction to General Relativity by Sean Carroll.
2. The large scale structure of space-time by S.W. Hawking & G. F. R. Ellis.
3. Riemannian Geometry by M. P. do Carmo.