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BENGALURU CITY UNIVERSITY

SYLLABUS FOR M.Sc. Physics
(III & VI Semester)

CHOICE BASED CREDIT SYSTEM

(SEMESTER SCHEME)

2020-2021

BENGALURU CENTRAL UNIVERSITY

Central College Campus, Bengaluru 560001

Papers, Teaching Hours, Examination Marks and Credits for M.Sc.(Physics) Degree Course (CBCS)effective from 2020-21

Paper Code	Paper Title	Teaching hours per week	Final Exam. Marks	Internal Exam. Marks	Total Marks	Credit hours	Remarks
	Third Semester						
PHY301	Quantum Mechanics II	3	70	30	100	3	HC*
PHY302	Computational Physics	3	70	30	100	3	HC
PHY303	Nuclear & Particle Physics (General)	3	70	30	100	3	HC
PHY304	Condensed Matter Physics (General)	3	70	30	100	3	HC
PHY305	Elective –I (One course to be opted from this group)	3	70	30	100	3	HC
PHY305a	Lasers & their applications						
PHY305b	Material Science & its application						
PHY305c	Physics at the Nano scale						
PHY306	General Nuclear Physics Lab	4	35	15	50	2	
PHY307	General Condensed Matter Physics lab	4	35	15	50	2	HC
PHY308 PHY309	Introduction to Modern Physics/ Space science & its Applications	3	70	30	100	3	HC OE**
	Total	**26**	**490**	**210**	**700**	**22**	
	Fourth Semester						
PHY401	Astrophysics & Cosmology	3	70	30	100	3	HC
PHY402	Methods of Data Analysis	3	70	30	100	3	HC
PHY403	Elective –II (One course to be opted from this group)	3	70	30	100	3	HC
PHY403a	Nuclear & Particle Physics (Elective)						
PHY403b	Condensed Matter Physics - I						
PHY403c	Atmospheric Physics						
PHY404	Elective –III (One course to be opted from this group)	3	70	30	100	3	HC
PHY404a	Nuclear decay & Reactor theory						
PHY404b	Condensed Matter Physics - II						
PHY404c	Space Physics						
PHY405	Astrophysics& CosmologyLab(Gen.)	4	35	15	50	2	HC
PHY406	Advanced Physics Lab (One to be opted from this group based on elective papers)	4	35	15	50	2	HC
PHY406a	Nuclear Physics Lab						
PHY406b	Condensed Matter Physics Lab						
PHY406c	Atmospheric & Space Physics Lab						
PHY407	Project work	8	70	30	100	4	HC
	Total	**28**	**420**	**180**	**600**	**20**	

*HC = Hard core, **OE = Open Elective (For Non Physics Students : One course to be opted)

BENGALURU CENTRAL UNIVERSITY

Syllabus for III Semester of M.Sc. Degree in Physics
(CBCS)

PHY 301: Quantum Mechanics II

Unit I

The Schrödinger equation in three dimensions: Separation of Schrödinger equation in Cartesian coordinates, the three dimensional box, three dimensional harmonic oscillator, central potentials, separation of the Schrodinger equation in spherical polar coordinates, the free particle, three –dimensional square well potential, the hydrogenic atom, the eigen functions of bound states, three dimensional isotropic oscillator, parity, time reversal and permutation symmetry operations, wave functions for systems of identical bosons and fermions, ortho and para helium states.

(16 hrs)

Unit II

Approximation methods: Time independent perturbation theory for a non-degenerate energy level, perturbed harmonic oscillator, time-independent perturbation theory for degenerate energy level, fine structure of hydrogenic atoms, the variational method, the WKB approximation, energy levels in a potential well, penetration of a potential barrier, alpha particle decay of nuclei.

Time dependent Perturbation theory: general features, time independent perturbation, two-level system with time-independent perturbation, the golden rule, periodic perturbation, charged harmonic oscillator in a time-dependent electric field.

(16 hrs)

Unit III

Scattering experiments and cross sections, Potential scattering, the method of partial waves, scattering by a square well, the integral equation of potential scattering, the Born approximation, the Coulomb potential.

Relativistic quantum mechanics: The Klein-Gordon equation for a free particle; charged particle in an electromagnetic field, stationary state solutions, interpretations of the Klein-Gordon equation, The Dirac equation for a free particle, properties of Dirac matrices, solutions of free particle Dirac equation, charged particle in an electromagnetic field, plane wave solutions of the Dirac equation, spin and helicity operators, solutions of the Dirac equation for a central potential, the hydrogenic atom, negative energy states, hole theory.

(16 hrs)

References

1. Quantum Mechanics, ***B.H. Bransden and C.J. Joachain***, 2nd Edition, Pearson Education, (2004).
2. Introduction to Quantum Mechanics, ***David J. Griffiths***, 2nd Edition, Pearson Education, (2005).
3. Modern Quantum Mechanics, ***J.J. Sakurai***, Pearson Education, (2000).
4. Quantum Mechanics, ***V. K Thankappan,***2ndEdition (2004).
5. Quantum Physics, ***Stephen Gasiorowicz***, John Wiley, (2003).
6. Quantum Mechanics, ***L. I. Schiff,*** Mc Graw-Hill, (1955).

7. Quantum Mechanics, **Aruldas**, PHI (2009).
8. A textbook of Quantum Mechanics, 2^{nd} ed. **P M Mathews & K Venkatesan**, TMH, (2010).
9. Introductory Quantum Mechanics, 4^{th}Edition, **R L Liboff**, Pearson Education, (2003).
10. Quantum Mechanics- Fundamentals, 2^{nd} ed.,K **Gottfried and T M Yan**, Springer,(2004).

Syllabus for III Semester of M.Sc. Degree in Physics
(CBCS)
PHY 302: Computational Physics

Unit I

Computer hardware and software, number representation and precision, linear interpolation, polynomial interpolation.
Data fitting- Regression, linear least squares, Millikan experiment.
Searching for roots- the bisection method, Newton-Raphson method, Secant method,the finite square well.
Numerical Quadrature- simple quadrature, the second ordinate rule, Euler-McLaurin integration, adaptive quadrature, Multidimensional integration.

(16hrs)

Unit-II

Ordinary differential equations, types of differential equations, types of solutions and initial conditions, first order ODE, the Euler method, modified and improved Euler methods,The Runge-Kutta method, Solving second order ODEs, coupled first order ODEs, oscillatory motion.
Partial differential equations, classes, boundary values and initial conditions, finite difference method, difference formulas, applications of difference formulas,
Numerical methods for solving PDEs, the heat equation with Neumann and Dirichlet boundary conditions, the wave equation and its solution.

(16 hrs)

Unit-III

Computational examples: Numerical solution of freely falling body, effect of air-resistance, motion in a viscous medium, motion of projectiles and satellites, simple harmonic motion, damped harmonic motion, Fourier analysis of waves, Interference of waves, motion of a charged particle in electric and magnetic fields, LCR circuits, Solution of time-independent Schrodinger equation, Particle in a box, simple harmonic oscillator eigenvalues and eigen functions.

(16 hrs)

References

1. Computational physics, **Darren Walker**, Med Tec (2015).
2. A first Course in computational Physics, 2^{nd} edition, **P L Devries and J E Hasburn**, Jones and Bartlett Learning, (2011).
3. Computational physics, **Mittal, Verma and Gupta**, Ane books India,(2008).
4. Problem solving with computers, **Rubin H Landau, Manuel J Paez, and Cristian C Bordeianu**, Wiley, (2007).
5. Computational Physics, **Ahluwalia, Verma and Sharma**, New Age International, (2007).
6. Computational Physics, **Koonin**, Addison Wesley, (1987).

