University College of Science, Osmania University
THE SYLLABUS FOR M.Sc. ASTROPHYSICS SEMESTER WISE COURSE
Scheme of Instruction and Examination (w.e.f. the academic year 2013-2014)
(Restructured CHOICE BASED SYSTEM)

1. This course will be of 4 semester duration opened to First and Second class B.Sc.'s with Physics and Mathematics as two optional.
2. Admission will be based on merit in the entrance test in Physics conducted by the University.
3. The syllabus for both Theory and Practical courses in I and II semesters is common for M.Sc. Astrophysics and M.Sc. Physics courses. Hence the theory and practical classes of I and II semester will be held in the Physics department, O.U. along with M.Sc. Physics students. The Theory and Practical courses of III and IV Semesters will be taught in the department of Astronomy.

Scheme of Instruction and Examination

SEMESTER – 3

Sl. No.	Sub. Code	Subject	Instructions Hrs/Week	Duration of Exam	Max. Marks	Credits
1	Ap 1	Basic Astronomy	4	3	100	4
2	Ap 2	Stellar Structure and Evolution	4	3	100	4
3	Ap 3	Galactic Structure and Interstellar Matter	4	3	100	4
4	Ap 4	Classical (Celestial)Mechanics	4	3	100	4
PRACTICALS						
5	Ap Pr 1	Numerical Methods	9	3	100	4
6	Ap Pr 2	Computer Applications	9	3	100	4
7		Seminar	2			1
		Total:	34+2		600	**25**

SEMESTER – 4

S. No.	Sub. Code	Subject	Instructions Hrs/Week	Duration of Exam	Max. Marks	Credits
1	Ap 5	Galaxies and Universe	4	3	100	4
2	Ap 6	Space Physics	4	3	100	4
3	Ap 7	Astronomical Techniques	4	3	100	4
4	Ap 8	(i) Dynamics of Stellar Systems (ii) Basics of Nanoscience	4	3	100	4
PRACTICALS						
5	Ap Pr 3	Positional Astronomy	9	3	100	4
6	Ap Pr 4	Project Work	9	3	100	4
7		Seminar	2			1
		Total:	34+2		600	**25**

SEMESTER -3

Theory Paper 1: Basic Astronomy

Unit - 1

Celestial Sphere and Time

Constellations and nomenclature of stars. The cardinal points and circles on the celestial sphere. Equatorial, ecliptic and galactic system of co-ordinates. Spherical triangle and related problems. Aspects of sky from different places on the earth. Twilight, Seasons, Sidereal. Apparent and Mean solar time and their relations. Equation of time. Ephemeris and Atomic Times. Calendar. Julian date and heliocentric correction.

Unit - 2

Apparent and Mean Position of stars

Effects of atmospheric refraction, aberration, parallax, precession, nutation and proper motion on the coordinates of stars. Reduction from apparent to mean places and vice versa.

Unit - 3

Stellar Distances and Magnitudes

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. Colour index. Black-body approximation to the continuous radiation and temperatures of stars. Variable stars as distance indicators.

Unit - 4

Binaries and Variable Stars

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.

REFERENCES

1. W.M.Smart: Text book of Spherical Astronomy.
2. A.E.Roy: Orbital Motion.
3. McCusky: Introduction to Celestial Mechanics.
4. K.D.Abhyankar: Astrophysics:Stars and Galaxies.Tata McGraw Hill Publication (Chap.2)
5. G.Abell: Exploration of the Universe.
6. A.Unsold: New Cosmos.
7. Baidyanath Basu: Introduction to Astrophysics.

Theory Paper 2: Stellar Structure and Evolution

Unit - 1

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.

Unit - 2

Stellar models

The overall problem and boundary conditions. Russell-Voigt theorem. Dimensional discussions of mass-luminosity law. Polytropic configurations. Homology transformations.

Unit - 3

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.

Unit - 4

Superdense Objects

Use of polytropic models for completely degenerate stars. Mass-radius relation. Non-degenerate upper layers and abundance of Hydrogen. 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. Neutron stars and black holes.

