Rayat Shikshan Sanstha's

YASHAVANTRAO CHAVAN INSTITUTE OF SCIENCE, SATARA
(AUTONOMOUS)
Syllabus for B.Sc. Part – II

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 astronomer and research.

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. General Objectives of the Course:

1. The students are expected to understand the fundamentals, principles, physical concepts and recent developments in the subject area.
2. The practical course is framed in relevance with the theory courses to improve the understanding of the various concepts in Astronomy & 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 learning in a supportive environment.

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

Sr. No.	Course Title	Theory			Practical		
		Paper No. & Paper Code	No. of lectures per week	Credits	Course Title	No. of lectures per week	Credits
1	Astrophysics	Paper-I: BPAT 301	6	2	Practical Paper – I: BPAP 303	8	4
		Paper-II: BPAT 302		2			

B.Sc. – II
Semester –IV

Sr. No.	Course Title	Theory			Practical		
		Paper No. & Paper Code	No. of lectures Per week	Credits	Course Title	No. of lectures Per week	Credits
1	Astrophysics	Paper-III: BPAT 401	6	2	Practical Paper – II : BPAP 403	8	4
		Paper-IV: BPAT 402		2			

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

9. Titles of papers of B.Sc. course:

B.Sc. – II Semester – III

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

Paper – I : BPAT 301 : **Fundamentals of Astronomy**

Paper – II: BPAT 302 : **Fundamentals of Astrophysics**

Practical : 80 lectures, 64 hours

Practical Paper I : BPAP 303: **Numerical Calculations, Parallax, Photometry and Sound**

B.Sc. – II Semester – IV

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

Paper – III : BPAT 401 : **Galaxies, Planets & Cosmology**

Paper – IV : BPAT 402 : **Hydrodynamics & Cosmic Electrodynamics**

Practical : 80 lectures, 64 hours

Practical Paper II : BPAP 403 : **Spectroscopy, Magnetism & Electronics**

10. Evaluation Structure : B. Sc. II Sem-III & IV (Astrophysics)

Semester	Paper No.& Code	ESE	Internal Exam		Paper No. & Code	Practical		Submission		**Total**
			ISE I	ISE II		Exam + Proj	Journal	Seminar	Day to Day Performance	
III	Paper V : BPAT 301	30	5	5	Pr. Paper I**:** BPAP 303 (A)	20 + 5	5	5	5	**150**
	Paper VI : BPAT 302	30	5	5	Pr. Paper I**:** BPAP 303 (B)	20 +5	5			
	Total	60	10	10	Total	50	10	5	5	**150**
IV	Paper VII BPAT 401	30	5	5	Pr. Paper II**:** BPAP 403 (A)	20 + 5	5	5	5	**150**
	Paper VIII BPAT 402	30	5	5	Pr. Paper II**:** BPAP 403 (B)	20 +5	5			
	Total	60	10	10	Total	50	10	5	5	**150**
Total of Sem. III & IV		120	20	20	Total	100	20	10	10	**300**

11. Other Features:

A. Library: Reference and Text books, Journals and Periodicals, reference books for advance studies.

B. Specific Equipments:

Necessary to run the course: Computers, LCD projectors, Visualizers, Smart board, Astronomical telescopes, star grazers software, constellation maps.

C. Laboratory Equipments:

1. Vernier calipers, Micrometer screw gauge, Meter scale and Travelling microscope.
2. AC and DC Voltmeters and Current meters.
3. Spectrometers, grating, adjustable slits and F. P. etalon.
4. Multimeter (Analog and Digital), PA system.
5. Lummer- Brothum photometer apparatus.
6. Sextant, Goniometer apparatus, mercury& sodium sources.
7. Ballistic galvanometer, Earth coil
8. Audio frequency generators, He-Ne LASER source, H & He discharge tubes.
9. AC and DC power supply and CRO.
10. Long distance focusing refracting telescope.