7. Introduction to Computational Physics, **Jong M L**, Addison Wesley, (1991).
8. Computational Techniques in Physics, **P K Mac Keown & D J Newman**, Adam Hilger,(1987).

Syllabus for III Semester of M.Sc. Degree in Physics
(CBCS)

PHY 303: Nuclear and Particle Physics (General)

Unit I

Interaction of nuclear radiation with matter: (a) Interaction of charged particles: Energy loss of heavy charged particles in matter, Bethe-Bloch formula, energy loss of fast electrons, Bremsstrahlung. (b) Interaction of gamma rays: Photoelectric, Compton, and pair production processes. Gamma ray attenuation-attenuation coefficients, absorber mass thickness, cross-sections.
Nuclear Reactions: Cross section for a nuclear reaction, differential cross section, Q-value of a reaction, threshold energy, Direct and compound nuclear reaction mechanisms, Bohr's independence hypothesis, experimental verification.
Nuclear Fission: Energy release in fission, neutron cycles in a thermal reactor and four factor formula.

(16 hrs)

Unit II

Nuclear detectors:Scintillation Detectors-NaI(Tl), Scintillation spectrometer, Semiconductor detectors: Surface barrier detectors, Li ion drifted detectors, relation between the applied voltage and the depletion region in junction detectors. Counter telescopes, particle identification and position sensitive detector.

Nuclear Models:
The Liquid drop model: Semi-empirical mass formula, stability of nuclei against beta decay, mass parabola, Fermi gas model: Kinetic energy for the ground state, asymmetry energy, Shell model: Evidence for magic numbers, prediction of energy levels in an infinite square well potential, spin-orbit interaction, prediction of ground state spin-parity and magnetic moment of odd-A nuclei, Schmidt limit.

(16 hrs)

Unit III

Elementary Particle Physics: Types of interactions between elementary particles, hadrons and leptons and neutrinos.
Symmetries and conservation laws: conservation of energy, momentum, angular momentum, charge and isospin, parity symmetry, violation of parity in weak interactions - handedness of neutrinos, Lepton number conservation, Charge conjugation symmetry, Strange particles, conservation of strangeness in strong interactions, Baryon number conservation, Gell-Mann-Nishijima formula, eight fold way (qualitative only), quark model, quark content of baryons and mesons, color degree of freedom, The Standard model (qualitative only).

(16 hrs)

References

1. Introduction to Nuclear Physics, **H. Enge**: Addison Wesley, (1971).

2. Atomic and Nuclear Physics,**S N. Ghoshal**: Vol. II., S Chand and Company (2000).
3. Introductory Nuclear Physics,**Kenneth S. Krane:** John Wiley and Sons, (1987).
4. The Atomic Nucleus,**Evans R. D.**: Tata McGraw Hill, (1955).
5. Nuclear Physics, **R. R. Roy and B. P. Nigam**: Wiley-Eastern Ltd. (1983).
6. Nuclear Physics- an Introduction, **S.B.Patel**: New Age international (P) Limited, (1991).
7. Radiation Detection and Measurements, **G.F. Knoll**: 3rd edition, John Wiley and Sons, (2000).
8. Nuclear Radiation Detectors, **S.S. Kapoor and V.S.Ramamurthy**: Wiley-Eastern, New Delhi, (1986).
9. Nuclear Radiation Detection,**W.J.Price**: McGraw Hill, New York, (1964).
10. Introduction to High Energy Physics,**D.H.Perkins**: Addison Wesley, London, 4th Edition, (2000).
11. Introduction to Elementary particles, **D. Griffiths**: John Wiley, (1987).
12. Nuclear Interaction,**S. de Benedetti**: John Wiley, New York, (1964).
13. Elementary Particles, **J. M. Longo**, II edition, Mc Graw-Hill, New York, (1973).
14. Introduction to Nuclear Physics, **S S MWong**, PHI, (2010).
15. Nuclear Physics, **S N Ghoshal**, S Chand& Company, (2014).
16. Introduction to Nuclear and Particle Physics, **Mittal,Verma,Gupta**, PHI (2009).

Syllabus for III Semester of M.Sc. Degree in Physics
(CBCS)

PHY 304: Condensed Matter Physics (General)

Unit I

Crystal Physics- Crystalline state- periodic arrangement of atoms-lattice translation vectors and lattice-basis and the crystal structure-primitive and non primitive lattice cell-fundamental types of lattices-2-d and 3-d-Bravias lattice and crystal systems. Elements of symmetry operations- points and space groups-nomenclature of crystal directions and crystal planes-Miller indices. Simple crystal structures: NaCl, CsCl, HCP, diamond, ZnS and Wurtzite.
X-diffraction in crystals-Scattering from atom-concept of reciprocal lattice-Braggs law-spacing formula-analysis of x-ray diffraction pattern from crystals-structure factor-atomic scattering factor-multiplicity factor-R-factor (definitions only).
(16 hrs)

Unit II

Superconductivity- Review of experimental survey-zero resistance and persistent current- isotope effect-effects of magnetic field-type I and II superconductors-Meissner effect-thermodynamic properties-heat capacity-thermal conductivity. BCS theory (qualitative)-high temperature superconductors (qualitative)-Applications - Tunneling- dc and ac Josephson effect-SQIUDS-applications

Semiconductors-Introduction to semiconductors-intrinsic and extrinsic semiconductors-band structure of semiconductors-expression for carrier concentration of intrinsic and extrinsic semiconductors-position of Fermi level -electrical conductivity-mobility and their temperature dependence-Hall effect in semiconductors

(16hrs)

Unit III

Dielectric and Ferroelectricity-Review of basic formulas-dielectric constant-polarizability -different kinds of polarizability -expression for electronic ionic orientational polarizabilty-Lorentzs field- Clausius- Mossatti relation-dielectric loss and optical phenomenon. Ferro electricity piezoelectricity –properties, structure and applications.

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Magnetism-Review of basic formulae-magnetic susceptibility-classification of magnetic materials-Langevins theory of dia and para(classical)-Ferromagnetism and domains-Wiess molecular field theory (classical)-Heisenberg's exchange interaction theory-anti ferromagnetism ferrimagnetism.

(16hrs)

References

1. Solid State Physics- **A J Dekkar,** MacMillan India Ltd, (2000).
2. Elementary Solid State Physic- **Ali Omar,** Adison –Wesly, (2000).
3. Elements of Solid State Physics- **C Kittle,** Wiely, (2014).
4. Elementary Solid State Physic, **J P Srivastava**,PHI,(2008).
5. Essential of crystallography, **M A Wahab**, Narosa Publications, (2009).
6. Solid State Physics-**F W Ashckroft and N D Mermin,** Harcourt Asia, (2001).
7. Principles of Condensed Matter Physics,**Chaikin & Lubensky**,CUP,(1998).
8. Solid State Physics, **C D Marathe**, Neeraj Pub. House, (2015).

PHY 305: ELECTIVE PAPERS

Syllabus for III Semester of M.Sc. Degree in Physics
(CBCS)
PHY 305a: Lasers and their Applications (Elective)

Unit I

Definitionof laser, spontaneous and stimulated emissions, population inversion, saturation intensity, growth of a laser beam, threshold requirements for a laser, oscillations above threshold, laser amplifiers, requirements for obtaining population inversions, inversions and two level systems, steady state inversions in three and four level systems, processes that inhibit or destroy inversions.

Laser pumping requirements and techniques, optical pumping, particle pumping.

Laser resonators, longitudinal laser cavity modes, properties of laser modes, stable curved mirror cavities, properties of Gaussian beams.

