DAVANGERE UNIVERSITY

Shivagangotri, Davangere-577 002

SYLLABUS: 2016-2017 onwards

M.Sc., PHYSICS

under CBCS scheme

REGISTRAR
DAVANGERE UNIVERSITY
Davangere-577002.

DAVANGERE UNIVERSITY
Shivagangotri, Davangere-577 002

POST-GRADUATE PROGRAMME-Choice Based Credit Scheme (CBCS)

Master of Science (M.Sc.) in Physics

SYLLABUS: 2016-2017

Structure, Course Titles, Workload & Credits

Course Number	Theory /Practicals	Workload per Week	FIRST YEAR		SECOND YEAR			
			Semester-I	**Semester-II**	**Semester-III**	**Semester-IV**		
			Honours' Degree		***Master's Degree***			
I	Theory-1	T-4	Mathematical Methods of Physics-I	Mathematical Methods of Physics-II	Astrophysics	I	1.1	Condensed Matter Physics-I
II	Theory-2	T-4	Classical Mechanics	Statistical Mechanics	Nuclear & Particle Physics	II	2.1	Condensed Matter Physics-II
III	Theory-3	T-4	Classical Electrodynamics and Plasma Physics	Quantum Mechanics-I	Quantum Mechanics-II	III		Electives-I
							3.1	Laser Physics or
							3.2	Nanophysics or
							3.3	Atmospheric Physics
IV	Theory-4	T-4	Electronic Circuits and Devices	Atomic and Molecular Physics	General Condensed Matter Physics	IV		Electives-II
							4.1	Crystal Physics or
							4.2	Solar & Hydrogen Energy or
							4.3	Space Physics
Course Related Practicals for 100 Marks each	Practical-1	P-8	I-1: Electronic Lab	II-1: Optics & Computational Techniques Labs	III-1: Nuclear Physics Lab	*IV.1: Condensed Matter Physics Lab*		
	Practical-2	P-8	I-2: General Physics Lab-I	II-2: General Physics Lab-II	III-2: General Condensed Matter Physics Lab	*IV.2: Atmospheric & Space lab Or* ***Project Work**** *(Instead of Practicals- for 4 Credits in 4th Sem.*		
TOTAL NO OF HOURS/CREDITS		T-16+ P-16 = 32 Hours	*T-16 Credits + P-16 (8 Credits) = 24 Credits*	*T-16 Credits + P-16 (8 Credits) = 24 Credits*	*T-16 Credits + P-16 (8 Credits) = 24 Credits*	*T-16 Credits + P-16 (8 Credits) = 24 Credits*		

Project Work - 100 Marks (of Which, 75 Marks for Dissertation and 25 Marks for Presentation at the Viva-Voce Exam)

Skill Development Courses *(With Test & Certificate at the Institution Level)*				**Interdisciplinary Course** (Examination to be Conducted by the University)	(**Additional Interdisciplinary Course Option to Students**)
Mandatory Courses	+4 Hours	Functional & Communicative English	*Computer Basis & applications*	1. Introduction to Energy Science and Technology 2. Atmospheric Science	Subject from Outside the Faculty (for Ex.about Science to Social Science Students)

** **Socially Relevant Credit Audit Courses** (Based on Lecture Series & Workshops) (No Exam but Title of the Courses & Credits will be entered in the IV Semester Marks Card)

Compulsory Skill Development Courses**	+2 Hours	Basic Law & Legal Awareness	*Socially Relevant Issues*	Administration & e-Governance	Personality Development.

Programme - M. Sc. Physics (2016-17 onwards)

