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 2016-2017)
Proposed Choice Based Credit System – (CBCS)

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 – III

Sl. No.	Sub. Code	Subject	Instructions Hrs/Week	Duration of Exam	Max. Marks	Credits
1	AP 301	Basic Astronomy	4	3	100	4
2	AP 302	Stellar Structure and Evolution	4	3	100	4
3	AP 303	Classical (Celestial) Mechanics	4	3	100	4
4	AP 304	CB – 1. Basics of Astronomy & Astrophysics CB – 2. Space physics	4	3	100	4
PRACTICALS						
5	AP Pr 351	Numerical Methods	8	3	100	4
6	AP Pr 352	Computer Applications	8	3	100	4
		Total:	**32**		**600**	**24**

SEMESTER – IV

S. No.	Sub. Code	Subject	Instructions Hrs/Week	Duration of Exam	Max. Marks	Credits
1	AP 401	Space Physics	4	3	100	4
2	AP 402	Astronomical Techniques	4	3	100	4
3	AP 403	Astrostatistics	4	3	100	4
4	AP 404	CB-1. The Milky Way Galaxy & ISM CB-2. Galaxies and Universe	4	3	100	4
PRACTICALS						
5	AP Pr 451	Photometry & Spectroscopy using IRAF and usage of Archival Data	8	3	100	4
6	AP Pr 452	Project Work	8	3	100	4
		Total:	**32**		**600**	**24**

SEMESTER -3

Theory Paper AP-301: 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 AP-302: Stellar Structure and Evolution

Unit – 1

Fundamental Equations

Basic properties of stars and observational methods. Stellar time scales. Equation of mass distribution. Equation of hydrostatic equilibrium. Virial Theorem. Equation of energy transport by radiative and convective processes. Equation of thermal equilibrium. Equation of state. Stellar Opacity. Eddington limit. Stellar energy sources.

Unit - 2

Stellar Models

Fundamental equations. Overall problem. Boundary conditions (central and surface). Russell-Vogt theorem. Polytropic model. Lane-Emden equation and its solution. Properties of polytropes. Applications (Polytrope for perfect gas, convective stars, Eddington model, solar polytrope). Hayashi Line. Hayashi Forbidden Zone. Homology transformations. Dimensional analysis: Mass – Luminosity and Mass – Radius relations.

Unit - 3

Stellar Evolution

Jean's criterion for gravitational contraction and its difficulties. Star forming regions. Protostars. T-Tauri stars. Brown Dwarfs. Pre-Main Sequence Evolution: Pre-Main Sequence contraction under radiative and convective equilibrium. HR diagrams. Hayashi tracks and Henyey tracks. Schoenberg-Chandrasekhar limit. Main-Sequence and Post Main Sequence Evolution of stars of different masses. Growth of isothermal core, Shell burning and subsequent development. Eddington Luminosity. Planetary Nebulae. Ages of galactic & globular clusters.

Unit - 4

Superdense Objects

White Dwarfs. Use of Polytropic model for completely degenerate stars. Chandrasekhar Mass. Mass-radius relation for White Dwarfs. Non-degenerate upper layers and abundance of Hydrogen. Stability of White Dwarfs. Cooling mechanism in White Dwarfs. Accretion by White Dwarfs and its consequences. Supernovae, Neutron stars, Black Holes. Pressure ionization and mass-radius relation for cold bodies. Maximum mass of a Neutron star. Masses of Stellar Black Holes.

REFERENCES

1. M.Schwarzschild: Stellar Evolution.
2. R.Kippenhahn A.Weigert: Stellar Structure and Evolution.
3. Dina Prialnik: An Introduction to the Theory of Stellar Structure and Evolution.
4. K.D.Abhyankar: Astrophysics: Stars and Galaxies.
5. Baidyanath Basu: An Introduction to Astrophysics.
6. S.Chandrasekhar: Stellar Structure.
7. Cox and Guili: Principles of Stellar Interiors – Vol. I & II.
8. Shapiro and Tevkolsky: White Dwarfs, Neutron Stars and Black Holes.
9. R.Bowers and T.Deeming: Astrophysics.
10. Frank H. Shu: The Physical Universe.