(16hrs)

Unit II

Specific laser systems: Helium Neon laser, Argon ion laser, carbon dioxide laser, excimer lasers, Nitrogen laser, Chemical laser, dye lasers, Ruby lasers, Neodymium YAG and glass lasers, Semiconductor diode lasers.

Characteristics of laser light – monochromaticity, coherence, directionality, intensity etc.

(16 hrs)

Unit III

Applications: Lasers in communication, spectroscopy, ranging and imaging. Laser fluorescence and Raman scattering and their application in pollution studies. Laser induced multiphoton processes and their applications. Ultrahigh resolution spectroscopy with lasers and its applications. Laser cooling.

Optical fiber communication using lasers, attenuation of lasers in optical fibers. Qualitative treatment of Engineering and Medical applications of lasers.

(16 hrs)

References

1. Lasers: Theory and Applications, ***K. Thyagarajan, A.K. Ghatak,*** McMilan India, (1981).
2. Principles of Lasers,***O.Swelto***, Springer, (1998).
3. Lasers, ***A.E. Sigman***, University Press, (1986).
4. Solid state laser engineering, ***W. Koechner***, Springer verlag, (1992) .
5. Laser spectroscopy, ***W. Demtroder***, Springer International, (2002).
6. Laser & Nonlinear Optics, ***BB Laud***, Wiley Eastern Limited, (1991).
7. Optical Electronics, ***Amn, Yariv on***, Holt Rinehart and Winston, (1985).
8. Fiber-optic communication, ***Djafar K. Myubaev*** and **Lowell L. Scheiner**,Prentice Hall (2001).
9. Introduction to fiber optics, ***A.K. Ghatak, K. Thyagarajan***, Cambridge University Press, (1997).
10. Optical Electronics, ***A.K. Ghatak, K. Thyagarajan***, Cambridge University Press, (1997).
11. Laser fundamentals, **Willium T Silfvast**, CUP, (1998).

Syllabus for III Semester of M.Sc. Degree in Physics

(CBCS)

PHY 305b: Materials Science and its Applications (Elective)

Unit-I

Formation and structure of materials: Introduction to Materials Science; classification of engineering materials; structure - property relationship in materials; Chemical bonding-Bond energy, Bond type and Bond length. Ionic bonding; Covalent bonding; Metallic bonding; secondary bonding.

Madelung constant- cohesive energy; van der Waal's Interaction- Lennard- Jones Potential; closed packed structure; packing efficiency and density of materials.

Elastic and plastic behavior of materials: Atomic model of elastic behavior-rubber like Elasticity; inelastic behavior; viscoelastic behavior; Maxwell element; Voigt-Kelvin element; fracture of materials-Ductile and brittle fracture.

(16 hrs)

Unit- II

Composite materials: Introduction and importance of composite materials; Classification of composite materials based on matrix phase and reinforcements; popular matrix materials-polymers, metals and ceramics; popular reinforcing materials-fibers, particles; particle reinforced composites, concrete (Portland and reinforced) structure, composition, properties and applications; polymer-concrete composites- fabrication, structure, applications; polymer matrix composites; metal matrix composites; ceramic matrix composites; carbon-carbon composites; rule of mixtures; fiber reinforced composites-influence of fiber length, orientation and concentration.

(16hrs)

Unit -III

Elements of polymer science: Definition-Monomers, Polymers; classification of polymers with examples; synthesis of polymers-chain polymerization, step polymerization; Industrial polymerization methods -bulk, solution and suspension polymerization; degree of polymerization; Average molecular weight- weight and number averaged; Microstructure of polymers- chemical, geometric, random, alternating and block polymers; polymer crystallinity; Phase transition-Polymer melting and glass transition; stereo isomerism; Process of plastic materials: Compression moulding, Injection moulding, Blow moulding; extrusion; spinning.

References (16 hrs)

1. Elements of Materials Science and Engineering, **Lawrence H Van Vleck,** Addison Wesley, (1975).
2. Callister's Materials Science and Engineering, **WD Callister, DG Rethwisch,** Adopted by R Balasubramaniam, Wiley, (2014).
3. Introduction to Ceramics, **WD Kingery, HK Bowen and DR Uhlmann,** John Wiley, (1960).
4. Foundations of Materials Science and Engineering, **WilliamF Smith,** McGraw Hills International Edition, (1986).
5. Materials Science and Engineering, **V Raghavan**, Prentice Hall, (1993).
6. Structure & Properties of materials, vol I-IV, **Rose, Shepard and Wulff,** (1987).
7. Polymer Science,**VR Gowariker, NV Vishwanathan, Joydev Shreedhar,** Wiley Eastern, (1987).
8. Text of Polymer Science, **Fred W Billmeyer**, John Wiley and Sons, Inc. (1984).

Syllabus for III Semester of M.Sc. Degree in Physics

(CBCS)

PHY 305c: Physics at the Nano Scale (Elective)

Unit I

Quantum confined systems: Quantum confinement and its consequences, quantum wells, quantum wires and quantum dots and artificial atoms. Electronic structure from bulk to quantum dot. Electron states in direct and indirect gap semiconductors, nanocrystals. Quantum dots as diffraction gratings, Quantum wire, Nanowires. Confinement in disordered and amorphous systems.

(16 hrs)

Unit II

Dielectric properties: Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures and charging of nanostructure. Quasi-particles and excitons: Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasiparticles and excitons. Charging effects.

(16 hrs)

Unit III

Optical properties: Optical properties and radiative processes: General formulation absorption, emission and luminescence; Optical properties of heterostructures and nanostructures. Carrier transport in nanostructures: Coulomb blockade effect, scattering and tunneling of 1D particle; applications of tunneling, single electron transistors. Defects and impurities: Deep level and surface defects.

Characterization basics: Direct imaging by scanning electron microscope, transmission electron microscope, and scanning probe techniques. Scanning tunneling microscope.

(16 hrs)

References

1. Nanostructures-Theory & Modelling, **C. Delerue and M. Lannoo,** Springer, (2004).
2. Nanostructure, V. **A. Shchukin, N. N. Ledentsov and D. Bimberg,** Springer, (2004).
3. Characterization of Nanophase Materials, **Z. L. Wang (Ed.)**,Wiley-VCH, (2000).
4. Semiconductor Nanocrystal Quantum Dots, **A. L. Rogach (Ed.)**,Springer NY, (2008).
5. Introduction to Nanotechnology,**C. P. Poole Jr. & F. J. Owens**,Wiley-Interscience, (2003).
6. A Hand book on Nanophysics, **John D Miller**, Dominant Publication, (2008).

Syllabus for III semester of M.Sc. Degree in Physics
(CBCS)

PHY 306: General Nuclear Physics Lab

List of experiments in Nuclear Physics

1. Statistics of counting.
2. Dead time of a G.M. counter by single source method.
3. Study of Beta absorption.
4. Analysis of the data to find the half life of In-116m state
5. Z-dependence of beta absorption co-efficient.
6. Gamma ray spectrometer (SCA)
7. Rest mass energy of electron using gamma ray spectrometer
8. Absorption of gamma rays.
9. Two stage amplifier.
10. Schmitt trigger as a discriminator.
11. Transistor coincidence and anticoincidence circuits
12. Voltage multipliers
13. Numerical fitting of binding energy curve using semi empirical mass formula and identifying the stable isobar for a given mass number.

References

1. Advanced practical physics for students, **Worsnop and Flint,**Asia Publications (1979).
2. Advanced practical physics, **Singh and Chauhan,** 2 vols., Pragati Prakashan (1976).
3. Physics Lab. Manual, **Misra and Misra,** South Asian publishers (2000).
4. Practical physics, **Gupta and Kumar,** Pragati prakashan (1976).
5. Techniques for Nuclear and Particle Physics Experiments, **W.R. Leo,** 2nd Ed., Springer, (2013).