B. Sc. – II Semester – III

Paper II: BPAT 301: Fundamentals of Astronomy (Credits: 2)

Learning objectives:

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

Learning outcomes:

Student will be able to:

1. understand earlier astronomical work, absolute & apparent luminosity and their measurement.
2. understand celestial sphere, celestial co-ordinates, universal equatorial system , the Moon, sun, stars as calendar, to study constellations and interesting objects in the sky.
3. understand the measurement of terrestrial distances and to study the methods of luminosity measurement.
4. understand comets, asteroids and meteors and to study estimation of solar mass from Kepler's third law.

REFERENCE BOOKS :

1. Astronomy Fundamentals & Frontiers by R. Jastrow, M. H. Thomson John Wiley & Sons Publications. [Unit No. II]
2. Exploration – An Introduction to Astronomy by Thomas T. Arny 1994 Mosley-Year Book Inc. [Unit No. I, II, III, IV].
3. Astronomy – From the Earth to the Universe 6th edition by Jay M. Pasachoff Books /Cole Thomson Learning. [Unit No.II].
4. An Introduction to Astrophysics by Baidhnath Basu, 2nd edition (2014) PHI Learning Pvt. Ltd. New Delhi. [Unit No.I, II]
5. In Quest of the Universe 7th edition by Theo Koupelis Jones & Barttlett learning, LLC Publications. [Unit No. I, II]
6. Exploring Space (The high Frontier) Jones & Barttlett learning, LLC Publications. [Unit No. I, II]
7. Astrophysics – Stars and Galaxies by K. D. Abhyankar Tata McGraw Hill Publishing Company. [Unit No. I, II, III, IV]
8. Introductory Astronomy and Astrophysics 4th edition by Michael Zeilik and Stephen A. Gregary Saunders College Publishing. [Unit No. I].
9. E – Book : Astrophysical Concepts by Martin Harwit 4th Edition A&A Library, Springer, USA. [Unit No. I, II, III, IV]

Paper II: BPAT 302: Fundamentals of Astrophysics (Credits: 2)

Learning Objectives:

1. To study electromagnetic radiationfrom stars, atomic spectra and classification of stars.
2. To study various tools of astronomer.
3. To learn Hertzsprung - Russel diagram for population of stars and nuclear energy source of stars.
4. To 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 & 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.

Learning outcomes:

Student will able to:

1. study the electromagnetic radiation and electromagnetic radiation from heated object, atomic spectra (emission & absorption) and stellar spectra.
2. study the optical telescopes (Galilean, Newtonian, Cassegranian and Hubble space telescope), magnifying and resolving powers of telescope, radio telescope, X-ray astronomy, UV-astronomy and IR-astronomy.
3. study the HR diagram (population of stars, main sequence, dwarfs and giants), nuclear reaction in stars.
4. understand birth, maturity and aging of stars, death of small stars and massive stars, pulsars (neutron stars) and black holes.

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1. Astronomy Fundamentals & Frontiers by R. Jastrow, M. H. Thomson John Wiley & Sons Publications. [Unit No. I, II, III, IV]
2. Exploration – An Introduction to Astronomy by Thomas T. Arny 1994 Mosley-Year Book Inc. [Unit No. I, II]
3. Astronomy – From the Earth to the Universe 6th edition by Jay M. Pasachoff Books /Cole Thomson Learning. [Unit No. I, II, IV]
4. In Quest of the Universe 7th edition by Theo Koupelis Jones & Barttlett learning, LLC Publications.
5. Exploring Space (The high Frontier) Jones & Barttlett learning, LLC Publications. [Unit No. I, II]
6. Astrophysics – Stars and Galaxies by K. D. Abhyankar Tata McGraw Hill Publishing Company. [Unit No. I]
7. Introductory Astronomy and Astrophysics 4th edition by Michael Zeilik and Stephen A. Gregary Saunders College Publishing. [Unit No.I]
8. E – Book : Astrophysical Concepts by Martin Harwit 4th Edition A&A Library, Springer, USA. [Unit No. III]
9. An Introduction to Astrophysics by Baidhnath Basu, 2nd edition (2014) PHI Learning Pvt. Ltd. New Delhi.[Unit I, II, III,IV]

