Shivaji University, Kolhapur

Syllabus For

B.Sc.III

Astrophysics and Space Science

[Sem V and SemVI]

(Syllabus to be implemented from June, 2018 onwards.)

Semester Pattern

SemV: Paper IX : Introduction to Cosmology

SemV: Paper X : Introduction to Space Science

SemV: Paper XI : Astronomical Techniques and Devices

SemV: Paper XII : Fundamentals of Solar Astronomy

Sem VI: Paper XIII : Stellar Evolution and structure

Sem VI: Paper XIV :Solar System and Planets

Sem VI: Paper XV :The Planet Earth

Sem VI: Paper XVI :Relativistic Astronomy and Astrophysics

Note: The Practical course work will be covered in 4 groups each of 40 marks.

Semester V

Paper IX: Introduction to Cosmology

Unit 1.General Structure of the Universe (15)

The Expanding Universe, Cosmological Theories- Big- Bang theory, Oscillating theory, Steady state theory,Tests for cosmological theories. The age of the Universe, Origin of the elements- The Neutron capture theory, Nuclear synthesis from protons, Formation of Lithium and Deuterium, Dark matter, The Cosmic Microwave Background.

Unit 2.Homogeneous and Inhomogeneous Universe(15)

Introduction and Fundamental Observations, Consequences of the Friedmann Expansion, Thermal History of the Universe, Gravitational Instability, Description of Density Fluctuations, Origin of the Density Fluctuations, Evolution of Density Fluctuations,

Unit 3.Galaxies(15)

The formation of Galaxies, Types of Galaxies- Spiral, Elliptical, Irregular, Properties of Galaxies- mass, mass to light ratio,Scaling relation- The Tully-Fisher relation, The Faber-Jackson relation, The D_n-σ relation, Black Holes in the Centers of Galaxies, Extragalactic distance determination.

Unit 4.The Milky Way Galaxy(15)

Origin of the Milky way galaxy, Spiral Structure of the galaxy, Galactic Coordinates, The Mass of the Galaxy, The galactic center, Stellar Populations in the Galaxy, Kinematics of the Galaxy

References:

1. Sourcebook of the space science, Samuel Glasstone, D. Van Nostrand Company, Inc., New York, 1965
2. Foundation of Astronomy, Michael A. Seeds,10^{th} edition, Thomson Learning, Inc., USA, 2008.
3. Extragalactic Astronomy and Cosmology, Peter Schneider, Springer Berlin Heidelberg New York, 2006
4. Astronomy, Andrew Fraknoi, David Morrison, Sidney C. Wolff, OpenStax, Rice University. 2017
5. Cosmology (The Origin and Evolution of Cosmic Structure), Second Edition, Peter Coles, Francesco Lucchin, John Wiley & Sons, Ltd, England, 2002

Semester V

Paper X: Introduction to Space Science

Unit 1: Ancient Astronomy(15)

Astronomy in India-Famous Astronomers and Their Works, Armillary sphere, Observatories- Mahodayapura, Kasi manmandira, Maharaja sawai Jay singh`s observatory Delhi, Instruments –Self rotating wheel, Shadow instrument, Water instrument.*Astronomy around the world*- Early Greek and Roman Cosmology, Measurement of Earth by Eratosthenes, Hipparchus and Precession, Galileo and the Beginning of Modern Science.

Unit 2: Observing the sky(15)

The Celestial Sphere, Celestial Poles and Celestial Equator, Locating Places in the Sky, The Cycles of the Sun – Constellations- Ursa major, Orion, Taurus, Auriga, Nakshatra- Formation and structure.

Unit 3: Applications of Space Studies(15)

The purpose of space exploration, Meteorology- problems of weather prediction, development of space meteorology, Communication- radio wave propagation, communication system, Navigation- position determination using Doppler technique, navigation by range measurement, Remote sensing.

Unit 4: Life in the Universe(15)

Cosmic context for life, Astrobiology- Building Blocks of Life, The Origin and Early Evolution of Life, Searching for life beyond earth- Life on Mars, Life in the Outer Solar System, Habitable Planets Orbiting Other Stars, The search for extraterrestrial intelligence- Interstellar Travel, Messages on Spacecraft, Radio Searches

Reference:

1. Astronomy in India: A Historical Perspective, ThanuPadmanabhan, Indian National Science Academy, New Delhi,2014
2. Indian Astronomy – a source book, B. V. Subbarayappa, K. V. Sharma, Nehru Centre Bombay, 1985
3. The Story Of Astronomy in India, Chander Mohan, 2015
4. Astronomy, Andrew Fraknoi, David Morrison, Sidney C. Wolff, OpenStax, Rice University. 2017
5. Astronomy And Astrophysics Library, Martin Harwit, 4th edition, Springer, 2006
6. Introduction to space science, Bruce A. Campbell, Samuel Walter, Gulf publishing Company, Texas, 1995

