Rayat Shikshan Sanstha's

Yashavantrao Chavan Institute of Science, Satara

(Autonomous)

Syllabus for B.Sc. Part – II (Astrophysics)

1. **Title:** Astrophysics
2. **Year of Implementation:** The syllabus will be implemented from June, 2019 onwards.

3. Preamble:

This syllabus is framed to give sound knowledge with understanding of Astrophysics to undergraduate students at B. Sc. – II as interdisciplinary subject.

Students learn Astrophysics as a separate subject at B.Sc. II. The goal of the syllabus is to make the study of Astrophysics popular, interesting and encouraging to the students for higher studies including research.

The new syllabus is based on a basic and applied approach with vigor and depth. At the same time precaution is taken to make the syllabus comparable to the syllabi of other universities and the needs of amateur astronomers and researchers.

The syllabus is prepared after discussion at length with number of faculty members of the subject and experts from various fields of Astronomy and Astrophysics and research fields.

The units of the syllabus are well defined, taking into consideration the level and capacity of students.

4. Program Specific Objectives:

1. The students are expected to understand the fundamentals, principles, physical concepts and recent developments in the Astrophysics area.
2. The practical course is framed in relevance with the theory courses to improve the understanding of the various concepts in Astronomy and Astrophysics.
3. It is expected to inspire and boost interest of the students towards Astrophysics as the interdisciplinary subject.
4. To develop the power of appreciations, the achievements in Astrophysics and role in nature and society.
5. To enhance student sense of enthusiasm for Astrophysics and to involve them in an intellectually stimulating experience of Course in a supportive environment.

5. Program Specific Outcomes:

1. Understand the fundamentals in the Astrophysics
2. Design and perform experiments in the laboratories to demonstrate the concepts, principles and theories of Astrophysics learned in the classroom.
3. Develop the ability to apply the knowledge acquired in the classroom and laboratories to specific problems in theoretical and experimental Astrophysics.
4. Identify their area of interest in academic, research and development.
5. Perform job in various fields' like space science, engineering and public service, etc. or be an entrepreneur with precision, analytical mind, innovative thinking, clarity of thought, expression, and systematic approach.

5. Duration: The course shall be a full time.

6. Pattern: Semester examination.

7. Medium of Instruction: English.

8. Structure of Syllabus: B.Sc. – II Semester –III

Paper Title	Theory			Practical		
	Paper Code	Lectures per week	Credits	Paper Code	Lectures per week	Credits
Fundamentals of Astronomy	BPAT 301	6	2	BPAP 303	8	4
Fundamentals of Astrophysics	BPAT 302		2			

B.Sc. – II Semester –IV

Paper Title	Theory			Practical		
	Paper Code	Lectures Per week	Credits	Paper Code	Lectures Per week	Credits
Galaxies, Planets and Cosmology	BPAT 401	6	2	BPAP 403	8	4
Hydrodynamics and Cosmic Electrodynamics	BPAT 402		2			

B: B.Sc. T: Theory, P: Practical

9. Titles of papers:

B.Sc. – II Semester – III

Theory: 45 lectures, 36 hours (for each paper)

BPAT 301 : **FUNDAMENTALS OF ASTRONOMY**

BPAT 302: **FUNDAMENTALS OF ASTROPHYSICS**

Practical: 80 lectures, 64 hours

BPAP 303: **NUMERICAL CALCULATIONS, PARALLAX, PHOTOMETRY and SOUND**

B.Sc. – II Semester – IV

Theory: 45 lectures, 36 hours (for each paper)

BPAT 401 : **GALAXIES, PLANETS AND COSMOLOGY**

BPAT 402 : **HYDRODYNAMICS and COSMIC ELECTRODYNAMICS**

Practical: 80 lectures, 64 hours

BPAP 403 : **SPECTROSCOPY, MAGNETISM and ELECTRONICS**

BPAT 301: FUNDAMENTALS OF ASTRONOMY (Credits: 2)

Course Objectives:

Student should :

1. learn history of Astronomy, apparent luminosity and its measurement and absolute luminosity.
2. learn calendar of sky, celestial sphere, celestial co-ordinates, universal equatorial system and objects in the sky.
3. study measurement of terrestrial distances and various methods for their measurement.
4. study comets, asteroids, meteors, measurement of mass and radii of stars.