Courses having focus on employability/ entrepreneurship/ Skill development

Paper Code	Title of the Paper	Activities with direct bearing on employability/ entrepreneurship/ Skill development
16PHY A01	**Mathematical Methods of Physics-I**	The knowledge of tensor analysis helps the students with skills to implement stress & strain related forces acting in civil engineering works. Further the understanding of materials helps in coding vector related problems.
16PHY A02	**Classical Mechanics**	The knowledge of Kepler's law helps the students to develop a skill to calculate the relative distance between the planets. Further the knowledge of Coriolis force helps them in implementing weather forecasting skills.
16PHY A03	**Classical Electrodynamics and Plasma Physics**	Felids of Moving charges, radiating systems propagation and interactions of electromagnetic waves, behavior plasma and interferometer and interference filters.
16PHY A04	**Electronic Circuits and Devices**	Student with Op Amp and digital electronics circuits handling skills enables them getting employability in functioning hardware industries.
16PHY A I-1	**Electronics Lab**	With the help of the practical skills students can obtain employability in hardware industries.
16PHY A I-2	**General Physics Lab - I**	Students will develop the skills of observing and developing optical devices for practical purpose by gaining employability in Telescope and Microscope designing industries.
Mandatory Credits: Functional and communicative English		
16PHY B01	**Mathematical Methods of Physics-II**	Working out the solution of partial differential equations. Group representation, identifying boundary conditions, errors analysis and Monte Carlo Calculations.
16PHY B02	**Statistical Mechanics**	The knowledge of statistical mechanics helps students develop skills that can infer for the statistical data obtained from various sample sizes.
16PHY B03	**Quantum Mechanics-I**	Wave function, working out the solution of Schrodinger, wave equation and Operator algebra.

16PHY B04	**Atomic and Molecular Physics**	The students will develop IR & Raman spectra recording skills and the knowledge of lasers and optical fibers helps them to get employability.
16PHY B II-1	**Optics and Computational labs**	The knowledge of latex helps students with a skill to compute large documents with ease of access. The understanding of octave helps students in developing coding skills that can give results in short span of time.
16PHY B II-2	**General Physics Lab - II**	Space dynamics, remotes sensing, concepts stellar interferometer, H-R diagram and Solar system.
Mandatory Credits: Computer Basics and Applications		
16PHY C01	**Astrophysics**	Space dynamics, remote Sensing, concepts stellar interferometer H-R diagram and Solar system.
16PHY C02	**Nuclear and Particle Physics**	Magnetic moment by molecular beam experiment, nuclear spin, nuclear reactions -Q values, threshold energy, working neutrons, nuclear forces and particle interactions.
16PHY C03	**Quantum Mechanics -II**	Employing approximation methods to various systems and Dirac's Concepts.
16PHY C04	**General Condensed Matter Physics**	The understanding of crystal structure, the behavior of solids helps in developing materials that has high withstanding capacity in its respective practical fields. This in turn helps students' employability in the respective manufacturing industries.
16PHY C III-1	**Nuclear Physics Lab**	The skills of handling Nuclear detector and counter helps them in employing in various energy related job opportunities.
16PHY C III-2	**General Condensed Matter Physics Lab**	With the skills of determining fermi energy, energy gap and hall coefficients of a material, students can obtain employability in the field of chip manufacturing and material synthesis.
16PHY D01	**Condensed Matter Physics (CMP)- I**	With the understanding of semiconductor properties and optical properties of solids students can obtain employability in the field of semiconductor industries.
16PHY D02	**Condensed Matter Physics (CMP)- II**	Dielectric, ferroelectric properties of Solids, growth of nanomaterials, and studies on imperfections & dislocations.
16PHY D03.1	**Laser Physics**	With skills of laser properties, students will have employability in the field of developing sensors and security devices.

16PHY D03.2	**Nanophysics**	The skill of designing materials helps them in developing materials that have practical application which intern helps them with employability in respective industries. Further with good professional experience students can work on entrepreneurship in this field as well.
16PHY D03.3	**Atmospheric Physics**	The skills of developing atmospheric models to study the pollution in the atmosphere helps them in getting employability in various instrument and radar systems.
16PHY D04.1	**Crystal Physics**	The understanding of crystal structure helps in materials' developing skills in respective practical fields.
16PHY D04.2	**Solar and Hydrogen Energy**	With the knowledge of solar photovoltaic cells students can gain employability in various industries that are focusing on harnessing solar energy efficiently. Further the understanding of hydrogen power helps them getting employability in its respective fields.
16PHY D04.3	**Space Physics**	Space dynamics, remote Sensing, and Solar system.
16PHY D IV-1	**Condensed Matter Physics Lab**	Four probe technique, Guy balance handling Measurement of magnetic Susceptibility, coercivity, retentivity, energy loss of ferromagnetic materials V-I Characteristics, magnetoresistance activation energy.
16PHY D IV-2	**Atmospheric and Space lab**	With the understanding of various experimental techniques students can obtain employability in scientific instruments manufacturing units.
Project Work		Working on specific projects students gain the skills to further their interest in the field of research and in solving various scientific problems.