Semester V

Paper XI: Astronomical Techniques and Devices

Unit 1: Coordinate systems (15)

Co-ordinates on a celestial sphere, Horizon coordinates, Equatorial coordinates, Galactic coordinates, Ecliptic coordinate system , Reference frames , Transformations

Unit 2: Time and calendar(15)

Solar time- introduction, variation in the apparent solar time, the equation of time, Calculation of equation of time- the two parts of equation of time, equation of the center, reduction of the equator, Other scales of time- Universal Time (UT), Zonal Standard Time (ZST), Ephemeris Time (ET), Sidereal Time (ST), Greenwich Mean Sidereal Time (GMST), Universal Coordinated Time (UTC), Terrestrial time, (TT), Tropical calender, Lunar and Luni-solar calender

Unit 3: Detectors and statistics(15)

Introduction, Position-insensitive detectors - Photomultiplier and photometry, Proportional counter, Position-sensitive detectors - Charge-coupled Device, Gamma-ray instruments - EGRET experiment • Detector subsystems, BATSE experiment, Statistics of measurements- Instrumental noise • Statistical fluctuations – "noise", Background, Comparison to theory

Unit 4: Tools for Astronomy(15)

Types of telescopes – Refractor, reflector, catadioptric, Ground based Telescopes-Radio Telescopes, Infrared Telescopes, Optical Telescopes, UV Telescopes, X-Ray Telescopes, Gamma-Ray Telescopes.

Observations outside Earth's Atmosphere-Airborne and Space Infrared Telescopes, Hubble Space Telescope

Reference:

1. Astrophysical Techniques, Fourth Edition, C R Kitchin, IOP Publishing Ltd 2003
2. Astronomy Methods, Hale Bradt, Cambridge University Press 2004
3. Astronomy, Andrew Fraknoi, David Morrison, Sidney C. Wolff, OpenStax, Rice University. 2017
4. Extragalactic Astronomy and Cosmology, Peter Schneider, Springer Berlin Heidelberg New York, 2006
5. Astrophysics of the solar system, K. D. Abhyankar, Universities press (India) private limited, 1999.

Semester V

Paper XII: Fundamentals of Solar Astronomy

Unit 1: Structure of Solar Atmosphere(15)

Hydrostatic Equilibrium in Solar Interior, Energy Generation, Energy Transport and Solar Model, The Neutrino Behavior, The Solar Constant - Solar Irradiance, Limb Darkening, Solar Rotation, Fast and Slow Streams, Rotation of the Chromosphere and Corona

Unit 2: The Active Sun(15)

Photospheric Activity, Faculae, Chromospheric Activity, Evolution of chromosphericactive regions, Largescale magnetic fields, Solar prominences and filaments, Support and Stability of Prominences, Solar flares, Coronal Mass Ejection (CME)

Unit 3: Observational Techniques(15)

Solar Parallax and Distance, Solar Mass, Solar Diameter, Density and Surface Gravity, Solar Luminosity L_o, Temperature of the Sun, Position Determination of Solar Features

Unit 4: Solar Optical Instrumentation(15)

Solar Optical Telescopy: Coelostat, Heliostat and Siderostat, Coronagraph, Solar Image Guiders, Spectrographs, Imaging the Sun: Spectroheliograph, Narrow Band Filters- Magneto-Optical Filter, Analysis of Filter-based Solar Magnetograph

References:

1. Fundamentals of Solar Astronomy, Arvind Bhatnagar, William Livingston, Vol. 6 , World Scientific Publishing Co. Pte. Ltd. Singapore, 2005
2. Astrophysics of the solar system, K. D. Abhyankar, Universities press (India) private limited, 1999.
3. The Fundamentals of Stellar Astrophysics George W. Collins II, Case Western Reserve University, 2003
4. Foundation of Astronomy, Michael A. Seeds,10^{th} edition, Thomson Learning, Inc., USA, 2008.