Syllabus for III Semester of M.Sc. Degree in Physics
(CBCS)
PHY 307: General Condensed Matter Physics Lab

List of experiments and exercises

2. Analysis of X-ray Diffractogram (NaCl, KCl).
3. Analysis of single crystal rotation photograph (Cu).
4. Analysis of X-ray powder photograph- Cu, Au, Ag.
5. Analysis of X-ray powder photograph-W, Mo.
6. Calibration of electromagnet and magnetic susceptibility determination of magnetic salts- $MnSO_4$, $MnCl_2$ by Quinke's method.
7. Fermi energy of copper and related parameter using constant current source and multimeter.
8. Experiments with pn- junction: Determination of n, E_g and dV/dt of pn junction.
9. Ionic conductivity of NaCl: study of the temperature variation of σ and estimation of activation energy.
10. Indexing of rotation photograph using Bernal Chart.
11. Analysis of X-ray diffraction of Si and estimation of R factor.
12. Determination of Curie temperature for ferromagnetic material- (Ni-Fe alloy).
13. Determination of coefficients of thermal expansion of some materials at room temperature (Al, Cu, Brass, NaCl, KCl).

References

1. Advanced practical physics for students,**Worsnop and Flint,**Asia Publications, (1979).
2. Advanced practical physics,**Singh and Chauhan,** 2 vols., Pragati prakashan, (1976).
3. Physics Lab. Manual, **Misra and Misra,** South Asian publishers (2000).
4. Practical physics, **Gupta and Kumar,** Pragati prakashan (1976).

OPEN ELECTIVE COURSES

Syllabus for III Semester
(For the students of non-M.Sc., Physics)
(CBCS)

PHY 308: Introduction to Modern Physics (Open elective)

Unit I

Atomic and Molecular Physics

Photons and the quantum nature of light, the photoelectric effect, momentum and energy of photons, electrons and matter waves, Schrodinger equation, the wave function and its interpretation, Heisenberg uncertainty principle, barrier tunneling, energies of trapped electrons, wave function of a trapped electron, electron in a finite well, the hydrogen atom, some properties of atoms, electron spin, Stern- Gerlach experiment, electronic configurations of atoms, the Pauli principle, building the periodic table, classification of molecules, rotational and vibrational spectra of molecules, Raman effect.

(16 hrs)

Unit II

Solid State Physics

Crystals and their structure, Bonding in solids, Types of bonding, ionic and covalent bonds, energy bands, conductors, semiconductors and insulators, magnetic materials, para, dia and ferromagnetic materials, Electrical properties of solids, energy levels in a crystalline solid, insulators, metals, semiconductors, doped semiconductors, p-n junction, the junction rectifier, light emitting diode, the transistor. Amorphous solids.

(16 hrs)

Unit III

Nuclear and Particle Physics

Atomic structure, nuclear constituents, nuclear mass and binding energy, stability of nuclei, nuclear size, energy levels, nuclear forces and their characteristics, semi-empirical mass formula, types of nuclear reactions, laws of radioactive decay, alpha decay, beta decay, gamma decay, radioactive dating, nuclear fission, nuclear reactors, nuclear fusion. Controlled nuclear fusion. Sub-nuclear particles. Fundamental interactions. Leptons, Mesons and Hadrons. The Quark model. Higgs bosons.

(16 hrs)

Text Books:

1. Concepts of Modern Physics, 6th ed., **A Beiser, S Mahajan and S RaiChoudhury,**
   McGraw Hill India (2009).
2. Modern Physics, **A B Gupta,** Books & Allied (p) Ltd. (2016).

References:

1. Fundamentals of Physics (extended), **Halliday,Resnick and Walker,** 6th Edition, John Wiley, (2005).
2. Introduction to Modern Physics**, Richtmyer, Kennard and Cooper**, TMH, (1997).
3. Modern Physics, **K Krane**, John Wiley, (1998).
4. Physics of the Atom, **A B Gupta**, Books and Allied, (2014).

Syllabus for III Semester

(For the students of non-M.Sc., Physics)

(CBCS)

PHY 309: Space Science and its Applications (Open elective)

Unit I

The Air around us

Origin and evolution of the atmosphere, vertical structure of the atmosphere, upper atmosphere, temperature structure of the atmosphere, atmospheric ozone, atmospheric aerosols, aerosols and climate, atmospheric dynamics, atmospheric motions, atmospheric waves.

Remote sensing- Solar and terrestrial radiations, concept of signatures, spectral responses of soil, water, snow and clouds, remote sensing systems, remote sensors, platforms, data analysis, remote sensing technology in India.

(16 hrs)

Unit II

The Solar System

Formation of the sun, formation of the solar nebula, from grains to planets, evolution of the solar system, the terrestrial planets, mercury, Venus, the earth, moon, mars, the outer solar planets, Jupiter, Saturn, their rings and satellites, Uranus and Neptune, Pluto and Charon, Kuiper belt objects, minor objects in the solar system, comets and asteroids, life in the solar system, extra solar planetary systems.

(16 hrs)

Unit III

Near Solar platforms- aircrafts, balloons for space research, sounding rockets, earth satellites, orbit fundamentals, launch considerations, mission planning, platform subsystems, and international cooperation.

Living in Space- manned space flight, space biology and medicine, impact of space flight on organisms, weightlessness.

Life in other worlds- life on earth, definition of life, origin of life on earth, lab simulation, possibility of life elsewhere, survey of the solar system, evidence from meteorites, searching for extraterrestrial intelligence.

(16 hrs)

References

1. Concepts in Space Science, ed. **R R Daniel**, University Press, (2002)
2. Elements of Space Physics, **R P Singhal**, PHI, (2009).
3. The Solar System, **K D Abhyankar**, University press, (2006)

BENGALURU CENTRAL UNIVERSITY

Syllabus for IV Semester of M.Sc. Degree in Physics

(CBCS)

PHY 401: Astrophysics and Cosmology

Unit I

Basic Concepts of Astronomy: Constellations-Coordinate systems- equatorial and ecliptic systems, precession and nutation of coordinates, Time systems-solar and sidereal times, apparent and absolute magnitudes- relation between them, Astronomical distances - trigonometric parallax, atmospheric extinction, Optical telescopes – types, characteristics, mounts and foci, modern optical telescopes, astronomical Instruments – the photometer-UBV photometry, photographic plates, spectrographs, Charge Coupled Detector.

(16 hrs)

Unit II

Stellar Physics: Stellar spectral features, classification of stars-spectral and luminosity classes and H-R diagram, Saha ionization Equation, Binary stars-types and characteristics, Variable stars-types and characteristics, Cepheid's variables -Period-luminosity relation, mass-luminosity relation, White dwarfs-discovery,types and properties, Chandrasekhar limit, Neutron stars and Supernovae, Black holes and their properties.

The Solar System: An overview of Sun, interior and atmospheric structure, Sun spots and solar rotation, Characteristic properties of terrestrial planets and Jovian planets, Moons of planets, comets, asteroids, meteorites.

(16 hrs)

Unit III

Galactic Astronomy and large scale structure of Universe: Historical models of Milky way, structural components Milky way galaxy, Hubble's classification of galaxies, Hubble's law, distances of external galaxies, rotation curves, galactic clusters and dark matter, Olber's paradox and its resolution, Big bang origin of the Universe, age of the Universe, COBE satellite and detection of cosmic microwave background radiation, Newtonian Cosmology – Models of the universe-open-closed-flat Universe, Critical density, accelerating universe, the Planck satellite mission.