Unit I: History and Luminosity of Stars (11)

Ptolemy's astronomical work, Copernican heliocentric system, Tycho and Kepler's system, Galileo work, Newton's law of gravitation, Kepler's laws of planetary motion, Luminosity (apparent and absolute) of stars, Magnitude scale, Measurement of apparent luminosity by i) visual method ii) photographic method iii) photoelectric method.

Unit II : The Sky and the Calendar (12)

Motion of the Earth, Sidereal day and sidereal time, Celestial co-ordinates, Celestial sphere, Universal equatorial system, Calendars, The Moon , Sun and stars as calendars , The constellations – Aries , Pisces, Orion and Cassiopeia, Interesting objects in the sky (Summer triangle, North Polaris and Big dipper (Saptarishi).

Unit III : The Stellar distances (11)

Measurement of terrestrial distances, Measurement of distances within solar system (Moon, planet and Sun), Astronomical unit and its measurement by aberration of star light, Trigonometric parallaxes of stars, The method of luminosity distance (concept of absolute magnitude), Spectroscopic parallax, Period luminosity law, Use of other bright objects.

Unit IV: Comets, Asteroids and Meteors, Masses and Radii of Stars (11)

Comets, Asteroids and meteors (structure, chemical composition and orbits), Kepler's third law for estimation of solar mass, Measurement of stellar radii (direct and indirect method).

Course outcomes:

Unit I- After completion, students are able to:

1. understand earlier astronomical work.

2. understand absolute and apparent luminosity and their measurement.

Unit II- After completion, students are able to:

1. understand celestial sphere, celestial co-ordinates and universal equatorial system .

2. understand the Moon, sun, stars as calendar, study constellations and interesting objects in the sky.

Unit III- After completion, students are able to:

1. understand the measurement of terrestrial distances.

2. study the methods of luminosity measurement.

Unit IV- After completion, students are able to:

1. understand comets, asteroids and meteors.

2. study estimation of solar mass from Kepler's third law.

REFERENCE BOOKS :

1. Astronomy Fundamentals and Frontiers, R. Jastrow, M. H. Thomson John Wiley and Sons Publications, (4^{th} revised edition) 1984.

2. Exploration – An Introduction to Astronomy, Thomas T. Arny Mosley-Year Book Inc (3rd edition) 1994.

3. Astronomy – From the Earth to the Universe Jay M. Pasachoff Books /Cole Thomson Course. W B Saunders Co Ltd; (4^{th} revised edition) 1992

4. An Introduction to Astrophysics by Baidhnath Basu, PHI Course Pvt. Ltd. New Delhi. (2^{nd} edition) 2014.

5. In Quest of the Universe Theo Koupelis Jones and Barttlett Course, LLC Publications. (6^{th} edition) 2010.

6. Exploring Space (The high Frontier) Jones and Bartlett , Jones & Bartlett Course; Har/Cdr (6^{th} edition) 2010.

7. Astrophysics – Stars and Galaxies by K. D. Abhyankar Tata McGraw Hill Publishing Company (1^{th} edition) 1992.

8. Introductory Astronomy and Astrophysics Michael Zeilik and Stephen A. Gregary Saunders College Publishing, (4^{th} edition) 1997.

9. Astrophysical Concepts by Martin Harwit A and A Library, Springer, USA. (4^{th} edition) 2006.

BPAT 302: FUNDAMENTALS OF ASTROPHYSICS (Credits: 2)

Course Objectives:

Student should:

1. study electromagnetic radiation from stars, atomic spectra and classification of stars.
2. study various tools of astronomer.
3. learn Hertzsprung - Russel diagram for population of stars and nuclear energy source of stars.
4. learn stellar evolution of small and massive star, pulsars, neutron star and black holes.

Unit I: Electromagnetic Radiation and Message of the star light (11)

Electromagnetic radiation, Electromagnetic radiation from heated object, Doppler shift, Atomic spectra, Emission spectra, Absorption spectra, Stellar spectra, Classification of stellar spectra. (Classification of star).

Unit II: Tools of the Astronomer (12)

Optical telescope (Galilean, Newtonian, Cassegranian and Hubble space telescope), Magnifying power of telescope, Resolving power of telescope, Spectroscope (Prism and grating), Radio telescope, X - ray Astronomy, UV Astronomy, IR Astronomy.