Semester VI

Paper XIII: Stellar Evolution and structure

Unit 1: Stellar astrophysics(15)

Introduction, Basic equations of stellar structure: Hydrostatic equilibrium in stars, Virial theorem for stars, Energy transport inside stars, Convection inside stars, Constructing stellar models, relations between stellar quantities, , Determination of stellar parameters, Important features of observational data,

Unit 2: The Birth of Stars(15)

Star Formation, The H–R Diagram- Main sequence, red giants and white dwarfs.Evolution from the Main Sequence to Red Giants, Star Clusters, Further Evolution of Starsand More Massive Stars

Unit 3: The Death of Stars(15)

The Death of Low-Mass Stars, Evolution of Massive Stars: An Explosive FinishSupernova Observations, Pulsars and the Discovery of Neutron Stars, The Evolution of Binary Star Systems, The Mystery of the Gamma-Ray Bursts

Unit 4: Black hole(15)

Introduction, Black HoleFormation- StellarStructure, StellarCollapse, Supermassive Black Holes, Intermediate-MassBlackHoles, MiniBlackHoles, Black Hole Thermodynamics, Black Hole Magnetospheres, BlackHole Interiors, Singularity, Evidence for Stellar-Mass Black Holes- Dynamical Arguments, The Search for the Signature of the Event Horizon

Reference:

1. Astrophysics for Physicists, Arnab Rai Choudhuri, Cambridge University Press, 2010
2. Astronomy, Andrew Fraknoi, David Morrison, Sidney C. Wolff, OpenStax, Rice University. 2017
3. The Fundamentals of Stellar Astrophysics George W. Collins II, Case Western Reserve University, 2003
4. Introduction to Black Hole Astrophysics, Gustavo E. Romero, Gabriela S. Vila, Springer-Verlag Berlin Heidelberg, 2014

Semester VI

Paper XIV: Solar System and Planets

Unit 1: Origin of Solar system(15)

Nebular Hypothesis, Difficulties with nebular hypothesis, The catastrophic theory, Relation to the formation of stars- consideration of angular momentum, star formation, shedding of the angular momentum by a single star, Formation of planets in the solar nebula- Weizacker's theory, Kuiper's theory, Hoyle's theory

Unit 2: A Survey of the Solar System(15)

A General View, Two Kinds of Planets- composition and structure, Space Debris, The Age of the Solar System, The process of Planet Building, The Chemical Composition of the Solar Nebula, The Condensation of Solids, The Formation of Planetesimals, The Growth of Protoplanets, Members of the Solar System, Explaination of the Characteristics of the Solar System

Unit 3: The Planets- An overview(15)

Physical properties- Size and shape, mass and density, Optical properties- Brightness, Albedo, Inference, Rotation and magnetic field –Mercury, Venus, Mars, Jupiter and Saturn, Uranus and Neptune, Surface temperature- theoretical and observed, Atmospheric structure of terrestrial and jovian planets, surface features of terrestrial planets, Planetary rings- Roche limit for the formation of rings.

Unit 4: Earthlike Planets: Venus and Mars(15)

Venus- History and celestial profile, rotation, atmosphere, Venusian greenhouse, surface, volcanism on Venus

Mars- History and celestial profile, canals on Mars, atmosphere, The Geology of Mars, Finding the Water on Mars, Search for life on Mars, Moons of Mars- origin and evolution

Reference:

1. Astrophysics of the solar system, K. D. Abhyankar, Universities press (India) private limited, 1999.
2. Foundation of Astronomy, Michael A. Seeds,10^{th} edition, Thomson Learning, Inc., USA, 2008.
3. Astronomy, Andrew Fraknoi, David Morrison, Sidney C. Wolff, OpenStax, Rice University. 2017
4. Sourcebook of the space science, Samuel Glasstone, D. Van Nostrand Company, Inc., New York, 1965

Semester VI

Paper XV: The Planet Earth

Unit 1: Structure of Earth(15)

Internal structure of Earth, Earth's magnetic field, Earths gravitational field, Motion of Earth, Earth's internal processes – Plate tectonics, earthquake, volcano, Solar – terrestrial relations, Origins of Life on Earth, The Chemical Basis of Terrestrial Life, The Evolution of the Atmosphere

Unit 2: The Ionosphere (15)

Discovery of ionosphere, electron density profile of ionosphere, minor ionospheric disturbances, major ionospheric disturbances, production and removal of electrons, the D Region, the E Region, the F Region, temperature in the ionosphere, interaction of radio frequency waves with ionosphere- attenuation of RF wave, reflection of RF wave, determination of electron density.

Unit 3: The magnetosphere(15)

The magnetosphere, geomagnetic field variation, sudden commencement magnetic storms, weaker magnetic disturbances, Sun Earth relationship, cosmic rays- solar and galactic.Van Allen radiation belt, characteristics of radiation zone.