M.Sc. PHYSICS

SEMESTER – I

Course Code: (**Phy.Core: I-1**)

MATHEMATICAL METHODS OF PHYSICS – I

(4 hours teaching per week)

Unit-1 **(13 HOURS)**

Vector Analysis in curved Coordinates and Tensors: Review of vector algebra and calculus, Gauss and Stokes theorems, Orthogonal coordinates, Differential vector operators, Special coordinate systems, Circular cylindrical coordinates, Spherical polar coordinates, Tensor analysis, Contraction, Direct product, Quotient rule, Non-cartesian Tensors, Metric Tensors, Christoffel Symbols, Covariant Differentiation, Tensor differential operators.

Unit-2 **(13 HOURS)**

Special Functions: Second order ordinary differential equations, Frobinus methods for solving second order linear ODE's, Beta and Gamma functions, Legendre's equation, Legendre polynomials and their properties, Bessel's equation, Bessel functions and their properties, Laguerre's equation - its solutions and properties, Hermite equation and its solutions, Hermite polynomials and their properties.

Unit-3 **(13 HOURS)**

Matrices and Calculus of Residues: Different types of Matrices - Orthogonal, Hermitian, Unitary and Normal, Independent parameters, Eigen values and Eigen functions of Matrices, Diagonalisation of Matrices.

Properties of Analytic functions, Cauchy-Riemann conditions, Cauchy's Integral theorem, Cauchy Integral formula, Taylor expansion, Laurent expansion, Singularities, Cauchy's Residue theorem.

Unit-4 **(13 HOURS)**

Fourier Series and Integral Transforms: Review of Fourier series, Generalized Fourier series, Expansion of functions in Fourier series, Fourier Integrals, Sine and cosine series, Fourier transforms of derivatives, Convolution Theorem, Laplace transforms and their properties, Laplace transforms of derivatives, Convolution theorem, Inverse Laplace transformations, Solution of differential equations using Laplace transformations.

References:

1. Arfken G. B. and Weber H. J., (1995) Mathematical Methods of Physicists, 4^{th} Edition, Books Pvt. Ltd., India.
2. Sathya Prakash, (1985) **Mathematical Physics**, Sultan Chand and Sons.
3. Chattopadhyaya P.K., (1980) Mathematical Physics, Wiley Eastern.
4. Bose H.K. and Joshi M.C, (1984) **Methods of Mathematical Physics**, Tata McGraw Hill.
5. Harper, **Introduction to Mathematical Physics**, PHI.
6. Sharma, **Matrix Methods and Vector Spaces in Physics**, PHI.
7. Harry Lass (1950) **Vector and Tensor Analysis**, McGraw Hill
8. Riley K.F., Hobson, Bence, (2010) **Mathematical Methods for Physics and Engineering** CUP.

M.Sc. PHYSICS

SEMESTER – I

Course Code: (**Phy.Core: I-2**)

CLASSICAL MECHANICS

(4 hours teaching per week)

Unit-1 **(13 HOURS)**

Newtonian Mechanics: Single and many particle systems - Conservation laws of linear momentum, angular momentum and energy. Application of Newtonian mechanics: Two-body central force field motion; Kepler's laws of planetary motion. Scattering in a central force field, Scattering cross-section, the Rutherford scattering problem.

Unit-2 **(13 HOURS)**

Lagrangian formulation: Constraints in motion. Generalized co-ordinates. Virtual work and D'Alembert's principle. Lagrangian equations of motion. Symmetry and cyclic co-ordinates. Hamilton variational principle; Lagrangian equations of motion from variational principle. Simple applications.

Unit-3 **(13 HOURS)**

Hamiltonian formalism: Hamilton's equations of motion - from Legendre transformations and the variational principle. Simple applications. Canonical transformations. Poisson brackets - Canonical equations of motion in Poisson bracket notation. Hamilton - Jacobi Equations.

