Course Number	PH623
Course credit (L-T-P-C)	3-0-0-6
Course title	Introduction to general relativity and cosmology
Learning mode	Offline
Learning objectives	• Understand the basic concepts of general relativity • Learn about various eras of our universe since the earliest known time • Learn about the standard model of cosmology • Know the various experimental or observational methods in cosmology research • Introduction to inflationary cosmology, and open research problems
Course description	This course provides a basic review of general relativity and presents a beginner level introduction to the science of understanding the origin, structure, and evolution of our universe. Based on the introductory text by B. Ryden, this semester-long course is aimed at graduate and undergraduate students with a keen interest in cosmology as a research discipline.
Course content	Brief review of special theory of relativity, equivalence principle, describing curvature – Riemannian spacetime, generalized coordinates, review of tensor algebra and calculus, metric, Christoffel connections, geodesic equation, metric as a classical field, Reimann curvature tensor, Ricci tensor and scalar, Einstein action, Einstein equations, FRW metric, proper distance; Cosmological observations: dark night sky, isotropy and homogeneity, redshift, cosmic particles, cosmic microwave background – overview of the CMB spectrum, recombination, temperature fluctuations; the standard model of the universe (ΛCDM); Friedmann equation, equation of state, cosmological constant, single component universe – spatially flat, radiation, and matter dominated; cosmological parameters – Hubble constant, deceleration parameter; introduction to dark matter; The inflationary universe: flatness problem, horizon problem, monopole problem, the paradigm of inflation, physics of inflation – example of a scalar field driven inflation, advances of inflation model building, confronting inflation models with observation, primordial gravitational waves.
Pre-requisites	• Classical mechanics • Differential equations, PDE, complex algebra
Learning outcomes	After the successful completion of this course, the students will achieve: • Basic understanding of general relativity, and computing covariant derivatives, solving tensor field equations. • An overview of the research field of cosmology, and developments in our understanding of the universe over the past 100 years. • The knowledge of observational aspects of cosmology, particularly the cosmic microwave background, Expansion rate of the universe, Hubble parameter, etc. • Basics of inflationary cosmology, and open problems therein.
Assessment method	Assignments (A), Paper Presentation (PP), MidSem (MS), EndSem (ES). Internal (A+PP)=40%, MS=30%, ES=30%
Textbooks and references	• Introduction to cosmology, B. Ryden, Cambridge Univ. Press, 2016. • Modern cosmology, Scott Dodelson, Academic Press, 2003. • Spacetime and Geometry: An introduction to general relativity, S. Carroll, Cambridge, 2019. Additional references: • Cosmology, D. Baumann, Cambridge, 2022. • A first course in general relativity, B. Schutz, Cambridge, 2009. • Introduction to Cosmology, J. V. Narlikar, Cambridge Univ Press, 2002. • Gravitation and cosmology: Principles and applications of the general theory of relativity, S. Weinberg, Wiley, 1972.