REFERENCES

1. M.Schwarzschild:Stellar Evolution
2. S.Chandrasekhar:Stellar Structure
3. K.D.Abhyankar:Astrophysics: Stars and Galaxies
4. Menzel,Bhatnagar and Sen:Stellar Interiors.
5. Cox and Guili:Principles of Stellar Interiors - Vol.I and II.
6. Shapiro and Tevkolsky: White Dwarfs, Neutron Stars and Black Holes.
7. R.Bowers and T.Deeming:Astrophysics (John and Barlett.Boston).

Theory Paper 3: Galactic Structure and Interstellar Matter

Unit - 1

Interstellar Matter

Composition and properties. Amount of interstellar matter. Oort limit. Interstellar extinction. Estimate of colour excess. Visual absorption. Interstellar reddening law and Polarization.

Unit - 2

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.

Unit - 3

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.

Unit - 4

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.

REFERENCES

1. A.Unsold: The New Cosmos (3rd Edition). Springer-Verlag 1983.
2. Mihalas and J.Binney: Galactic Astronomy. W.H.Freeman 1981.
3. K.D.Abhyankar: Astrophysics - Stars and Galaxies. Tata McGraw Hill Publication (Chap.13-18).
4. L.Spitzer: Physical Processes in the Interstellar Medium. John Wiley 1978.
5. M.Sandage and J.Kristian: (Ed.) Galaxies and the Universe. University of Chicago Press.
6. Bowers and Deeming: Astrophysics Vols.1 and 2.
7. Baidyanath Basu: Introduction to Astrophysics.

Theory Paper 4: Classical (Celestial) Mechanics

Unit – 1

Newtonian Formulation and The Two Body Problem

Newton's laws of motion. Mechanics of a particle. Equations of motion of a particle. Mechanics of a system of particles. Law of Gravitation. Motion in a Central Force Field. Motion in an inverse square law force field. Kepler's Laws. Formulation of the two body problem. Integrals of area, angular momentum and energy. Equation of the relative orbit and its solution. Kepler's equation and its solution. F and g series. Orbit computation by Laplace and Gauss methods.

Unit – 2

Three-Body Problem and The N-Body Problem

The Three Body Problem – its equations of motion. Lagrange's solution for the motion of three bodies. Restricted three body problem. Surfaces of zero relative velocity. Double points. Stability of straight line and equilateral triangle solutions. Tisserand's Criterion for identification of comets. The ten integrals of motion of the n-body problem. Transfer of origin to one of the particles. The perturbing function. Virial theorem.

Unit – 3

The Lagrangian Formulation

Constraints, Classification of Constraints, Principal of Virtual Work, D' Alembert's Principal, Lagrangian formulation of Mechanics. Equations of motion in Lagrangian formulation. Mechanics of a particle in Lagrangian formulation. Equations of motion of two body problem and three body problem in Lagrangian formulation. Cyclic or ignorable coordinates.

Unit – 4

Rigid body motion and Orbital Mechanics

Euler's theorem. Euler's equations of motion. Euler's angles. Motion of a rocket. Step rockets. Minimum energy orbits. Transfer orbits. Parking orbits. Perturbations of artificial satellites due to atmospheric drag and flattening of the earth.

REFERENCES

1. Classical Mechanics by H.Goldstein , Narosa Publishing Home,, New Delhi.
2. N.C.Rana: Classical Mechanics
3. R.G.Takwale and P.S.Puranik: Introduction to Classical Mechanics.
4. W.M.Smart: Text book of Spherical Astronomy.
5. A.E.Roy: Orbital Motion.
6. McCusky: Introduction to Celestial Mechanics
7. K.D.Abhyankar: Astrophysics of the solar system.
8. F.R.Moulton: An Introduction to Celestial Mechanics
9. Danby: Fundamentals of Celestial Mechanics.

Practical 1: Numerical Methods

1. Precision of measurements and accuracy of calculations.
2. Normal Distribution and method of least squares.
3. Numerical interpolation.
4. Numerical differentiation and integration.
5. Solution of ordinary differential equations.

Practical 2: Computer Applications

1. Operating Systems : WINDOWS, UNIX/LINUX.
2. Editors : Word and vi
3. Numerical Analysis using available software.
4. Programming concepts: Language : C/ FORTAN
5. Basics of image processing & data analysis : IRAF

REFERENCES

1. J.B.Scarborough: Numerical Analysis.
2. R.Subramanian. P.Achutan. and K.Venkatesan(Translators): Numerical Analysis for Engineers and Physicists.
3. P.S.Grover: Programming and computing with Fortran IV.
4. M.K.Jain. S.R.K.Iyengar and R.K.Jain: Numerical Methods for Scientific and Engineering Computation.
5. R.C.Desai: Fortran Programming and Numerical Methods.
6. Aarseth, S.J. 1985, Multiple Time Scales, ed. J.U.Brachsbill & B.I. Cohen (Orlando: Academic Press), p. 377.

