502. Astronomy

(ASTRONOMY/ASTROPHYSICS)

Unit I: Basic Physics
Hamiltonian Mechanics

Generalized coordinates. Principle of Least Action. Lagrange's and Hamilton's mechanics.

Statistical Mechanics

Entropy and probability. Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics. Planck's law of radiation. Equation of state of matter in non-degenerate and completely degenerate states. Saha and Boltzmann equations.

Theory of Relativity

Lorentz transformation. Length contraction and time dilation. Relativistic addition of velocities. Conservation of mass and momentum. Equivalence of mass and energy. Relativistic Doppler shift and aberration of light. Elementary ideas about general theory of relativity with observational tests.

Mathematical Methods of Physics
Ordinary differential equations

Solution of ordinary differential equation. Solution by power series methods, Solutions of Legender's, Bessel's, Laguerre's and Hermit's differential equations.

Partial differential equations

Solutions by the method of separation of variables. wave, diffusion and Laplace's equations and their solutions.

Special functions

Gamma, Beta, Legendre and Bessel functions of the first kind and their properties.

Fourier Series and Transforms

Definition and expansion of a function of x. Extension of interval. Complex form of Fourier series. Fourier's integrals. Fourier transform and their inverse. Applications of Fourier transform.

Celestial Mechanics
Fundamentals of Celestial Mechanics

Newton's laws of motion. Newton's Law of Gravitation, Kepler's Laws of Planetary motion.

N - Body problem

The ten integrals of motion of the n-body problem. Transfer of origin to one of the particles. The perturbing function. Virial theorem.

The Three Body problem

Lagrange's solution for the motion of three bodies. Restricted three body problem . Surfaces of zero relative velocity. Roche lobes.

UNIT - II

Basic Astronomy

<u>Celestial Sphere and Time</u>

Equatorial, ecliptic and galactic system of co-ordinates. Aspects of sky from different places on the earth. Seasons, Sidereal, Apparent and Mean solar time and their relations. Equation of time.

<u>Apparent and Mean Position of stars</u>

Effects of atmospheric refraction, aberration, parallax, precession, nutation and proper motion on the coordinates of stars.

<u>Stellar Distances and Magnitudes</u>

Distances of stars from the trigonometric. secular and moving cluster parallaxes. Stellar motions. Magnitude scale and magnitude systems. Atmospheric extinction. Absolute magnitudes and distance modulus. color index.

<u>Binaries and Variable Stars</u>

Visual, spectroscopic and eclipsing binaries. Importance of binary stars as source of basic astrophysical data. Classification and properties of various types of intrinsic and eruptive variable stars. Astrophysical importance of the study of variable stars. Novae and Supernovae.

Solar System

Origin of the solar system.

<u>The Earth's Upper Atmosphere</u>

Variations of atmospheric densities and temperature. Formation and structure of Ionosphere. Studies of ionosphere by ground based and space techniques. The radiation belts. Aurorae.

<u>The Sun</u>

Surface features of the sun. Internal structure of the Sun its photosphere, chromosphere and corona. Sun spots, Solar granulation and super granulation, solar flares, solar activity solar wind, solar radio bursts, Solar convection and differential rotation. Large scale & small magnetic fields and solar-terrestrial relations.

<u>Planets</u>

General features and internal structure of planets.

<u>Asteroids, Meteors and Meteorites</u>

Minor planets (Asteroids), their orbits and physical nature. Origin of the minor planets. Meteors and Meteorites, their types and composition.

<u>Comets</u>

Periodic comets. Physical nature. Spectra. Brightness variation. Gas production rates, dust and ion tails. Nature of dust particles and origin of comets.

Astronomical Techniques

<u>Telescopes</u>

Types of telescopes. Design and construction of a simple optical telescopes. Schmidt telescopes. Solar telescopes.

<u>Detectors</u>

Detectors for optical and infrared regions. Astronomical CCD's

<u>Photometry and Spectroscopy</u>

Astronomical photometry. Simple design of an astronomical photometer. Observing technique with a photometer. Correction for atmospheric extinction. Transformation to a standard photometric system. Design of a simple spectrograph. Radial velocity measurements.

<u>Radio Astronomy Techniques</u>

Electro-magnetic spectrum. Radio window. Design and construction of a simple radio telescope. Receiver systems and their calibration. Design and construction of a simple radio interferometer. Design of Giant Meter Radio Telescope (GMRT) at Pune and its applications in astronomical studies.
Design of the MST Radar at Tirupati and its applications for Ionospheric and astronomical studies.

UNIT - III

Stellar Spectroscopy

Spectra of Stars
HR diagram, HD and MK spectral classification of stellar spectra. Radiation laws and basic ideas on spectral line formation. Explanation of stellar spectra in terms of Boltzmann and Saha equations.
Qualitative description of Causes of Line Broadening
Natural damping. Collisional damping. Doppler broadening and microturbulence. Effect of rotation, pulsation and macro turbulence on line profiles.
Curve of Growth
Theory of the curve of growth. Application of the curve of growth to the study of solar and stellar atmospheres. Limitations of the curve of growth method.

Stellar Structure and Evolution
Fundamental Equations
Equation of mass distribution. Equation of hydrostatic equilibrium. Equation of energy transport by radiative and convective processes. Equation of thermal equilibrium. Equation of state. Stellar opacity. Stellar energy sources.
Stellar models
The overall problem and boundary conditions. Russell-Voigt theorem. Dimensional discussions of mass-luminosity law. Polytropic configurations. Homology transformations.

Stellar Evolution
Jean's criterion for gravitational contraction and its difficulties. Pre-main-sequence contraction under radiative and convective equilibrium. Evolution in the main sequence. Growth of isothermal core and subsequent development. Ages of galactic and globular clusters.
Superdense Objects
Use of polytropic models for completely degenerate stars. Mass-radius relation.. Stability of white dwarfs. Final cooling of white dwarfs. Accretion by white dwarfs and its consequences. Pressure ionisation and mass-radius relation for cold bodies. Supernova remnants and pulsars, neutron stars and black holes.

UNIT - IV

Galactic Structure and Interstellar Matter

Interstellar Matter
Composition and properties of interstellar matter. Interstellar extinction. Estimate of colour excess. Visual absorption. Interstellar reddening law and Polarisation.
Distribution of HI in the Galaxy
21-cm line observations. Spin temperature. Interstellar magnetic fields. Stromgren's theory of H II regions. Physical processes in planetary nebulae.
Stellar Motions
Distribution of stars in space. Statistical parallaxes. Local standard of rest. Solar motion and its determination. Peculiar velocities. Single and Two star stream hypothesis. Velocity ellipsoid. Comparison with solar neighbourhood. Bottlinger's diagram.
Galactic Structure
General galactic rotational law. Oort's theory of galactic rotation. Determination of Oort's constants. Spiral structure of our Galaxy from optical and radio observations. Size and mass of our galaxy.

Galaxies and Universe
Extragalactic Systems
Classification of galaxies and clusters of galaxies. Galaxy interactions. Determination of the masses. Determination of extragalactic distances.
Active Galaxies
Active galaxies and galactic nuclei. Properties of Radio galaxies and Quasars. Their energy problem and accretion discs.
High Energy Astrophysics
The importance of X-ray and Gamma ray windows. General observational techniques. The distributions of sources in our galaxy. Extragalactic sources. Emission mechanism. Nature and origin of Cosmic rays.
Cosmology
The expanding universe. Microwave background radiation. Cosmological models and observational tests. Interpretation of Red-shift. Dark matter in galaxies and clusters of galaxies and its implications on the models of cosmology. Composition of the dark matter.