(16 hrs)

References

1. Introduction to Modern Astrophysics, **Bradley W Carroll and Dale A Ostlie,** Pearson-Addison Wesley, II Edition, (2007).
2. The New Cosmos, ***A. Unsold***, Springer Verlag, (1977).
3. The Physical Universe,***Frank Shu***, University Science Book, (2000).
4. Introduction to Cosmology, ***J.V. Narlikar***, CUP (1993).
5. Principles of Physical Cosmology, ***Peebles P.J.E.,*** Princeton U.P. (1993).
6. Galaxies; their Structure and Evolution, ***R.J. Taylor***, CUP, (1993).
7. Solar System Astrophysics,***Brandt J.C. and Hodge***, McGraw-Hill, (1964).

8. Astrophysics Concepts, ***M. Herwit***, John Wiley, (1990).
9. An Introduction to Astrophysics, ***Baidyanath Basu***, PHI, (2006).
10. A textbook of Astrophysics and cosmology, ***V.B.Bhatia***, New Age, (2001).
11. Our solar system, ***Rana* and Jog,** University press, (1993)
12. Stars and Galaxies, 2nd ed. ***K.D. Abhyankar***, University Press, (2004).
13. Astrophysics. ***Krishnaswamy,*** New Age International Publishers, (2003).
14. Pulsar Astronomy, ***A.G.Lyne and G.Smith***, CUP, (2005).

Syllabus for IV Semester of M.Sc. Degree in Physics
(CBCS)

PHY 402: Methods of Data Analysis

Unit I

Probabilities: Experiments, events, sample spaces; the concept of probability; rules of probability calculus; examples.

Random variables and their distributions: random variables; examples; distribution of single random variable; functions of a single random variable, expectation values, variance, moments; distribution function and probability density of two variables; expectation values, variance, covariance and correlation; transformation of variables; linear orthogonal transformations; error propagation.

(16 hrs)

Unit II

Some Important distributions and theorems: The binomial and multinomial distributions, frequency: the law of large numbers; the hyper geometric distribution; the Poisson distribution; the characteristic function of a distribution; the standard normal distribution; the normal or Gaussian distribution; quantitative properties of the normal distribution; the central limit theorem; the error model of Laplace; convolution of distributions; folding integrals; convolutions with the normal distribution.

(16 hrs)

Unit III

Samples: Random samples, distribution of a sample, estimators; mean and variance of a sample; graphical representation of samples- histograms and scatter plots; full width at half maximum; mean square deviation, degrees of freedom; samples from Gaussian distributions- chi squared distribution; chi squared and empirical variance; sampling by counting, small samples with background.

Testing statistical hypotheses: the Chi squared test for goodness of fit, testing with maximal number of degrees of freedom; testing with reduced number of degrees of freedom.

(16 hrs)

References:

1. Data Analysis: Statistical and Computational methods for Scientists and engineers, 4th ed., **S Brandt**, Springer, (2014).
2. Theory and Problems of Statistics, 3rd ed., **M R Spiegel & L J Stephens**, TMH,(2000).
3. Experimental Measurements: Precision, Error and Truth, **N C Barford**,John Wiley, (1967).
4. Probability and Statistics: A course for Physicists and Engineers, **A M Mathai, H J Haubold**, DeGruyter, (2018).

ELECTIVE COURSES

Syllabus for IV Semester of M.Sc. Degree in Physics
(CBCS)

PHY 403a: Nuclear and Particle Physics (Elective)

Unit I

Nuclear Forces: Deuteron Problem: Inadequacies of the central force, experimental evidence for the tensor force, magnetic moment and quadrupole moment of the deuteron, deuteron ground state as an admixture of s and d states, Rarita-Schwinger equation, magnetic moment of the deuteron for s and d states, quadrupole moment of the deuteron. Meson theory of nuclear forces, charged and neutral pions.

Low Energy Nucleon-Nucleon Interaction:

n-p scattering: Partial wave analysis, expression for total scattering cross section, n-p incoherent scattering using square well potential, singlet and triplet potentials, scattering length and its significance, coherent scattering by ortho and para hydrogen, spin dependence of nuclear forces, effective range theory for n-p scattering.

p-p scattering: Qualitative features, effect of Coulomb and nuclear scattering, charge symmetry and charge independence of nuclear forces, isospin formalism, generalized Pauli principle.

(16hrs)

Unit II

Nuclear Electronics: Preamplifiers: charge sensitive, current and voltage sensitive preamplifiers, Linear pulse amplifier: linearity, stability, pulse shaping and pulse stretching operational amplifiers, Integral and differential discriminators, Schmitt trigger as a discriminator, Analog to digital converters(ADC), time to amplitude converters, scalars, timers, memories, single channel analyzer (SCA), multichannel analyzer (MCA): functional block diagram; its use in data processing.

(16 hrs)

Unit III

Elementary Particle Physics:

SU(3) symmetry and eight fold way, Gell-Mann Okubo mass formula, mass formula for baryon octet; equal spacing rule for baryon decuplet, fundamental representation of SU(3) and quarks.

Weak interaction: Weak decays, lifetimes and cross-sections, Feynman diagrams, leptonic, semi-leptonic and non-leptonic processes, quark flavour changing interactions with examples, muon decay – Fermi's four particle coupling and modern perspective with a mediating vector boson, W and Z bosons; their masses and range of weak interactions.

Weak interactions of quarks: Cabibbo factor, GIM-mechanism (Glashow-Iliopoulos- Miani mechanism).

Neutral kaons: CP as a symmetry, CP violation in neutral kaon decay (Fitch-Cronin experiment), CPT theorem (qualitative), evolution of a neutral kaon beam with time, regeneration experiments.

Standard model and its predictions (qualitative), Grand Unified Theories (qualitative).

(16 hrs)

References

1. Nucleon-Nucleon Interaction, **G.E. Brown and A.D. Jackson**, North-Holland, Amsterdam, (1976).
2. Nuclear Interaction, **S. de Bendetti**, John Wiley, New York, (1964).
3. Physics of Nuclei and Particles,**P. Marmier and E. Sheldon**, Vol. I and II, Academic Press, (1969).
4. Introduction to Nuclear Physics, **H. A. Enge**, Addison Wesley, (1975).
5. Structure of the Nucleus,**M. A. Preston and R. K. Bhaduri**, AddisonWesley, (1975).
6. Theoretical Nuclear Physics,**M. Blatt and V. F. Weisskopf**, John Wiley, (1952).
7. Nuclear Physics- Theory and Experiments, **R. R. Roy and B. P. Nigam**, John Wiley, (1967).
8. Atomic and Nuclear Physics,**S. N. Ghoshal**, Vol. II., S Chand and company, (2000).
9. Practical Gamma Ray Spectrometry,**G. Gilmore and J. D. Hemingway**, John Wiley and Sons, (1995).
10. Radiation Detection and Measurements,**G.F. Knoll**, 3rd edition, John Wiley and Sons,(2000).
11. Nuclear Radiation Detectors, **S.S. Kapoor and V.S.Ramamurthy**, Wiley-Eastern, New Delhi, (1986).
12. Radiation Detection,**W.H. Tait**, Butterworths, London, (1980).
13. Nuclear Radiation Detection,**W.J.Price**, Mc Graw Hill, New York, (1964).
14. Introduction to High Energy Physics, **D. H. Perkins:** Addison Wesley, London, 4th Edition, (2000).
15. Introduction to Elementary Particles, **D. Griffiths,** John Wiley, (1987).
16. Quarks and Leptons, **F. Halzen and A.D. Martin,** John Wiley and sons, New York, (1984).
17. Modern Elementary Particle Physics, **G.Kane,** Addison Wesley, (1987).
18. Unitary Symmetry and Elementary Particles, **D. B. Lichtenberg,** 2nd edition, Academic Press, (1978).
19. Elementary Particles, 2nd ed.,**J. M. Longo,**Mc Graw-Hill, New York, (1973).