Unit-4 **(13 HOURS)**

Continuum mechanics: Basic Concepts**,** Equations of continuity and motion - Navier-Stokes equations; Simple applications.

Relativistic mechanics: Four-dimensional formulation-four-vectors, four-velocity, four-momentum and four-accleration. Lorentz co-variant form of equation of motion.

References

1. Classical Mechanics: **H. Goldstein**, (Addison-Wesley, 1950)
2. Introduction to Classical Mechanics: **R.G. Takawale** and **P. S. Puranik** (TMH, 1979)
3. Classical Mechanics: **N. C. Rana** and **P. S. Joag** (Tata McGraw, 1991)
4. Mechanics: **Landau L. D.** and **Lifshitz E. M.** (Addition-Wesley, 1960)

M.Sc. PHYSICS

SEMESTER – I

Course Code: (**Phy.Core: I-3**)

CLASSICAL ELECTRODYNAMICS AND PLASMA PHYSICS

(4 hours teaching per week)

Unit-1 **(13 HOURS)**

Electrostatics and Magnetostatics: Coulomb's Law, Gauss's Law and applications, Electric potential, Possion's equations; Work, Energy in Electrostatics, Laplace equation and its solution in one, two and three dimensional cartesian co-ordinates, Boundary conditions and Uniqueness theorem, Multipole expansion of potential, Dipole field, Biot-Savart Law and applications, Ampere's Law and applications, Magnetic vector potential, Multipole expansion of the vector potential, Magnetisation, the field of a magnetized object, Linear and non-linear media.

Unit-2 **(13 HOURS)**

Electrodynamics and Electromagnetic Waves: Review of Maxwell's equations, Formulating electrodynamics using scalar and vector potentials, Gauge transformations, Coulomb and Lorentz Gauges; Energy and momentum of electromagnetic waves, Propagation through linear media, Reflection and Transmission of electromagnetic waves; Plane waves in conducting media, Skin depth, Dispersion of electromagnetic waves in non-conductors, wave Guides, TE-waves in rectangular waveguide.

Unit-3 **(13 HOURS)**

Electromagnetic Radiation: Retarded potentials, Electric and magnetic dipole radiation, Liendard – Wiechert potentials, Fields of a point charge in motion, Power radiated by a point charge, Larmor formula, Bremsstrahlung.

Special Relativity and Maxwell's Equations: Review of Lorentz transformations, Four vectors, Magnetism as a relativistic phenomenon, Lorentz transformation of electric and magnetic fields, the electromagnetic field tensor, Potential formulation of electrodynamics.

Unit- 4 **(13 HOURS)**

Plasma Physics: Definition of Plasma, Debye shielding, Charged particle motion in Electric and magnetic fields at right angles, Time varying E and B fields, Adiabatic invariants, Dielectric constant of a plasma, Equations of motion of a plasma fluid, Magnetic pressure, Plasma confinement, Pinch effect, Plasma as a conducting fluid, Drift velocities, Plasma oscillations, Plasma waves, Propagation of electromagnetic waves in plasma.

References:

1. Bittencourt J. A., (2004) **Fundamentals of Plasma Physics**, Springer.
2. Choudhuri A. R., (1998) **The Physics of Fluids and Plasmas**, Cambridge, UP.
3. Grant I.S. and Phillips W.R., (1975) **Electromagnetism**, John Wiley and Sons Ltd.
4. Griffths D. J., (2004) **Introduction to Electrodynamics**, Third Editions, PHI.
5. Jackson J. D., **Classical Electrodynamics**, Wiley Eastern.
6. Laud B. B., (1987) **Electromagnetics**, New Age International Pvt. Ltd.
7. Lorrain P. and D. Corson, (1986) **Electromagnetic Fields and Waves**, CBS.
8. Paul Bellan, (2006) **Fundamentals of Plasma Physics**, CUP.
9. Pramanik, **Electromagnetism**, PHI.