Unit III: The Hertzsprung-Russell diagram and Nuclear Energy source (11)

The colour of glowing object (stars), Brightness (luminosity) of stars, HR diagram (population of stars, main sequence, dwarfs and giants), Nuclear fission, Nuclear fusion, Nuclear reaction in stars.

Unit IV: Stellar Evolution (11)

Protostar, birth, maturity, Aging of stars (main sequence), Death of small stars, Death of massive stars (supernova explosion), Pulsars and neutron stars, Black hole

Course outcomes:

Unit I- After completion, students are able to:

1. study the electromagnetic radiation and electromagnetic radiation from heated object.
2. study atomic spectra (emission and absorption) and stellar spectra.

Unit II- After completion, students are able to:

1. study the optical telescopes (Galilean, Newtonian, Cassegranian and Hubble space telescope).
2. understand magnifying and resolving powers of telescope, radio telescope, X-ray astronomy, UV-astronomy and IR-astronomy.

Unit III- After completion, students are able to:

1. study the HR diagram (population of stars, main sequence, dwarfs and giants).
2. study nuclear reaction in stars.

Unit IV- After completion, students are able to:

1. understand birth, maturity and aging of stars.
2. study death of small stars and massive stars, pulsars (neutron stars) and black holes.

REFERENCE BOOKS:

1. Astronomy Fundamentals and Frontiers, R. Jastrow, M. H. Thomson John Wiley and Sons Publications, 4th revised edition, 1984.
2. Exploration – An Introduction to Astronomy, Thomas T. Arny Mosley-Year Book Inc 3rd edition, 1994.
3. Astronomy – From the Earth to the Universe Jay M. Pasachoff Books /Cole Thomson Course. W B Saunders Co Ltd, 4th revised edition, 1992
4. In Quest of the Universe Theo Koupelis Jones and Barttlett Course, LLC Publications, 6th edition 2010.
5. Exploring Space (The high Frontier) Jones and Bartlett, Jones & Bartlett Course; Har/Cdr, 6th edition, 2010.
6. Astrophysics – Stars and Galaxies by K. D. Abhyankar Tata McGraw Hill Publishing Company,1st edition, 1992.
7. Introductory Astronomy and Astrophysics Michael Zeilik and Stephen A. Gregary Saunders College Publishing, 4th edition, 1997.
8. Astrophysical Concepts by Martin Harwit A and A Library, Springer, USA. 4th edition, 2006.
9. An Introduction to Astrophysics by Baidhnath Basu, PHI Course Pvt. Ltd. New Delhi. 2nd edition, 2014.

BPAP 303: NUMERICAL CALCULATIONS, PARALLAX, PHOTOMETRY and SOUND

Course Objectives:

Student should:

1. learn the numerical calculations.
2. learn the parallax.
3. study magnifying and resolving powers of telescopes.
4. learn the drawing of constellation maps.

Experiments:

Group A:

1. Numerical integration.
2. Numerical differentiation.

3. Numerical Interpolation.
4. Solution of ordinary differential equations.
5. To use idea of parallax to determine large distance.
6. Measurement of terrestrial distance using Sextant.
7. Lummer Brothum Photometer (comparison of intensities).
8. Spherical Aberration (Caustic Curve).
9. Michelson Interferometer.

Group B:

1. Resolving power of telescope.
2. Magnifying power of telescope.
3. Goniometer (Equivalent focal length).
4. Goniometer (Cardinal points).
5. Study of scattering of light (Diameter of Lycopodium powder).
6. Velocity of sound using CRO and Microphone.
7. Constellation Map drawings- a) Orion b) Ursa Major(Big Dipper)
8. Constellation Map drawings c) Auriga d) Taurus.
9. Sun spot activity analysis.

Course outcomes:

After completion, students are able to:

1. solve the numerical problems in astronomy and astrophysics.
2. understand the skill of parallax zeroing techniques.
3. determine the magnifying and resolving powers of refracting telescopes.
4. study the drawing of constellation maps of Orion, Big dipper, Auriga and Taurus.

REFERENCE BOOKS:

1. Advanced practical Physics for Students, B. L. Worsnop and H. T. Flint, Littlehampton Book Services Ltd, 9th revised edition, 1951.
2. B. Sc. Practical Physics, Harnam Singh and Dr. P. S. Hemne S. Chand Publishing Delhi 2014.
3. Practical Physics, C. L. Arora S. Chand Publishing New Delhi 2009.
4. Advanced Practical Physics Vol. – I, Dr. S. P. Singh Pragati Prakashan, Meerat, 2012.
5. Advanced Practical Physics Vol. – II, Dr. S. P. Singh Pragati Prakashan, Meerat, 2012.