Syllabus for IV Semester of M.Sc. Degree in Physics
(CBCS)

PHY 403b: Condensed Matter Physics I (Elective)

Unit I

Energy bands in solids-Consequences of periodicity-Bloch theorem and proof-Bloch functionand their eigen values-Kronig Penny model-nearly free electron model-zone scheme-energy band in general periodic potential, number of states in a band, Energy gap, Distinction between metals, insulators and intrinsic semiconductors concept of hole-effective mass.Tight binding method of energy bands.

Fermi surfaces-Construction of Fermi surfaces-electrons uniform magnetic field-anomalous skin effect-cyclotron resonance-closed orbits and open orbits-de-Hass-van Alphen effect.

(16 h rs)

Unit II

Lattice vibrations-Vibration modes of 1-d lattice –mono and diatomic linear lattice –dispersion relation-acoustical and optical modes-phase and group velocity-Brillouin zone-derivation of force constant-quantization of elastic waves.

Thermal properties of solids-specific heat of solids-classical, Einstein, Debye models, Density of states. Phonon -phonon interactions: normal and umklapp process, thermal conductivity of insulators at high and low temperatures, effect of impurity and imperfections on thermal conductivity, effect of finite size of specimen, derivation of the expression for the conductivities of metals, comparison of the conductivities of metals due to electrons and phonons-Anhormonic effects-thermal expansion-phonon collision process.

(16 hrs)

Unit III

Optical properties of solids-classical model-ionic conduction-refractive index-optical absorption-photoconductivity-photo electric and photovoltaic effect- optical properties of fibers, Optical properties of semiconductors.
Elastic constants: Stress components. Analysis of elastic strains, elastic compliance and stiffness constants, elastic energy density, stiffness constants of cubic crystals, elastic waves in cubic crystals, waves in [100] direction, [110] direction, experimental determinations of elastic constants.

(16 hrs)

References

1. Solid State Physics, **A J Dekker,** MacMillan India Ltd. (2000).
2. Elementary Solid State Physics, **MA Omar,** Addison Wesley, New Delhi, (2000).
3. Solid State Physics, **C Kittle,** V Edition, Wiley Eastern Ltd. (1976).
4. Elementary Solid State Physics, **J P Srivastava,** PHI, (2008).
5. Essential of crystallography, **M A Wahab,** Narosa Publications, (2009).
6. Solid State Physics, **F W Asckroft and N D Mermin**-Saunders College, (1976).
7. Solid State Physics-**S O Pillai**-New Age Intnl. Publishers, (2001).

Syllabus for IV Semester of M.Sc. Degree in Physics

(CBCS)

PHY 403c: Atmospheric Physics(Elective)

Unit - I

Atmosphere: Brief survey of the atmosphere, optical properties, mass, chemical composition, vertical structure, winds and precipitation.**(6 hrs)**

(Chapter -1, Atmospheric Science - an introductory survey, JM Wallace and PV Hobbs, 2nd edition, Elsevier publications, 2006)

Atmospheric thermodynamics: Gas laws - virtual temperature; Hydrostatic equation geopotential, scale height, constant pressure surfaces, reduction of pressure to sea level; first law of thermodynamics - Joule's law, specific heats, enthalpy; Adiabatic process - concept of an air parcel, dry adiabatic lapse rate, potential temperature; water vapour in air - moisture parameters, latent heat, adiabatic processes, lapse rate, potential temperature; Second law of thermodynamics - Carnot cycle, entropy, Clausius - Clapeyron equation. **(10 hrs)**

(Chapter -3, Atmospheric Science - an introductory survey, JM Wallace and PV Hobbs, 2nd edition, Elsevier publications, 2006)

Unit - II

Radiative transfer: Spectrum of radiation; Black body radiation - Planck function, Wien's displacement law, Stefan-Boltzmann law, Radiative properties of non-black materials, Kirchhoff's law, Greenhouse effect; Physics of scattering and absorption and emission Scattering by air molecules and particles, absorption by particles, absorption and emission by gas molecules; Radiative transfer - Beer's law, reflection and absorption by a later of the atmosphere, absorption and emission of IR radiation in cloud-free air; vertical profiles of radiative heating rate; passive remote sensing by satellites; radiative balance at the top of atmosphere. **(12 hrs)**

(Chapter -4, Atmospheric Science - an introductory survey, JM Wallace and PV Hobbs, 2nd edition, Elsevier publications, 2006)

Weather system: Tropical cyclones - structure, thermodynamics, dynamics; genesis and lifecycle; storm surges. **(4 hrs)**

(Chapter -8, Atmospheric Science - an introductory survey, JM Wallace and PV Hobbs, 2nd edition, Elsevier publications, 2006)

Unit - III

Atmospheric motions: Atmospheric forces, Coriolis force, equations of motion, applications of the horizontal equation of motion, equations of motion on a constant pressure surface, Geostrophic wind and its variation with height; Circulation theorem; verticity equation, potential vorticity and conservation, Rossby waves, Acoustic-gravity waves. **(16 hrs)**

(Chapter - 4, An introduction to Atmospheric Physics, 2nd edition, RG Fleagle, JA Businger, Academic Press, 1980)

References

1. Atmospheric Science - an introductory survey, **JM Wallace and PV Hobbs,** 2nd edition, Elsevier publications, (2006).
2. An introduction to Atmospheric Physics, 2nd edition, **RG Fleagle, JA Businger,** Academic Press, (1980).
3. Basics of Atmospheric Science, **Chandrasekhar A,** PHI Learning Private Ltd. (2010).

ELECTIVE COURSES

Syllabus for IV Semester of M.Sc. Degree in Physics
(CBCS)

PHY 404a: Nuclear decay and Reactor theory (Elective)

Unit I

Beta Decay: Fermi's theory of beta decay, Kurie plots, ft values, selection rules.
Gamma Decay: Selection rules for gamma decay, multipole expansion of electromagnetic radiation in the source free region, sources of multipole radiation, quantum mechanical derivation of the single particle transition probabilities, multipole moments, parity selection rule, Weisskopf estimates.
Angular distribution of the multipole radiation, angular distribution function for dipole and quadrupole radiations, gamma-gamma angular correlation for dipole transitions, angular correlation studies in Cobalt-60, life time measurements.
Internal conversion: Elementary theory of internal conversion, derivation of the K-conversioncoefficient, 0→0 transitions in nuclei.
(16 hrs)

Unit II

Nuclear Fission: Fission cross section, spontaneous fission, mass energy distribution of fission fragments, Liquid drop model applied to fission, Bohr-Wheeler theory, saddle point, barrier penetration, comparison with experiment.Shell correction to the liquid drop model, Strutinsky's smoothing procedure, induced fission below the fission barrier, evidence for the existence of second well in fission isomers, photo fission.
Nuclear Fusion: Basic fusion processes, characteristics of fusion, fusion in stars, controlled thermonuclear reactions. Recent trends and development in fusion technology. **(16 hrs)**

Unit III

Nuclear Reactors: Slowing down of neutrons by elastic collisions, logarithmic decrement in energy, number of collisions for thermalisation, elementary theory of diffusion of neutron flux (i) in an infinite slab with a plan source at one end (ii) in an infinite medium point source at the center, reflections of neutrons, albedo.
Slowing down density, Fermi age equation, correction for absorption, resonance escape probability, the pile equation, buckling, critical size for a spherical and rectangular piles, condition for chain reaction, the four factor formula, classification of reactors, thermal neutron and fast breeder reactors.
(16 hrs)

References

1. Introduction to Nuclear Reactor Theory, **J. R. Lamarsh**, Addison Wesley,(1966).
2. The Elements of Nuclear Reactor Theory, **S. Glasstone and M. C. Edlund**, Van Nortrand Co. (1953).
3. Physics of Nuclei and Particles, **P. Marmier and E. Sheldon**, Vol. I and II, Academic Press,(1969).
4. Elementary Pile Theory, **H. Soodak and B. C. Campbell**, John Wiley,(1950).
5. Structure of the Nucleus, **M. A. Preston and R. K. Bhaduri**, Addision Wesley,(1975).