M.Sc. PHYSICS

SEMESTER – I

Course Code: (**Phy.Core: I-4**)

ELECTRONIC CIRCUITS AND DEVICES

(4 hours teaching per week)

Unit-1: **(13 HOURS)**

Physics of Devices: P-N junction, Abrupt junction, Band structure, Thermal equilibrium, Depletion region, Depletion capacitance, Current and voltage characteristics, BJT - Band structure, Transistor action, Static Characteristics, MOS structure - MOSFET working, MOSFET characteristics, Width of depletion region, Junction capacitance, Threshold voltage, Metal semiconductor contacts - Ohmic and Schottky contacts, MESFET principle – Structure, working, characteristics. Principle of operation of Photoelectronic devices: Photo Conductor - Efficiency, Current Gain, Response Time. Effect of Light on I-V characteristics of a junction photo device - Principle and working of a Photodiode, Light Emitting Devices - Principle, working and factors affecting the efficiency of LED.

Unit-2: **(13 HOURS)**

Transistor Circuits: The Common Base Configuration - I-V Characteristics, Alpha - equivalent circuit, Common Collector configuration (the Emitter Follower), Input and output impedances – Gain; Common Emitter configuration - I-V characteristics, Beta of a transistor, Base bias with single supply – Gain. Loadlines for CE connection – DC Loadline, AC Loadline, Optimum operating point. Push-pull amplifier. The Darlington Pair. Astable multivibrator using transistors, Voltage regulator using transistors, Basic concept of oscillator, RC Phase shift oscillator.

Unit-3: **(13 HOURS)**

Operational Amplifiers: Block diagram of an operational amplifier, Characteristics of an ideal operational amplifier - comparison with 741, Operational amplifier as a open loop amplifier – Limitations of open loop configuration, Operational amplifier as a Feedback amplifier; Closed loop gain, input impedance, output impedance of inverting and non-inverting amplifiers, Voltage follower, Differential amplifier - Voltage gain. Applications of Op-Amp; Linear Applications, Phase and frequency response of low pass, high pass and band pass filters (first order), Summing amplifier - inverting and non-inverting configurations, Subtractor, Difference summing amplifier, Ideal and practical differentiator, Integrator. Non-linear Applications: Comparators, Schmitt Trigger IC-555 Timer - Monostable and astable multivibrator, Positive and negative clippers, Positive and negative clampers, Small signal half wave rectifiers.

Unit-4: **(13 HOURS)**

Digital Circuits: Review of Gates (AND, OR, NAND, NOR, NOT, EX-OR), Boolean laws and theorems, Simplification of SOP equations, Simplification of POS equations, Simplification using Karnaugh Map technique (4 Variables), Conversion of Binary to Grey Code, Flip-Flops: Latch using NAND and NOR Gates, RS Flip-Flop, Clocked RS Flip-Flop, JK Flip-Flop, JK Master slave Flip-Flop Racing, Shift registers – basics, Counters: Ripple counters - Truth Table, timing diagram, Synchronous counters – Truth Table, timing diagram, Decade counter.

M.Sc. PHYSICS

SEMESTER - I

Course Code: (**Phy.Pra: I-1**)

ELECTRONICS LAB

List of Experiments
(At least Ten of the following to be performed)

1. Active Low Pass Filter using Op-Amp.
2. Active High Pass Filter using Op-Amp.
3. RC Phase Shift Oscillator using transistor.
4. Astable Multivibrator using Timer.
5. Summing, Scaling and Averaging Amplifier using Op-Amp.
6. Astable Multivibrator using Transistors.
7. Twin T Notch Filter using Op-Amp.
8. Boolean Expression Implementation.
9. Series Voltage Regulator using Transistors.
10. Differentiator and Integrator using Transistors.
11. Half Wave Precission Rectifier using Op-Amp.
12. Push Pull Amplifier using Transistors.
13. Clipping and Clamping Circuits.
14. Differentiator and Integrator Circuits.
15. Logic Gates.
16. Monostable Multivibrator using timer.
17. MOSFET Common Source Amplifier.

(Experiments may be added with BOS approval whenever new experiments are setup and tested)

References:

1. Albert Malvino, **Electronic Principles, Experimental Manual**.
2. Grob, Pugh, Ponic, (1997) **Experiments in Basic Electronics**, McGraw Hill.
3. Horowitz and Hill, (1989) **The Art of Electronics**, CUP.

