Master of Science in Physics
M. Sc. (Physics) Semester I

Course Code	**PS01EPHY52**	Title of the Course	**Non-Linear Dynamics, Relativity & Cosmology**
Total Credits of the Course	**04**	Hours per Week	**04**

Course Objectives:	This course on Non-Linear Dynamics, Relativity & Cosmology is one of the elective courses of physics intended at the MSc level. Its basic objective is to provide training on the basic characteristics of nonlinear dynamics its mathematical treatment and characteristics of chaotic motion. The other units of this paper aim to provide basic training on general theory of relativity and its applications to understand various structure and evolution of cosmology and our universe. It thus aims to provide a flavor of the study related to cosmology and the physical processes of early universe.

Course Content		
Unit	Description	Weightage* (%)
1	Dynamical systems: Dissipative systems, Attractors, Equilibrium solutions, Limit cycles, Periodic solutions, Poincare cuts, Static bifurcations, bifurcations of time-dependent solutions. Lyapunov Exponents and Chaos: One dimensional system, Multidimensional systems Stretching and folding in phase space, Fractal geometry, Systems with chaotic dynamics: dynamics of discrete systems, One dimensional mappings	**25%**
2	General relativity: Space, time and gravitation, Covariant differentiation, Riemannian geometry, Space-time curvature, Geodesics, Principle of equivalence Gravitational equations, The Schwarzschild solution. From Relativity to Cosmology: The Einstein Universe, The expanding Universe, Assumptions of Cosmology, The red shifts Apparent magnitude, Hubble's law, Angular size, Einstein Field equations in Cosmology, Energy tensors of the universe, Solution of Friedmann's equations, Luminosity vs distance, Cosmological models.	**25%**
3	The Large Scale Structure of the Universe: Astronomy and Cosmology, Our galaxy, Types of Galaxies Radio sources, Quasars Structures on the large scale, Co-ordinates and catalogues of astronomical objects, Classification of stars, HR diagram; Expansion of the universe, Background radiation, Relativistic cosmology.	**25%**
4	Big Bang and the Early Universe: The Early Universe,	**25%**

	Thermodynamics of the early Universe, Primordial neutrinos, the proton – neutron ratio, Synthesis of helium and other nuclei, The microwave background, Formation of structures in the Universe, The expanding Universe, Growth in the post recombination era, Observational constraints, The inflationary phase, role of dark matter and dark energy.	
Teaching-Learning Methodology	Off line , Online mode of direct teaching learning, Tutorials, class assignments	

Evaluation Pattern		
Sr.No.	Details of the Evaluation	Weightage
1	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
	Acquire o the knowledge of mathematical methods to solve nonlinear systems. o better understanding of the chaotic dynamics and its characterization. o skills to the mathematical details of general theory of relativity and its applications towards the understanding of cosmology, large scale structure of the Universe. o the knowledge related to various physical processes that would have occurred at the early universe.

Suggested References:	
Sr.No.	References
1	1 Classical Mechanics – System of particles and Hamiltonian Dynamics' by Greiner, Springer International Ed. 2003 (second Indian Reprint 2006).
2	2 Introduction to Cosmology by J V Narlikar, Cambridge Univ Press, 1998.
3	3 General Theory of Relativity by P A M Dirac, Prentice Hall of India, 2001.

On-line resources to be used if available as reference material
On-line Resources
www.iiserpune.ac.in www.nrce.niepa.ac.in imagine.gsfc.nasa.gov asppublications.org