6. Theoretical Nuclear Physics, **M. Blatt and V. F. Weisskopf**, John Wiley,(1952).
7. Nuclear Physics- Theory and Experiments, **R. R. Roy and B. P. Nigam**, John Wiley, (1967).
8. Classical Electrodynamics, **J. D. Jackson**, John Wiley, (1975).
9. Atomic and Nuclear Physics, **S. N. Ghoshal**, Vol. II., S Chand and Company, (2000).
10. Alpha, beta and gamma spectroscopy, **K. Seighbahn**, Vol. I and II,John Wiley,(1967).

Syllabus for IV Semester of M.Sc. Degree in Physics

(CBCS)

PHY 404b: Condensed Matter Physics –II(Elective)

Unit I

Crystal Physics : Introduction -symmetry elements of crystals, concepts of point groups, space groups, derivation of equivalent point position, experimental determination of space groups, powder diffraction interpretation, expression for structure factor-analytical indexing-Weiss Enbergand rotating crystal method, determination of relative structures, Amplitudes from measured intensities-Multiplicity and Lorentz polarization factors.

Atomic cohesion and crystal binding-primary and secondary bonds- expression for cohesion energy in ionic- calculation of repulsive exponent from compressibility data and nobel gas crystals-Born Hyber cycle -atomic radii vs. lattice constant. Properties of covalent, ionic, metallic and hydrogen bonds.

(16 hrs)

Unit II

Ferromagnetism: Weiss theory of ferromagnetism-Weiss field- -spontaneous magnetization-Curies Weiss Law- Heisenberg exchange interaction-Ising model-ferromagnetic domains-anisotropy energy-Bloch wall- Spin waves-magnons-Bloch3/2law, High temperature properties: corrections to Curie law, analysis of critical point, mean field theory, effect of dipolar interactions, demagnetization factors.

Anti-ferromagnetism: Two sub lattice model-molecular field theory -Neel temperature. Ferrimagnetism, structure of ferrites, saturation magnetization, Curie temperature, susceptibility of ferrimagnets, GMR and CMR materials.

(16 hrs)

Unit III

Ferroelectrics: Classification and properties-crystal types of ferroelctrics-properties of Roshelle salt and $BaTiO_3$-dipole theory-dielectric constant near Curie temperature-microscopic source of Ferroelectricity- -thermodynamics of ferroelectric phase transition-second and first order-ferroelectric domains.

Thinfilms: Preparation - Thermal Vapor Deposition, Chemical Vapor Deposition, laser ablation, Molecular Beam Epitaxy, study of surface topography by multiple beam interferometry, conditions for accurate determination of step height and film thickness Fizeau fringes, Electrical conductivity of thin films, difference of behavior of thin films from bulk material, expression for electrical conductivity for thin film.

(16 hrs)

References
1. Solid State Physics- **A J Dekkar**, MacMillan India Ltd (2000).
2. Elementary Solid State Physic- **Ali Omar**, Adison Wiesly, (2000).
3. Solid State Physics- **C Kittel**, Wiley Eastern, (1996).
4. Elementary Solid State Physic, **J P Srivastava,**PHI (2008).
5. Essential of crystallography, **M A Wahab,**Narosa Publications, (2009).
6. Solid State Physics-**F W Asckroft and A D Mermin**-Saunders College, (1976).
7. Solid State Physics-**S O Pillai**-New Age Int. Publishers, (2001).

Syllabus for IV Semester of M.Sc. Degree in Physics
(CBCS)

PHY 404c: Space Physics(Elective)

Unit - I

Planetary science: Solar system - history, origin, processes - collisions, accretion, volcanism; evolution of the atmosphere, terrestrial planets, outer planets, comets, asteroids, magnetospheres -magnetised planet interaction, comet-solar-wind interaction, effect of charged particles on surfaces; planetary missions, other solar systems. **(10 hrs)**

(Chapter -3, Space science, LK Harra and KO Mason, Imperial College Press, 2004)

Space Plasma Physics: Space plasma, realm of plasma, single particle dynamics, frozen-in flux, MHD plasma waves, solar wind and interplanetary magnetic field, terrestrial magnetosphere. **(6 hrs)**

(Chapter -4, Space science, LK Harra and KO Mason, Imperial College Press, 2004)

Unit – II

Space Weather: Solar activity, solar wind, aurora, solar flares, ionosphere, solar energetic particles, other sources of energetic particles, Coronal Mass Ejections and geomagnetic storms, Halo CMEs.
(8 hrs)
(Chapter -5, Space science, LK Harra and KO Mason, Imperial College Press, 2004)

Physics of Sun: Sun, interior structure of Sun, energy source, solar neutrinos, helioseismology, Sun's magnetic field, butterfly diagram, photosphere, chromosphere, corona, solar flares, solar wind.
(8 hrs)
(Chapter -6, Space science, LK Harra and KO Mason, Imperial College Press, 2004)

Unit - III

Planetary physics: History of planetary science, solar system - giant planets, terrestrial planets, minor planets, comets, satellite and ring systems, planetary properties - orbit, mass, size, rotation, shape, structure, temperature, magnetic field, surface composition, surface structure, atmosphere, interior; formation of solar system.

(8 hrs)

(Chapter - 1, Fundamental planetary science, JJ Lissauer, I de Pater, Cambridge University Press, 2013)

Planetary dynamics: Two-body problem, Newton's laws of motion and gravity, reduction of the two-body problem to the one-body problem, Generalization of Kepler's laws, orbital elements, bound and unbound orbits.
(5 hrs)

(Chapter - 2, Fundamental planetary science, JJ Lissauer, I de Pater, Cambridge University Press, 2013)

Planetary satellites: Moons of Mars, satellites of Jupiter, Saturn, Uranus and Neptune.

(3 hrs)

(Chapter - 10, Fundamental planetary science, JJ Lissauer, I de Pater, Cambridge University Press, 2013)

References

1. Space science, **LK Harra and KO Mason,** Imperial College Press, (2004).
2. Fundamental planetary science, **JJ Lissauer, I de Pater,** Cambridge University Press, (2013).

Syllabus for IV Semester of M.Sc Degree in Physics
(CBCS)

PHY 405: Astrophysics and Cosmology Lab(General)

List of Astrophysics Experiments

1. Characteristics of Telescopes
2. Atmospheric Extinction Coefficient using CLEA software and photometric data
3. Spectral Classification of Stars using CLEA software
4. Distance of Pleiades Cluster by Main Sequence Fitting and using CLEA software.
5. Estimation of Surface Temperature of Stars
6. Mass of Globular Cluster
7. Proper Motion of Stars
8. Distance of Cepheid Variable
9. Solar Rotation period using Sun's images from CLEA Software.
10. Efficiency of Solar cell
11. Determination of Sun's temperature and Luminosity using Sun's flux data
12. Mass of globular cluster NGC 362
13. Determination of the declination of the Sun using Equatorial Sun-dial model
14. Estimation of the Hubble's constant using CLEA
15. Large scale structure of the Universe

16. Estimation of the Solar constant using Suryamapi
17. Estimation of the distance galactic center using given data
18. Spectral study of Seyfert-1 galaxies using IUE data
19. Estimation of the distance of Hyades cluster using given data (Convergent point method)
20. Distances of Pulsars using CLEA software
21. Gravitational Bending of star light using vector-representation data

References

1. Astrophysical techniques, **C Kitchen,** Adam Hilger, **(**1999).
2. Observational Astronomy for Amateurs, **P Moore**, Springer-Verlag,(1994).
3. Exercises in Practical astronomy, **M T Bruck**, Adam Hilger,(1990).
4. Observational astrophysics, **P Lena et. al.**, Springer-Verlag,(2012)
5. Explore the solar system- 25 projects, activities and experiments, **A Yasuda and B Stone**, Nomad press,(2009).