M.Sc. PHYSICS

SEMESTER - I

Course Code: (**Phy.Pra: I-2**)

GENERAL PHYSICS LAB - I

List of Experiments
(At least Ten of the following to be performed)

1. Thermal Conductivity of a Material of Rod by Forbe's Method.
2. Thermal Conductivity of a Material of a Rod by Angstrom's Method.
3. Determination of the Size of the Lycopodium Particles by Diffraction Method using
   a) Spectrometer, b) Young's method.
4. Verification of Fresnel's Law of Reflection.
5. Determination of Elastic Constant of a Material of Glass plate by Cornu's Interference method.
6. Verification of Stefan's Law by Electrical method.
7. Determination of Hartmann's constants and hence to verify the Hartmann's formula and study of Electronic Absorption Band of $KMnO_4$.
8. Determination of Wavelength of Iron Arc Spectral Lines using Constant Deviation Spectrometer.
9. Experiments with Babinet Compensator.
10. Determination of Wavelength of Sodium Light by Michelson's Interferometer.
11. Fabry-Perot Etalon.
12. Energy Gap of a Semiconductor.
13. Ultrasonic Interferometer.
14. Michelson Interferometer experiments.
15. Modes of Vibration of a fixed Free Bar.
16. Susceptibility by Quinke's Method.
17. Experiments with Constant Deviation Spectrometer.

(Experiments may be added with BOS approval whenever new experiments are setup and tested)

References:

1. Gupta and Kumar (1976) **Practical Physics**, Pragati Prakashan.
2. Misra and Misra, (2000) **Physics Lab, Manual**, South Asian Publishers.
3. Misra and Mohanty, (2007) **Advanced Physics Lab Manual**, South As An Publication.
4. Rajkumar and Madan Lal, **Advanced Practical Physics**, Kedarnath Ramnath.
5. Sawyer R. A., (1963) **Experimental Spectroscopy**, Dover.
6. Singh and Chauhan (1976) **Advanced Practical Physics**, 2 Vol., Pragati Prakashan.
7. Worsnop and Flint (1979) **Advanced Practical Physics for Students**, Asia Publishers.

M.Sc. PHYSICS

SEMESTER – II

Course Code: (**Phy.Core: II-1**)

MATHEMATICAL METHODS OF PHYSICS - II

(4 hours teaching per week)

Unit-1: **(13 HOURS)**

Partial Differential Equations: Classification of PDE's, System of surface and characteristics, Examples of Hyperbolic, Parabolic and Elliptic Equations, Solution by the method of Direct integration, Method of separation of variables, the Wave equation, Laplace equation, Heat conduction equations and their solutions in cartesian coordinate system in One, Two and Three dimensions, Plane polar coordinates, cylindrical polar and spherical polar coordinates, Spherical harmonics and their properties.

Unit-2: **(13 HOURS)**

Group Theory: Definition and examples of Groups, Symmetry Group of a square, Multiplication table, Classes and subgroups, Cyclic Groups, Direct product of Groups, Isomorphism and homomorphism, Permutation Group, Reducible and Irreducible Group representations, Schur's Lemmas - examples, Topological and Lie Groups, Connectedness and Compactness, Group Generators, Representation of a continuous Group, SO(2), SO(3) and SU(2) Groups and their representation, the Lorentz Group.

Unit-3: **(16 HOURS)**

Green's Functions and Integral Equations: Boundary value problems, Sturm-Lioville theory, Self adjoint operators, Dirac delta functions and its properties, Green's functions for One, Two and Three dimensional equations, Eigen function expansion of Green's functions, Fredholm and Volterra type integral equations, Solution of equations with separable Kernals, Neumann series method – examples, Non-homogeneous integral equations.

Unit-4: **(16 HOURS)**

Numerical Techniques and C Programming: Solution of Linear algebraic equations using matrix method, Solution of transcendental equations by bisection, Iteration and Newton-Raphson methods, Curve fitting by least squares method, Numerical integration by Trapezoidal and Simpon's rules, Numerical solutions of differential equations by Euler's and Runge-Kutta methods. Fundamentals of C Language, Operators and expressions, Control statements, Functions and programs.

