PHY4042 : Physics of the Universe

Programme: B.Tech. (CSE,CCE,ECE,MME) Year: 4th Semester : 2
Course : Elective Credits : 4 Hours :40

Course Context and Overview (100 words):

We are fortunate to be living in an era where sophisticated satellite-borne and cutting edge ground-based technologies are enabling discoveries about both the fundamental physics and the contents of the universe we live in. This course will introduce the fundamental physics required to understand the universe we all live in. In addition to providing a general framework for understanding the universe we live in and the modern developments taking place this course will also show the interplay between the different parts of physics such as the General Theory of Relativity, Thermodynamics, Nuclear and Particle Physics. This is so because, we of course, need to use the General Theory of Relativity, Thermodynamics, Nuclear and Particle Physics in order to understand the universe we live in.

Prerequisites Courses:

Only Core Courses

Course outcomes(COs):

On completion of this course, the students will have the ability to:
CO1 Use mathematical and physical principles to describe the laws governing the universe as a whole.
C02 Use Einstein's General Theory of Relativity to describe and understand the dynamics of space-time.
C03 Describe the time evolution of the Universe by using the appropriate Differential Equations (Friedmann Equations) and determine the rate of expansion of the Universe ever since the Big Bang by solving these differential equations (Friedmann's Equations) for the cases of physical interest: namely for the radiation dominated universe, the matter dominated universe and and the vacuum energy dominated universe. They will also be able to determine the age of the Universe, its relationship to the Hubble constant and hence use the observational data to arrive at the necessity for the vast majority of the energy density of the Universe to be in the form of Dark Energy.
C04 Use Thermodynamics and apply it to the Universe at large and arrive at the appropriate expressions for the pressure, the energy density, the equation of state and entropy starting from first principles.
C05 Acquire and use the knowledge of the fundamental constituents of matter and radiation and the fundamental interactions of nature so as to get the total number of degrees of freedom present at any given moment in the history of the Universe and use the knowledge of

thermodynamics and the fundamental constituents of matter to trace the history of the Universe from the Big Bang till today.

Course Topics:

Topics	Lectures
❖ **General Introduction**	**5**
❖ **Dynamics of Space-Time: The General Theory of Relativity**	**10**
❖ **Standard Cosmology: Space-Time for Cosmology described by the Robertson-Walker Metric; Time Evolution for Cosmology described by the Friedmann Equations; Expansion Age of the Universe**	**10**
❖ **Equilibrium Thermodynamics**	**5**
❖ **Brief Thermal History of the Universe**	**5**
❖ **Structure Formation in the Universe**	**5**

Textbook references (IEEE format):
Text Book:
Gravitation and Cosmology, by S. Weinberg

Reference books:
The Early Universe, by E. W. Kolb and M.S. Turner.

Additional Resources (NPTEL, MIT Video Lectures, Web resources etc.):

Evaluation Methods:

Activities	**Percentage**
Mid Sem Exam	**30**
Attendance and Participation	**20**
End Sem Exam	**50**
Total	**100**

Prepared By: Anupam Singh
Last Update: _____