Unit 4: Upper atmospheric phenomena(15)

Aurora-Auroral morphology, Auroral cycle, distribution of aurora, polar cap aurora, Auroral spectroscopy.

Airglow- introduction, airglow spectrum and emission mechanism, important chemical reactions for airglow, airglow and ionosphere

Magnetic storm- introduction, atmospheric dynamo and motor, sudden ionospheric disturbances (SID), magnetic storm- at polar region and other latitude

Reference:

1. Sourcebook of the space science, Samuel Glasstone, D. Van Nostrand Company, Inc., New York, 1965
2. Astrophysics of the solar system, K. D. Abhyankar, Universities press (India) private limited, 1999.
3. Research in geophysics (Volume 1), Hugh Odishaw, The M.I.T. Press, 1964
4. Earth Science, McGraw Hill, 2005
5. Astrophysical Concepts (Fourth Edition), Martin Harwit, Springer, 2006
6. Space science and Earth's environment, shrinivasDegaonkar, Gujrat University, 1975

Semester VI

XVI: Relativistic Astronomy and Astrophysics

Unit 1: The special theory of relativity(15)

Historical background, The origin of special relativity, The law of addition of velocities, Lorentz contraction and time dilatation, Relativity of simultaneity, Relativistic mechanics, The mass–energy relation, Compton scattering, The twin paradox, The Doppler effect

Unit 2: Experimental tests of general relativity(15)

Introduction, The PPN parameters, The gravitational redshift, The Pound–Rebka experiment, The precession of the perihelion of Mercury, The binary pulsar, The bending of light, Radar echo delay, The equality of inertial and gravitational mass, Precession of a gyroscope

Unit 3: Relativistic astrophysics(15)

Strong gravitational fields, Equilibrium of massive spherical objects, Gravitational binding energy, The Schwarzschild interior solution revisited, Supermassive stars, The post-Newtonian approximation, The first gravitational lens, The basic features of a gravitational lens, The magnification and amplification of images

Unit 4: Observational cosmology(15)

The redshift–magnitude relation, The Hubble diagram using Type Ia supernovae, Number counts of extragalactic objects- Counts of galaxies, Counts of radio sources, The variation of angular size with distance, The age of the Universe- Stellar evolution, Nuclear cosmochronology, Abundances of light nuclei, The microwave background radiation, Dark matter- Spiral galaxies, Clusters of galaxies, Dark energy

Reference:

1. An Introduction to Relativity, Jayant V. Narlikar, Cambridge University Press, 2010
2. Special and General Relativity, Springer, 2007
3. General relativity, astrophysics, and cosmology, A K Raychaudhuri; S Banerji; A Banerjee, Springer-Verlag, 1992
4. Relativity in Astrometry, Celestial Mechanics and Geodesy, Privatdozent Dr. Michael H. Soffel, Springer-Verlag Berlin Heidelberg, 1989

Practical course work for B. Sc. III

Astrophysics and Space Science(Sem V and Sem VI)

Practical course work for B. Sc. III Astrophysics and Space Science (Sem V and Sem VI)

The Practical course work will be covered in 4 Groups each of 40 Marks.

Group A: Group B: Group C: Group D:

Group A:

1. Temperature determination of an artificial star
2. Laboratory set up of Michelson Interferometer
3. Determination of Speed of light in air using Foucault's rotating mirror.
4. Verification of Bernoulli's Theorem
5. Verification of Beer's Law using simple Prism Spectrometer
6. Study of Lissajous figures.
7. Analysis of cubic powder pattern
8. Solar cell (Series and parallel)
9. Frequency response curve of Operational Amplifier.

Group B:

Project report on two significant astronomical events in the astronomical calendar of that Academic Year

Group C:

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. Solving differential equations s by Runge-Kutta Method
6. Analysis of material using Raman Spectroscopy
7. Identification of Functional groups using IR Spectroscopy.
8. Analysis of DTA Pattern.
9. Atmospheric pressure experiment.

Group D:

1. Working with Python Software for data handling
2. C-Programming fundamentals
3. Fortran Programming fundamentals
4. Getting familiar with Aldian sky atlas
5. Using Planetarium Software C2A
6. Examples on Fourier series and transform.
7. Devising a laboratory built 5 V power supply using rectifier and Zener diode.
8. Thermocouple.
9. Study of TGA pattern.

The scheme of practical marks distribution is as below.

- Each group of practical = 40 marks.(40×4=160)

- Journal= 20 marks.
- Tour report= 20 marks
- Total Marks= 200

The theory examination rules and regulation and nature of question paper for this subject will remain similar to the Physics exam. pattern.