SEMESTER -4

Theory Paper 5: Galaxies and Universe

Unit - 1

Extragalactic Systems

Classification of galaxies and clusters of galaxies. Galaxy interactions. Determination of the masses. Determination of extragalactic distances.

Unit - 2

Active Galaxies

Active galaxies and galactic nuclei. Properties of Seyferts. Radio galaxies and Quasars. Their energy problem and accretion discs.

Unit - 3

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

Unit - 4

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 dark matter.

REFERENCES

1. A.Unsold: The New Cosmos (3rd Edition). Springer-Verlag 1983.
2. Mihalas and J.Binney: Galactic Astronomy. W.H.Freeman 1981.
3. K.D.Abhyankar: Astrophysics - Stars and Galaxies. Tata McGraw Hill Publication, (Chap.13-18).
4. L.Spitzer: Physical Processes in the Interstellar Medium. John Wiley 1978.
5. M.Sandage and J.Kristian: (Ed.) Galaxies and the Universe. University of Chicago Press.
6. Bowers and Deeming: Astrophysics Vols.1 and 2.
7. Baidyanath Basu: Introduction to Astrophysics.

Theory Paper 6: Space Physics

Unit - 1

The Earth's Upper Atmosphere

Variations of atmospheric densities and temperature. Formation and structure of Ionosphere. Studies of ionosphere by ground based and space techniques. The radiation belts. Auroras. Lyman glow of the night sky. The geo-corona and airglow studies.

Unit - 2

Sun and Interplanetary Medium

Structure of solar atmosphere. Solar convection and differential rotation. Large scale and small scale magnetic fields. Solar granulation and super granulation. Sunspots. Solar flares. EUV, X-ray and g-ray studies of sun. Solar X-ray and radio bursts.

Solar wind. Interaction with planetary atmosphere. Structure of bow shocks. Magnetosphere. Ring Current. Radiation belts and interplanetary magnetic field.

Unit - 3

Moon

Origin of Moon. Solar and Lunar eclipses. Lunar ranging experiments. Studies of lunar surface from various space missions and their results. Satellites of other planets of the solar system.

Unit - 4

Planets

Infrared spectroscopy of planetary atmospheres. Principal results of the Mariner, Venera and Viking Space Missions to Mars and Venus. Voyager space mission studies of outer planets and their satellites and rings. Comparative studies of planetary atmospheres. Planetary ionospheres. Extra-solar system planets.

REFERENCES

1. J.A.Ratcliffe: An Introduction to the Ionosphere and Magnetosphere.
2. Kaula. W.M.: An Intoduction to Planetary Physics.
3. Harold Zirin: Astrophysics of the Sun.
4. W.N.Hess and G.Mead(Ed): Introduction to Space Science.
5. V.Bedmtay and Kleczek:Basic Mechanism of Solar Activity.
6. Sagan C. Owen T. C. and Smith. H.J.: Planetary Atmospheres.
7. Kaufmann, W.J. : Exploration of the Solar System.
8. Baugher, J.F.: The space age solar system
9. K.D. Abhayankar: Astrophysics of the solar system.

Theory Paper 7: Astronomical Techniques

Unit - 1

Telescopes

Types of telescopes. Design and construction of a simple Optical telescopes. Schmidt telescopes. Sky charts and their importance. Solar telescopes.

Unit - 2

Detectors

Detectors for optical and infrared regions. Application of CCD's to stellar imaging, photometry and spectroscopy. Techniques of observations of astronomical sources from space in infrared. EUV, X-ray and gamma-ray regions of the electromagnetic spectrum.

Unit - 3

Photometry and Spectroscopy

Astronomical photometry. Simple design of an astronomical photometer. Observing technique with a photometer Correction for atmospheric extinction. Tansformation to a standard photometric system. Astronomical spectroscopy. Spectral classification. Simple design of astronomical spectrograph. Radial velocity measurements.