B.Sc. II Semester IV

BPAT 401: GALAXIES, PLANETS and COSMOLOGY (Credits:2)

Course Objectives:

Student should:

1. learn galaxies, types of galaxies, evolution of galaxies, their halos, radio galaxies and quasars
2. study our own galaxy the Milky way, stellar population and solar system (condensation theory)
3. study planet. the Earth, Venus, mercury and Earth's natural satellite- the Moon.
4. study structure of universe, different theories of cosmos.

Unit-I: Galaxies (12)

Types of galaxies, Dwarf galaxies, Colliding galaxies, Galactic cannibalization (CD galaxies), Anomalously luminous galaxies, The massive galactic halo, The evolution of galaxies, Cluster of galaxies, The intergalactic medium, Super clusters and voids. Radio galaxies, Twin lobed shape of radio galaxy. Quasars-Discovery, Red shift, Distances, Luminosities and nature of quasar energy source.

Unit – II: The Milky Way Galaxy and Solar System (11)

Properties of Milky way galaxy, The spiral structure of the galaxy, The interstellar medium, Clusters of stars, Globular clusters, Stellar population. General properties of Solar system – Origin of planets (condensation theory), Origin of earthlike planets, Composition of planets.

Unit – III: Planets (11)

The Earth – early history, Radioactive heating of the earth, Differentiation of earth's interior, The floating crust, Plate tectonics- the zone of weakness, A map of earth's plates, Evidence for continental drift, Terrestrial planets – Mercury, Venus, Mars- planetary properties, Prospects for life on mars. The Moon – Lunar surface and interior, theories of Moon.

Unit – IV: Cosmology (11)

The expanding Universe, The Big-bang cosmology, The Hubble law, The age of the Universe, The steady state cosmology, Evidence for the Big-bang, Conditions in the evolving Universe, The oscillating Universe, Open and closed Universes.

Course outcomes :

Unit I- After completion, students are able to:

1. understand types of galaxies and the mysteries object in the sky- the quasars.
2. study galaxy the Milky Way galaxy, intergalactic medium, properties of solar system and the condensation theory.

Unit II- After completion, students are able to:

1. understand the interior of our planet- the Earth and radioactive heating of Earth.
2. study the plate tectonics, continental drift, the two super continents- Laurasia and Gondwana land, the terrestrial planets, the red planet- Mars.

Unit III- After completion, students are able to:

1. understand the structure and evolution of cosmos.
2. study empirical formula of Hubble's law.

Unit IV- After completion, students are able to:

1. study the three theories of cosmology.
2. study the open and closed universe.

REFERENCE BOOKS:

1. Astronomy Fundamentals and Frontiers, R. Jastrow, M. H. Thomson John Wiley and Sons Publications, 4th revised edition, 1984.

2. In Quest of the Universe Theo Koupelis Jones and Barttlett Course, LLC Publications. 6th edition, 2010.

3. Exploring Space - The high Frontier Jones and Bartlett, Jones & Bartlett Course; Har/Cdr, 6th edition, 2010.

4. Astronomy – From the Earth to the Universe Jay M. Pasachoff Books /Cole Thomson Course. W B Saunders Co Ltd, 4th revised edition, 1992

5. Exploration – An Introduction to Astronomy, Thomas T. Arny Mosley-Year Book Inc, 3rd edition, 1994.

6. Astrophysical Concepts by Martin Harwit A and A Library, Springer, USA. 4th edition, 2006.

BPAT 402: HYDRODYNAMICS and COSMIC ELECTRODYNAMICS (Credits: 2)

Course Objectives:

Student should:

1. study real fluid, continuous flow, the continuity equation (the conservation of mass)
2. understand the potentials in electrodynamics, EM waves, scattering of light.
3. study the MHD equation, the plasmas.
4. understand the interior of Sun, the photosphere, the chromospheres and corona.

Unit-I: Hydrodynamics (11)

Real fluid, Continuous fluid, Differentiation following the motion, Equation of continuity, The stream function, Stream line, Law of isotropic pressure, Euler's equation of motion, The Navier-Stoke's equation.

