Course: M.Sc (Physics)

Semester	4
Paper Number	15 (MPHC4401)
Paper Title	Introduction to Astrophysics and Cosmology
No. of Credits	6
Course description/objective	**Group A:** This course aims at showing how basic physics principles can be applied to learn about different astrophysical settings. It also aims to enable a student to use order of magnitude arguments to be able to formulate and proceed into getting important insights of astrophysical problems. Finally, it aims at teaching stellar physics and stellar evolution and learn how this understanding can be applied to other astrophysical objects to understand them. **Group B:** This course aims to present the standard model of cosmology as a first course. Beginning with the idea of cosmological magnitudes, the course introduces the cosmological principle as the basis for understanding the phenomenon of cosmological expansion. Different scenarios of cosmological evolution are addressed within the ambits of FRW cosmology with special reference to the “Benchmark Model”, followed by an exposure to the theory of thermal evolution and structure formation, emphasizing the role of the Dark sector of the universe.
Course Outcome	**Group A** CO1: Appreciate distance and mass scales involved in Astrophysical and Cosmological scenario CO2: Understand and appreciate how physical laws are applied into Astrophysical scenarios CO3: Learn order of magnitude arguments from simple basic physics to visualize and formulate astrophysical problems CO4: Understand stellar observations, stellar structure and stellar evolution CO5: Understand the importance of studying binary stellar systems in the context of stars. **Group B** CO1: Appreciate the facts about the origin, evolution and structure of the universe. CO2: Understand the role of Copernican Principle in the formulation of standard Cosmology CO3: Gain thorough understanding of the implications of FLRW cosmology for single component universe models. CO4: Understand the role of Dark matter and Dark energy in the context of two and multi-component universe models. CO5: Develop an elementary understanding of the theory of structure formation of the universe.

Syllabus	**<u>Group A:</u>** **Physics of Astrophysics and Stellar Astrophysics [36 Lectures]** Overview of Astrophysics: different scales and orders of magnitude in astrophysics and cosmology: mass, distances (distance ladder) and time. The Celestial sphere: Celestial coordinates, Celestial times, Conversion between two coordinate systems [6 lectures] Photometry: Magnitude scales, Distance modulus. Determination of luminosity, radius and distance of a star: Stellar Parallax, Blackbody radiation (Recap), Color Index, Characteristic temperature in astrophysics, Extinction of light. [4 lectures] Stellar spectral classification: Observed Hertzsprung-Russel diagram, Physical basis of the classification---Boltzmann's equation and Saha equation. [3 lectures] Stellar atmospheres: Radiation Transfer: Description of Radiation Fields, Transfer Equation, Plane parallel atmosphere, Gray atmosphere, Eddington approximation and formation of spectral lines. [6 lectures] Stellar structure: Structure of Main Sequence stars, Virial theorem and Stellar energy sources. Nuclear burning in stars: H burning, He burning, Core collapse. Polytropic Stars, Convection in stars and their stability, Chandrasekhar Mass. [9 lectures] Theory of Main Sequence (MS) stars: Homologous model, Eddington luminosity: Radiative stability, Evolution of low and high mass MS stars, Post MS Evolution. [4 lectures] Binary Systems and Stellar Parameters: Classification of Binary stars, Mass determination using Visual, Eclipsing and Spectroscopic Binaries, Search for Extrasolar planets [4 lectures] **<u>Group B:</u>** **Introduction to Cosmology [36 Lectures]** Cosmological Models Review of Special and General Relativity: Equivalence Principle, Coordinates and Metric, Einstein's Equation. De Sitter Space, FLRW Spacetime: Friedman Equation: Continuity and acceleration equations – Study of Single and Multicomponent Universes. [12 lectures]

	Particles and Fields Particle Components and Particle Phenomenology relevant to cosmology, Thermodynamics in the Early Universe: Decoupling and Freezeout. Thermal Relics from the Big Bang, Dark Matter, Nucleosynthesis, Photon Recombination and Decoupling. [8 lectures] Accelerating Universe Problems of the standard B.B Cosmology, Inflation, Dark Energy [8 lectures] CMBR and the Growth of Structures Thermal nature of CMBR, Anisotropy, Density Perturbations, Jeans mass, Results from WMAP. [8 lectures]
References	**Group A:** 1. Fundamental Astronomy by H. Karttunen et. Al (Springer, 2013) 2. An Introduction to Modern Astrophysics by B. W. Carrol and D. A. Ostlie (Pearson, 2006) 3. Astrophysics for Physicists by Arnab Rai Choudhuri (CUP, 2010) 4. Radiative Processes in Astrophysics by G. B. Lightman and A. P. Lightman (Wiley, VCH, 1985) 5. Stellar Interiors –Physics Principles, Structure amd Evolution by C. J. Hansen, S. D. Kawaler and V. Pringle (Springer) 6. Astronomy: A Physical Perspective by M. L Kutner (CUP, 2003) 7. An Introduction to the Theory of Stellar Structure and Evolution, Dina Prialnik, (CUP, 2000) **Group B:** 1.Barbara Ryden: Introduction to cosmology 2. Andrew Liddle: Modern Cosmology (2e / 3e) 3. Bergstrom and Goober: Particle Astrophysics 4. V. Mukhanov: Physical Foundations of Cosmology 5. Scott Dodelson: Modern Cosmology
Evaluation	Total: 100 CIA: 10 (Group A) + 10 (Group B) End Semester Examination: 40 (Group A) + 40 (Group B)