

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI- HYDERABAD CAMPUS
FIRST SEMESTER 2021-2022
COURSE HANDOUT (PART-II)

29-08-2022

In addition to part I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course.

Course No. : **MATH F456**
Course Title : **Cosmology**
Instructor-in-charge : **P K SAHOO**
Instructor :

1. Scope and Objective of the Course:

This course will serve as an introduction to Cosmology, which is a fascinating branch of science and deals with large scale structure of the Universe as a whole, in particular the origin, evolution and ultimate fate of the Universe. In this course, we shall introduce the fundamentals of modern cosmology via the Mathematics of Newtonian Mechanics starting with the observational overview of the Universe. With the derivation of necessary equations governing the evolution of Universe, we will motivate and analyse the basic mathematical models of the Universe. The remainder of the course will be devoted to explain and understand the observed features of the Universe by extending the basic mathematical models, where we will discuss topics such as cosmic acceleration, cosmological constant, cosmic microwave background, inflation and nucleosynthesis in early Universe.

2. **Text Book:** A. Liddle: An Introduction to Modern Cosmology, Relativity and Cosmology, 3rd edition, Wiley (2015).

3. Reference Books:

R1. S. Weinberg, Gravitation and Cosmology, John Wiley, New York, (1972).

R2. M. Rowan-Robinson, Cosmology, 3rd edition, Oxford University Press (1996).

R3: J. A. Peacock: Cosmological Physics, Cambridge University Press (1999).

4.Course Plan: (Sections/Articles refer to Text Book)

| Lect No. | Learning Objectives | Topics to be covered | Chapter in the Text Book |
|-----------------|---|---|---------------------------------|
| 1 | Introduction | Brief history of cosmological ideas | Chapter 1 |
| 2-5 | Observational overview of the Universe | In visible light, In other wavebands, Homogeneity and isotropy, The expansion of the Universe, Particles in the Universe | 2.1-2.5 |
| 6-8 | Newtonian Gravity and basic equations of the Universe | The Friedman equation, Meaning of the expansion, Things that go faster than light, The fluid equation, The acceleration equation, Mass, energy and vanishing factors of c^2 | 3.1-3.6 |
| 9,10 | The geometry of the Universe | Flat, Spherical and Hyperbolic geometries, Infinite and observable Universes, Place of Big Bang, Three values of k | 4.1-4.6 |
| 11-13 | Simple cosmological models | Hubble's law, Expansion and redshift, Matter, Radiation, Mixtures, Particle number densities, Evolution including Curvature | 5.1-5.5 |
| 14,15 | Observational parameters | Hubble parameter, Density parameter, Deceleration parameter | 6.1-6.3 |

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|--------|---|---|--------------------------|
| 16,17 | Cosmological constant and age of the Universe | Cosmological constant, Fluid description, Cosmological models with cosmological constant, Age of the Universe | 7.1-7.3 Chapter 8 |
| 18-21 | Density of Universe and dark matter | Weighing the Universe through counting stars, nucleosynthesis, galaxy rotation curves, galaxy cluster composition, bulk motions, formation of structure, brightness of supernovae, Nature of dark matter and its searches | 9.1-9.3 |
| 22-24 | Cosmic microwave background | Properties of the microwave background, photon to baryon ratio, origin of microwave background | 10.1-10.4 |
| 25-27 | Early Universe and nucleosynthesis | The early Universe, Hydrogen and Helium, Comparing with observations, Contrasting decoupling and nucleosynthesis | Chapter 11 12.1-12.3 |
| 28-32 | Inflationary Universe | Problems with Hot Big Bang: Flatness, horizon and relic particle abundances, Inflationary expansion, Solution of Big Bang problems, Extent of inflation, Inflation and particle physics | 13.1-13.5 |
| 33, 34 | Initial singularity and the overview of standard cosmological model | The initial singularity, Overview of the standard cosmological model | Chapter 14 Chapter 15 |
| 35-40 | Advanced topics | General relativistic cosmology, Distances and luminosities, Structures in the Universe | Advanced topics 1-2,5 |

5. Evaluation Scheme:

| Evaluation Component | Duration | Weightage | Date & Time | Nature of Component |
|----------------------|----------|-----------|---------------------|---------------------|
| Quiz 1 | 30 min | 10% | | Open Book |
| Seminar | | 10% | | Open Book |
| Midsemester | 90 min | 30% | 04/11 3.30 - 5.00PM | Closed Book |
| Quiz 2 | 30 min | 10% | | Open Book |
| Compre. Exam | 3Hr. | 40% | 28/12 AN | Closed Book |

6. Make-up: Make up for the tests will normally be held in the following week. Prior permission must be taken for make-up in advance except extreme medical cases.

7. Chamber consultation hour: To be announced in the class.

8. Notices: All notices related to the course will be put up on CMS.

9. Academic Honesty and Integrity Policy: Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

Instructor-in-charge