Theory Paper AP-303: Classical (Celestial) Mechanics

Unit – 1
Newtonian Formulation and The Two Body Problem

Frames of reference. Generalised coordinates. 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 & Hamiltonian 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. Contact transformation, Hamilton-Jacobi partial differential equation.

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. H.Goldstein: Classical Mechanics, 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.

Theory Paper AP-304 – CB -1. Basics of Astronomy & Astrophysics

(Course suited for students with Mathematics & Physics background at Graduation level)

Unit 1:

The Heavens Above

Celestial Sphere and Time

Constellations. The celestial sphere. Coordinate systems: Equatorial, ecliptic system. Seasons, Sidereal, Apparent and Mean solar time. Calendar. Julian date.

Stellar Distances and Magnitudes

Distance scale in astronomy. Determination of distances to planets and stars. Magnitude scale. Atmospheric extinction. Absolute magnitudes and distance modulus.

Unit 2:

Our Solar System

Theories of formation of the Solar System.

The Sun

Photosphere, chromosphere and corona of the Sun. Sun spots and magnetic fields on the sun. Solar activity, solar wind.

Planets and their Satellites

Surface features, atmospheres and magnetic fields of Earth, Moon and Planets. Satellites and rings of planets. Asteroids, Meteors, Meteorites and Comets.

Unit 3:

Stars: What are they?

Stars. Spectral classification. Energy generation in stars. Basics of Star formation & Evolution. The HR diagram.

Super dense objects - White dwarfs, Neutron stars & Pulsars. Black holes.

Unit 4:

The Milky Way Galaxy & Galaxies beyond

Structure of the Milky Way Galaxy

What are galaxies? Different types of galaxies. Hubble's classification. Structure, size & mass of the Milky Way galaxy. Position of our Sun and its motion around the galactic centre.

Cosmology

The expanding universe. Cosmological models: Big Bang and Steady State models. Dark matter

REFERENCES

1. H. Karttunen, P Kroger, H Oja, M Poutanen & K. J. Donner editors. Fundamental Astronomy.
2. W.M.Smart: Foundations of Astronomy..
3. Frank H. Shu: The Physical Universe-An Introduction to Astronomy.
4. K D Abhyankar: Astrophysics of the Solar System.
5. Baidyanath Basu: Introduction to Astrophysics.
7. Jayant Narlikar: Structure of Universe

Theory Paper AP-304 – CB -2. Space Physics

(Course suited for students of M. Sc., Earth Sciences)

Unit 1:

Introduction to space physics

Introduction to the Electromagnetic radiation, fundamentals of EM waves, effects of environment, propagation of waves, the sun and the solar corona, the sunspots and solar cycle, solar flares, solar wind and the heliosphere, planetary magnetospheres.

Unit 2:

Atmospheres

The Neutral atmosphere, atmospheric nomenclature, geopotential height, expansion and contraction, fundamental forces in the atmosphere, apparent forces, atmospheric composition, solar radiation interaction with the neutral atmosphere, climate change, atmospheric aerosols.

Unit 3:

Ionosphere

Formation of the ionosphere, morphology of ionosphere, the D, E and F-regions, Ionospheric variations, chemistry of the ionosphere, ionospheric parameters, E and F region anomalies and irregularities in the ionosphere, the aurora, Lyman glow of the night sky, the geo-corona and airglow studies, ionosondes.