Unit-II: Electrodynamics and Scattering of Radiations (11)

Scalar electric potential (ϕ or V), Magnetic vector potential ($\vec{A}$), Poisson's and Laplace's equations, Maxwell's equations in vacuum, Electromagnetic waves in vacuum and wave equation, Thomson and Raleigh scattering, Scattering cross section, Explanation for blue of the sky, Red colour of sunset and sunrise.

Unit-III: Principles of Cosmic Electrodynamics (12)

Idealized Magnetohydrodynamics, Interpretation, Moving magnetic field lines, Magnetohydrodynamics of plasmas.

Unit-IV: The Sun and Solar Activity (11)

Magnetic fields, The hot corona, Morphology of active regions, The flare event, The post flare period.

Course outcomes:

Unit I- After completion, students are able to:

1. study the continuity equation and the conservation of mass.
2. study the hydrodynamic equations – Euler's equation and Navier-Stoke's equation.

Unit II- After completion, students are able to:

1. define electrodynamics potentials, EM wave equations, Poisson's and Laplace's equations.
2. understand Maxwell's equations, Thomson scattering and Rayleigh scattering.

Unit III- After completion, students are able to:

1. study the idealized magnetohydronamics equation.
2. study moving magnetic field and MHD plasmas.

Unit IV- After completion, students are able to:

1. study the Sun and Solar activity.

2. study the photosphere, the flare and the post flare periods.

REFERENCE BOOKS:

1. Fluid Dynamics, D.E. Rutherford, D. E. Rutherford Oliver and Boyd Publications, London First edition, 1959.

2. Introduction to Electrodynamics, David J. Griffiths, PHI Course Pvt. Ltd. 4th edition, 2012.

3. Cosmic Electrodynamics, J. H. Piddington A Wiley-Interscience Publication, 99th Edition, 1969.

4. An Introduction to Astrophysics by Baidhnath Basu, PHI Course Pvt. Ltd. New Delhi. 2nd edition, 2014.

5. Astrophysical Concepts by Martin Harwit A and A Library, Springer, USA. 4th edition, 2006.

BPAP 403: SPECTROSCOPY, MAGNETISM and ELECTRONICS

Course Objectives:

1. Student should learn the optical leveling of spectrometer and Schuster's method.
2. Student should study the spectrums of different sources.
3. Student should study the thickness of Fabry-Perot etalon and wavelength of LASER source.
4. Student should study the Earth's magnetic field.
5. Student should learn the inverse square law.
6. Student should study the Planck's constant using LED.

Experiments:

Group A:

1. Calibration of Spectrometer.
2. Measurement and identification of spectral lines.
3. Study of Balmer lines.
4. Band absorption spectrum of liquid ($KMnO_4$ solution).
5. Study of line absorption spectrum and measurement of temperature of sodium flame.
6. Study of solar spectrum.
7. Measurement of thickness of F. P. Etalon.
8. Measurement of wavelength of given LASER source using diffraction grating.
9. Measurement of Earth's magnetic field using Earth inductor.

Group B:

1. Study of hysteresis curve using CRO.
2. I-V characteristics of solar cell.

3. Verification of inverse square law of intensity.
4. Study of Lissajeous figures using CRO.
5. D. C. amplifier using operational amplifier.
6. Phase shift measurement of RC network using CRO.
7. Verification of Stefan's forth power law.
8. Determination of Planck's constant using LED.
9. Crystal oscillator.

Course outcomes: After completion, students are able to:

1. adjust the spectrometer for parallel light.
2. study the H_α and H_β lines of hydrogen spectrum.
3. determine thickness of F. P. etalon and wavelength of He-Ne LASER source.
4. determine horizontal and vertical components of Earth's magnetic field.
5. determine the Planck's constant using LED.

REFERENCE BOOKS:

1. Advanced practical Physics for Students, B. L. Worsnop and H. T. Flint, Asia Pub. House, 1971.
2. Practical Physics, C. L. Arora S. Chand Publishing New Delhi 2009.
3. B. Sc. Practical Physics, Harnam Singh and Dr. P. S. Hemne S. Chand (Publishing Delhi) 2014.
4. Advanced Practical Physics Vol. – I, Dr. S. P. Singh Pragati Prakashan, Meerat, 2012.
5. Advanced Practical Physics Vol. – II, Dr. S. P. Singh Pragati Prakashan, Meerat, 2012.