Unit - 4

Radio Astronomy Techniques

Basic parameters of an antenna. Various types of antennas. Non-steerable, partially steerable and fully steerable radio telescopes. Receiver systems and their calibration. Two-element and multi-element Interferometers. LB. and VLBI Systems. Aperture Synthesis.

REFERENCES

1. C.R.Kitchin: Astrophysical Techniques.
2. Gordon Walker: Astronomical Observations - an Optical Perspective (Cambridge University press).
3. Henden and Kaitchuck: Astronomical Photometry.
4. Astrophysics-Stars and galaxies by K.D.Abhyankar.
5. C.R.Miczaika and W.M.Sinton: Tools of the Astronomers
6. W.A.Hiltner (Ed): Astronomical Techniques.
7. Carleton: Methods of Experimental Physics. Vol.XIIA.

Theory Paper 8 (i): Dynamics of Stellar Systems

Unit - 1

Dynamics of Star Clusters

Jacobi criterion of stability and Virial theorem. Masses from Virial theorem. Effects of Stellar encounters. The relaxation time. Isothermal model for globular clusters. Tidal effects of the galaxy and interstellar clouds. Dynamical evolution of star clusters.

Unit - 2

Stellar Dynamics and the structure of Galaxies

The collisionless Boltzamnn equation. The hydrodynamical equations . Jean's theorem. Some basic properties of the galaxies. Mass models of the galaxy. Epicyclic orbits. The theird integral. Classifications of galaxies. Luminosity and colour distributions in galaxies. Internal motions. Masses and content of falaxies. Models of elliptical galaxies and globular clusters. Masses of clusters of galaxies.

Unit - 3

Dynamics of Interacting Galaxies

Basic principles. Energy changes in the distant and non-penetrating pairs. Hyperbolic close collisions. Slow collisions and mergers Galactic bridges, tails and rings. Results of N-body simulations.

Unit - 4

Dark Matter in the Universe

Dark Matter in individual galaxies and systems of galaxies and its implications on the models of cosmology. Composition of dark matter.

REFERENCES

1. D. Mihalas: Galactic Astronomy
2. S. Chandrasekhar: Principles of Stellar Dynamics
3. James Binney and Scoth Tremaine: Galactic Dynamics: Chapters 2, 4, 5 &7
4. K. C. freeman: Galaxies and Universe< Chapter 2, Pp.409-448
5. D. Mihalas and J. Binney: Galactic Astronomy
6. S. D. M. White: The Origin and Evolution of Galaxies
7. S. M. Alladin: Lecture notes on Dynamics of Stellar Systems.
8. J. E. Barnes: Dynamics of Ga;axy Interactions, Lecture notes 1996, Swiss society for Astrophysics and Astronomy "Galaxies Interactions and induced star formation".

Theory paper 8(ii): Basics of Nanoscience

Unit – 1

History of Nanoscience and Technology – Conceptual origins and experimental advances, Differences between micro and nano type materials, Benefits and Potential risks – Implications of nanomaterials – Health isues, Environmental issues, Societal implications. Need for regulations.

Unit –2

Classification of nano materials – Three, Two, One and Zero dimensional materials with examples, Synthesis of Nanomaterials – Methods of synthesis, Bottom up methods – Solgel, Hydrothermal, Spray pyrolysis, Coprecipitation, Top down methods, Mechanical milling, Chemical vapor deposition.

Unit – 3

Characterization of Nanomaterials – X– ray diffraction, Atomic force microscope (AFM), Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), UV-Visible spectroscopy, Raman spectroscopy, Particle size analyzer.

Unit – 4

Applications of Nanomaterials – Medical, Chemical, Environmental, Energy, Information and Communication, Defence, Consumer goods, Nanosensors, Nanoelectronics, Applications based on Mechanical, Electrical, Optical, Magnetic properties of Nanomaterials and Biology at nanoscale.

REFERENCE BOOKS

1. Nanomaterials by A.K. Bandyopadhyay, New Age International Publications, 2009
2. Chemistry of nanomaterials: Synthesis, Properties and applications by CNR Rao et al.

Practical 3: Positional Astronomy

1. Computation of a lunar eclipse.
2. Computation of a solar eclipse.
3. Computation of an ephemeredes of a planet, asteroid or comet.
4. Computation of lunar and planetary occultation of a star.

Practical 4: Project Work