Unit :4

Satellite Communication

Satellite System – Historical development of satellites – communication satellites – orbiting satellites – satellite frequency bands – satellite multiple access formats, satellite orbits and inclination – Look angles, orbital perturbations, space craft and its subsystems – attitude and orbit control system – Telemetry, Tracking and Command – Power system –Transponder – Reliability and space qualification – launch vehicles

REFERENCES

1. An Introduction to Dynamic Meteorology – James R Holton.
2. Climatology, An atmospheric Science – John E. Oliver and John J. Hindore.
3. Electronic Communication systems – George Kennedy and Bernard Davis.
4. Introduction to Ionospheric Physics – Henry Rishbeth and Owen K. Garriot.
5. Satellite Communication – Robert M. Gagliardi
6. Satellite Communication – Manojit Mitra

Practical Paper AP-351: 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 Paper AP-352: Computer Applications

1. Operating Systems : WINDOWS, UNIX/LINUX.
2. Editors : Word and vi
3. Numerical Analysis using available software.
4. Programming concepts: Language : C/ FORTRAN
5. Installation of 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.

Theory Paper AP-401: 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. Aurorae. Lyman glow of the night sky. The geo-corona and airglow studies. Atmospheric extinction, Aerosols, gases.

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 gamma-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. Interplanetary dust.

Unit - 3

Moon

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

Unit - 4

Planets

Infrared spectroscopy of planetary atmospheres. Exploration of Mars. Recent space missions to Mars. Indian MOM mission. Voyager space mission studies of outer planets and their satellites and rings. Comparative studies of planetary atmospheres. Planetary ionospheres. Extra-solar system planets (qualitative).

REFERENCES

1. J.A.Ratcliffe: An Introduction to the Ionosphere and Magnetosphere.
2. Kaula. W.M.: An Introduction 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 AP-402: Astronomical Techniques

Unit 1

Telescopes

Basic Optics, Types of telescopes. Telescope mounting systems. Optical telescopes, Infrared, Ultraviolet, X-ray and Gamma-ray telescopes. Schmidt telescopes. Solar telescopes. Design and construction of a simple optical telescopes. Active and adaptive optics in astronomical study. Sky charts and their importance.

Unit 2

Detectors

Classification of detectors, characteristics of detectors. Detectors for optical and infrared wavelength regions. Working of Charge Coupled Device (CCD). sensitivity, noise, quantum efficiency, spectral response, Johnson noise, signal to noise ratio, Application of CCD for stellar imaging, photometry and spectroscopy. Importance of space based astronomy. Observational techniques 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. Transformation to a standard photometric system. Astronomical spectroscopy. Spectral classification. Simple design of astronomical spectrograph. Radial velocity measurements.

Unit 4

Radio Astronomical Techniques

Electromagnetic spectrum. Radio window. Antenna parameters. Various types of antennas. Non-steerable, partially steerable and fully steerable radio telescopes. Design and construction of a simple radio telescope. Receiver systems and their calibration. Design and construction of a simple radio interferometer. MST Radar for Ionospheric studies. LB and VLBI Systems. Aperture Synthesis.

REFERENCES

1. C.R.Kitchin: Astrophysical Techniques (4^{th} edition).
2. Ian S. McLean: Electronic Imaging in Astronomy: Detectors and instrumentation (2^{nd} edition).
3. Steve B. Howell: Handbook of CCD Astronomy (2^{nd} edition).
4. A. E. Roy and D. Clarke: Astronomy Principles and Practice (Part-3, 4^{th} edition).
5. W. A. Hiltner (Ed): Astronomical Techniques.
6. Gordon Walker: Astronomical Observations - an Optical Perspective (Cambridge Univ Press).
7. Henden and Kaitchuck: Astronomical Photometry.
8. C. R. Miczaika and W.M.Sinton: Tools of the Astronomers
9. Carleton: Methods of Experimental Physics. Vol.XIIA.
10. G. F. Knoll: Radiation Detection and Measurement (2nd edition).

Theory Paper AP-403: Astrostatistics

Unit 1
Basic Statistics

Diagrammatic and graphical presentation of data, tabulation of data, frequency distribution. Mean, Median, Mode. Standard deviation. Binomial, Poisson and Gaussian distributions. Concepts of probability theory, discrete and continuous random variables, bivariate probability distributions.