Syllabus for IV Semester of M.Sc Degree in Physics
(CBCS)

PHY 406a: Nuclear Physics Lab (Elective)

List of Nuclear Physics experiments

Experiments using alpha ray spectrometer

1. Energy loss of alpha particles.
2. Scattering of alpha particles.

Experiments using GM counting system

3. Randomocity of nuclear counts (using a weak source).
4. Dead time of GM counting system using two source method.
5. End point energy of beta particles by half thickness measurement
6. End point energy of beta particles by nomogram method
7. Feather analysis – End point energy of beta particles
8. End point energy of beta particles using Fermi Kurie plot
9. Beta efficiency of GM counting system.

Experiments using Gamma Ray Spectrometer

10. Gamma ray spectrum using Multi Channel Analyser (MCA)
11. Z-dependence of external Bremsstrahlung radiation using SCA.
12. Internal conversion using MCA
13. Resolving time of a coincidence module

Nuclear Electronics Experiments

14. Preamplifier circuit
15. Linear Pulse amplifier

Numerical analysis of experimental data

16. Numerical fitting of binding energy curve using semi-empirical mass formula and identifying stable isobar for a given mass number.
17. Evaluation of masses of baryons and mesons using Gell-Mann & Okubo mass formula
18. Multipole analysis of gamma using data.
19. Study of range-energy relations using experimental data.

References

1. Advanced practical physics for students, **Worsnop and Flint,** Asia Publications, (1979).
2. Advanced practical physics,**Singh and Chauhan,** 2 vols., Pragati prakashan, (1976).
3. Physics Lab. Manual, **Misra and Misra,** South Asian publishers, (2000).
4. Practical physics,**Gupta and Kumar,** Pragati Prakashan, (1976).
5. Techniques for Nuclear and Particle Physics Experiments, **W.R. Leo**, 2nd Ed., Springer,(2013).

Syllabus for IV Semester of M.Sc Degree in Physics
(CBCS)

PHY 406b: Condensed Matter Physics Lab (Elective)

List of experiments and exercises:

1. Analysis of X-ray powder photographs (NaCl, KCl, Cu)
2. Analysis of a backscattering of powder photograph of copper
3. Estimation of R-factor using X-ray diffractogram.
4. Determination of Curie temp for a ferromagnetic material (Ni-Fe alloy)
5. Study of B-H curve of a Ferromagnetic material (both hard and soft).
6. Electrical resistivity of semiconducting Ge sample using four probe method.
7. Magnetic susceptibility of Ferrous ammonium sulphate by Gouy's balance method
8. Temperature variation of dielectric constant and determination of Curie point of a Ferro electric solid PZT (Lead Zirconium Titanate)
9. Thermo-stimulated luminescence of F-centre in Alkali halide.
10. Hall effect experiment in semiconductors.
11. Determination of Fermi energy of copper.
12. Determination of Plank's constant using LED's
13. Determination of energy gap of a semiconductor using diode.
14. Determination of Solar cell characteristics
15. Energy band gap of a thermistor
16. Determination of lattice parameter using Bernal Chart

References

1. Advanced practical physics for students, **Worsnop and Flint,** Asia Publications (1979).
2. Advanced practical physics,**Singh and Chauhan,** 2 vols., Pragati prakashan (1976).

3. Physics Lab. Manual, **Misra and Misra,** South Asian publishers (2000).
4. Practical physics, **Gupta and Kumar,**Pragati prakashan (1976).

Syllabus for IV Semester of M.Sc Degree in Physics
(CBCS)

PHY 406c: Atmospheric and Space physics Lab (Elective)

List of Atmospheric and Space Physics Experiments

1. Estimation of Relative Humidity of the Atmosphere
2. Simulation of altitude from pressure and also writing code in c-program
3. Estimation of atmospheric pressure using height, temperature and humidity from GPS-RS data
4. Computation of potential temperature for various heights with GPS-RS data
5. Estimation of horizontal wind speed and direction from radiosonde observations
6. Study of the variations of temperature, pressure and humidity and plotting their contours by making use of given experimental data
7. Estimation of dew point temperature
8. Measurement and analysis of wind speed by anemometer and wind direction by wind wane
9. Zeroth order Climate Model
10. Study of atmospheric parameters and their variations
11. Analysis of incoming solar radiation and outgoing long wave radiation
12. Determination of extinction coefficient of earth's atmosphere using Beer's law using satellite data
13. Determination of extinction coefficient of earth's atmosphere using Beer's law from multi wavelength radiometer using observed values of aerosol optical depth
14. Analysis of Satellite cloud imageries- OLR and cyclone genesis and movement
15. Measurement of magnetic field of earth using magnetometers
16. Total Electron Content measurement using GPS receiver
17. Study of atmospheric features from satellite images and obtaining derived parameters
18. Ionograms for reducing real-height profiles of ionospheric layers and electron densities
19. Study of the variation of sunspot numbers and its cycle
20. Analysis of the trend of solar cycle and activity of Sun

References

1. A course in Dynamic meteorology, Naval Pandarinath, BS Publications, (2006).
2. An introduction to Atmospheric physics, David G Andrews, 2 Edition, Cambridge Univ press, (2010).
3. Atmospheric Science-An Introductory Survey, John M Wallace and Peter V Hobbs, Academic Press, (2006).
4. Basics of Atmospheric Science, Chandrasekhar A, PHI Learning Private Limited, (2010).
5. Fundamentals of Atmospheric physics, Murry L Salby, Academic Press, (996).
6. Guide to meteorological instruments and methods of observations, WMO report no. 8, (2014).

7. Introduction to planetary science, Gunter Faure and Teresa M Mensing, Springer, (2007).
8. Ionospheres: Physics, Plasma Physics and Chemistry, RW Schunk & AF Nagy, Cambridge Univ. Press, (2000).
9. Orbital Motion, AE Roy, 4th Edition, CRC Press, (2004).
10. Practical meteorology by Roland Stull, Whole book version, (2015).
11. Solar Planetary systems, AB Bhattacharya, JM Lichtman, Taylor and Francis group, (2017).
12. The atmosphere, Frederick K Lutgens and Edward J Tarbuck, Pearson Prentice Hall, (2007).

Syllabus for IV Semester of M.Sc Degree in Physics

(CBCS)

PHY 407: PROJECT WORK

The project work may be theoretical or experimental. It should be done under the guidance of a faculty member. A report has to be submitted by the end of the semester. Marks shall be awarded on the basis of the report and a viva-voce examination.

(8 hrs per week)

References

1. Physics Experiments and Projects, Vols. I,II, III, **C Isenberg and S Chomet** eds., Viva books,(1998).
2.125 projects for the evil genius, **J Silver**, McGraw Hill, (2009).

3. Writing up your University assignments and research projects, **N Murray and G Hughes**,Open Univ.Press, (2008).
4. Painless Research Projects, **R S Elliot & James Elliot**, Barons educational series, (1998).
5. Exploring Quantum Physics through hands on projects, **D Prutchi and Shanni Prutchi**, Wiley,(2012).