Practical Paper I: BPAP 303: Numerical Calculations, Parallax, Photometry and Sound

Learning objective:

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

Learning outcomes:

Student will able to:

1. solve the numerical problems in astronomy & 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, 1971 Asia Pub. house
2. B. Sc. Practical Physics by Harnam Singh and Dr. p. S. Hemne S. Chand Publishing Delhi.
3. Practical Physics by C. L. Arora S. Chand Publishing New Delhi.
4. Advanced Practical Physics Vol. – I by Dr. S. P. Singh Pragati Prakashan, Meerat.
5. Advanced Practical Physics Vol. – II by Dr. S. P. Singh Pragati Prakashan, Meerat.

B.Sc. II Semester IV

Paper III: BPAT 401: Galaxies, Planets & Cosmology (Credits:2)

Learning objectives:

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

Learning outcomes:

Student will able to:

1. understand types of galaxies, the mysteries object in the sky- the quasars, galaxy the Milky Way galaxy, intergalactic medium, properties of solar system, the condensation theory.
2. understand the interior of our planet- the Earth, radioactive heating of Earth, the plate tectonics, continental drift, the two super continents- Laurasia & Gondwana land, the terrestrial planets, the red planet- Mars.
3. understand the structure & evolution of cosmos, empirical formula of Hubble's law
4. study the three theories of cosmology, the open & closed Universe.

REFERENCE BOOKS:

1. Astronomy Fundamentals & Frontier by Robert Jastrow and Malcolm H. Thomson 4th edition John-Wiley and Sons. [Unit No. I, II, III &IV].
2. In Quest of the Universe By Theo Koupelis 7th edition Jones & Bartlett Learning. [Unit No. III].
3. Exploring Space – The High Frontier Jones & Bartlett Learning. [Unit No. III].
4. Astronomy – From the Earth to the Universe 6th edition by Jay M. Pasachoff Books/Cole Thomson Learning
5. Exploration – an Introduction to Astronomy by Thomas T. Arny 1994 Mosley-Year Book Inc
6. E – Book: Astrophysical Concepts by Martin Harwit 4th Edition A&A Library, Springer, USA. [Unit No. I, II, III &IV].

Paper IV: BPAT 402: Hydrodynamics &Cosmic Electrodynamics (Credits: 2)

Learning objectives:

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

Learning outcomes:

Student will able to:

1. study the continuity equation, the conservation of mass, the hydrodynamic equations – Euler's equation & Navier-Stoke's equation.
2. study electrodynamics potentials, EM wave equations, Poisson's and Laplace's equations, Maxwell's equations, Thomson scattering and Rayleigh scattering.
3. study the idealized magnetohydronamics equation, moving magnetic field, MHD plasmas.
4. study the Sun and Solar activity, the photosphere, the flare, the post flare periods.

REFERENCE BOOKS:

1. Fluid Dynamics by D. E. Rutherford Oliver & Boyd Publications, London. [Unit No. I]
2. Introduction to Electrodynamics by David J. Griffiths 4th edition PHI Learning Pvt. Ltd. [Unit No. II]
3. Cosmic Electrodynamics by J. H. Piddington A Wiley-Interscience Publication. [Unit No. III, IV]
4. An Introduction to Astrophysics by Baidyanath Basu 2nd edition PHI Learning Pvt. Ltd. [Unit No. II]
5. E – Book : Astrophysical Concepts by Martin Harwit 4th Edition A&A Library, Springer, USA.

Practical Paper II: BPAP 403: Spectroscopy, Magnetism & Electronics

Learning objective:

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

Learning outcomes:

Student will 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, 1971 Asia Pub. house
2. Practical Physics by C. L. Arora S. Chand Publishing New Delhi.
3. B. Sc. Practical Physics by Harnam Singh and Dr. P. S. Hemne S. Chand Publishing Delhi.
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5. Advanced Practical Physics Vol. – II by Dr. S. P. Singh Pragati Prakashan, Meerat.