Unit 2
Regression & Testing of Hypothesis

Covariance, correlation and regression, point estimation, interval estimation. Testing of hypothesis –null hypothesis, alternate hypothesis, types of errors, critical and acceptance regions, level of significance. Large sample tests for mean(s), variances. Small sample tests - t, F and Chi-square, ANOVA - one way and two way classifications.

Unit 3
Multivariate Data Analysis

Categorical data analysis and model building. Principal components classification & discriminate analysis and clustering (k-means and hierarchical).

Unit 4
Data Mining and Analysis

Association rules, Neural networks, Decision trees, , – using case based methods for astronomy applications. Analysis of data from astronomical catalogues and public domain using R package.

REFERENCES

1. Statistical Methods by S P Gupta.
2. Applied Multivariate Statistical Analysis by Richard A Johnson and Dean W Wichern.
3. An Introduction to Statistical Learning, with Applications in R by James, Witten, Hastie and Tibshirani (Springer, 2013).
4. Practical Statistics for Astronomers by J.V.Hall, Cambridge Observing Handbook for Astronomers.
5. Modern Statistical Methods for Astronomy: with R Applications by Eric Feigelson and G Jogesh Babu.
6. Statistical Challenges in Modern Astronomy, edited by Eric Feigelson, G Jogesh Babu.
7. Data Mining Concepts & Techniques by Jiawei Han and Micheline Kamber. (Elsevier)

Theory Paper AP-404: CB – 1. The Milky Way Galaxy & Interstellar Matter

Unit 1
The Milky Way Galaxy

The structure, size and mass of the Milky Way Galaxy. Methods of determining the mass of our galaxy. Stellar populations in the Milky Way. Position of our Sun in the Galaxy. Distribution of Gas in the Milky Way. The interstellar medium – its composition and properties. Amount of interstellar matter. Oort limit. Interstellar extinction. Estimate of colour excess. Visual absorption. Interstellar reddening law and Polarization. 21-cm line observations. Interstellar magnetic fields in the Milky Way. Stromgren's theory of H II regions.

Unit 2
Stellar Motions

Standards of Rest – the Fundamental Standard of Rest and the Local Standard of Rest. Solar motion and its determination. Motion of stars in spiral galaxies. Oort's theory of galactic rotation. Determination of Oort's constants. Statistical parallaxes. Peculiar velocities. Bottlinger's diagram. Spiral structure in the Milky Way. Determination of its structure from optical and radio observations.

Unit 3
Spiral Wave Kinematics

Epicycles, Spiral density Waves, Resonances. Resonance features. Motion of stars near the center of the Milky Way. Inference of the presence of supermassive black hole at the center. Rotational curve and its interpretation. Dark Matter. Candidates for Dark Matter.

Unit 4
Structure & contents of the Milky Way Galaxy

Location of the Spiral Arms. Star forming regions in the Milky Way. Distribution of X-ray and Gamma ray sources in the Milky Way. Emission mechanisms associated with high energy emissions. Importance of multi-wavelength studies of the Milky Way. Mass distribution in the Milky Way. Mathematical models of the Milky Way. Galactic encounters of the Milky Way in its neighbourhood.

REFERENCES

1. James Binney: Galactic Astronomy: Structure and Kinematics of Galaxies
2. Elmegreen: Galaxies & Galactic Structure. Prentice Hall 1998.
3. Sparke and Gallagher: Galaxies in the Universe.
4. Frank Shu: The Physical Universe. A.Unsold: The New Cosmos (3rd Edition). Springer-Verlag 1983.
5. Mihalas and J.Binney: Galactic Astronomy. W.H.Freeman 1981.
6. K.D.Abhyankar: Astrophysics - Stars and Galaxies. Tata McGraw Hill Publication.
7. L.Spitzer: Physical Processes in the Interstellar Medium. John Wiley 1978.
8. M.Sandage and J.Kristian: (Ed.) Galaxies and the Universe. University of Chicago Press.
9. Bowers and Deeming: Astrophysics Vols.1 and 2.
10. Baidyanath Basu: Introduction to Astrophysics.

Theory Paper AP-404: CB – 2. Galaxies and Universe

Unit – 1

Fundamental concepts

Introduction – What are galaxies? The Universe of galaxies and their discovery. Various catalogues and data sources. Classification of galaxies – Hubble's Morphological Classification, de Vaucouleur's Classification, The Yerkes (or Morgan) scheme, DDO system. Masses and sizes of galaxies and the techniques of determining them. Methods of determining extra-galactic distances. Integrated galaxy light, Reddening, K correction. Broad band colors of galaxies.

Unit 2

Profiles of Galaxies

Differential galaxy light, Azimuthal profiles of Ellipticals and Spirals, Isophotal twists in Ellipticals and Spirals. Radial profiles for Spirals and Barred Spirals. Distribution of gas in galaxies. Radiation from neutral atomic, molecular and ionised gas. Total gas mass in a galaxy. Distribution of clouds. Radial gas density profiles.

Unit 3

Dynamical aspects of galaxies

Stellar motion in elliptical and spiral galaxies. Doppler-shift motions in spiral disks, rotational curves, Tully-Fisher relation. Mass distribution in disk galaxies. Early-type galaxy rotations and velocity dispersions. The fundamental plane of Elliptical galaxies. Masses of early-type galaxies. Dark matter in galaxies. Dark matter in galactic clusters. Gravitational lensing.

Unit 4

Star formation in galaxies

Global star formation rates. Complexes and propagating star formation. Starburst galaxies, Active Galaxies. Star formation in Interacting galaxies. Role of galaxy interactions on evolution of galaxies. Seyferts, Radio galaxies and Quasars. The unified model of Quasars, Radio Galaxies and Seyferts. Importance of multi-wavelength studies of galaxies. Galaxy formation. Expansion of the universe. Interpretation of the red-shift. CMBR. Fundamentals of cosmology – the Big Bang & the Steady State models.

REFERENCES

1. Elmegreen: Galaxies & Galactic Structure. Prentice Hall 1998.
2. Sparke and Gallagher: Galaxies in the Universe.
3. Frank Shu: The Physical Universe.
4. A.Unsold: The New Cosmos (3rd Edition). Springer-Verlag 1983.
5. Mihalas and J.Binney: Galactic Astronomy. W.H.Freeman 1981.
6. K.D.Abhyankar: Astrophysics - Stars and Galaxies. Tata McGraw Hill Publication.
7. L.Spitzer: Physical Processes in the Interstellar Medium. John Wiley 1978.
8. M.Sandage and J.Kristian: (Ed.) Galaxies and the Universe. University of Chicago Press.
9. Bowers and Deeming: Astrophysics Vols.1 and 2.
10. Baidyanath Basu: Introduction to Astrophysics. Prentice Hall of India, 2004.
11. Jayant Narlikar: Introduction to Cosmology. Jones & Bartlett Publishers, Inc, 1998.

Practical Paper AP-451: Photometry & Spectroscopy using IRAF and usage of Archival Data

1) Photometry

a) DS9
b) Ximtool
c) Imexamine
d) Apphot

2) **Spectroscopy**

a) Twodspec
b) Apextract
c) Apall
d) Wavelength calibration
e) Splot

3) Archival Data

a) SIMBAD
b) VIZIER
c) NED
d) HEASARC

Practical AP-452: Project Work

REFERENCES

1. Peter MB Shames, Doug Tody: A user's Introduction to the IRAF command language version 2.3
2. Frederic P. Miller Agnes F. Vandome, Mc Brewster John: IRAF, VDM Publishing, 2010
3. Chrisphin Karthick, M: Astronomical data Reduction guide