References:

1. Arfken G., (2001) **Mathematical Methods for Physicists**, 5th Edition, Academic Press.
2. Balaguruswamy E., (1992) **Programming in C**, TMH.
3. Bose H. K., and Joshi M. C., (1984) Methods of Mathematical Physics.
4. Byron Gottfried, (1996) **Programming with C**, Schaum's Outline Series, TMH.
5. Chattopadhyaya P. K., (1980) **Mathematical Physics**, Wiley Eastern.
6. Joshi A.W., (1997) **Group Theory for Physicists**, New Age International.
7. Kanitkar, **C Programming**.
8. Sastry S. S., (2003) **Introductory Methods of Numerical Analysis**, PHI.
9. Sathya Prakash 91985) **Mathematical Physics**, Sultan Chand and Sons.
10. Shankar Rao, **Introduction to Partial Differential Equations**, PHI.
11. Sokolnikoff I. S.**Tensor Analysis**.

M.Sc. PHYSICS
SEMESTER – II
Course Code: (**Phy.Core: II-2**)
STATISTICAL MECHANICS

(4 hours teaching per week)

Unit-1: **(16 HOURS)**

Classical statistical ideas: The State of a system, Statistical ensemble, Basic postulates, Probability calculations, Density of states, Thermal and mechanical interactions between macroscopic systems, Quasi –static processes, Work done by pressure, Equilibrium conditions and constraints, Reversible and irreversible processes, Distribution of energy between systems in equilibrium, Temperature, Heat reservoirs, Statistical description of isolated systems, Systems in contact with heat reservoirs, Simple applications of the canonical distribution, Calculation of mean values in a canonical ensemble, Connection with thermodynamics, Grand canonical and other ensembles.

Unit-2: **(16 HOURS)**

Applications of Classical statistical mechanics: Partition functions and their properties, Thermodynamic quantities of ideal monoatomic gas, Gibbs paradox, Validity of the classical approximation, The Equi-partition theorem and its applications, Specific heats of solids, Paramagnetic susceptibility, Maxwell velocity distribution, Pressure and momentum transfer.

Unit-3: **(16 HOURS)**

Quantum statistics: Identical particles and symmetry requirements, Formulation of the statistical problem, Quantum distribution functions, Photon statistics, Fermi-Dirac statistics, Bose-Einstein statistics, Maxwell-Boltzmann statistics, Quantum statistical in the classical limit, Quantum states of a single particle, Evaluation of partition function, Black body radiation, Conduction electrons in metals, Electronic specific heat.

Unit-4: **(16 HOURS)**

Irreversible processes and fluctuations: Transition probabilities and master equation for an isolated system, System in contact with a heat reservoir, Langevin equation for Brownian motion, Mean square displacement, Relation between dissipation and the fluctuating force, Fourier analysis of random functions, Ensemble and time averages, Wiener-Khintchine relations, Nyquist's theorem and equilibrium conditions, Fluctuations and Onsager relations, Symmetry properties.

References:

1. Gopal E. S. R., (1976) **Statistical mechanics and Properties of Matter**, Macmillan, India.
2. Huang K., (1975) **Statistical Mechanics**, Wiley Eastern Limited, New Delhi.
3. Kittel, (1958) **Elementary Statistical Physics**, John Wiley, New York.
4. Landau and Lifshitz, (1974) **Statistical Physics**, Pergamon Press, Oxford.
5. Patria R. K., (1972) **Statistical mechanics**, 2nd Edition, Pergamon Press.
6. Reif F., (1985) **Fundamentals of Statistical and Thermal Physics**, McGraw Hill.
7. Salinas S. R. A., (2009) **Introduction to Statistical Physics**, Springer International.
8. Srivastava and Ashok, **Statistical Mechanics**, PHI.

M.Sc. PHYSICS

SEMESTER – II

Course Code: (**Phy.Core: II-3**)

QUANTUM MECHANICS - I

(4 hours teaching per week)

Unit-1: **(13 HOURS)**

Basic concepts in Quantum mechanics: Wave-particle duality, the wave function and its interpretation, Free particle wave function, Wave packets, Gaussian wave packet evolution, Heisenberg uncertainty principle and illustrations, Time-energy uncertainty, Complementarity principle.

Time-dependent Schrodinger equation, Conservation of probability, Expectation values and operators, Ehrenfest's theorems, Time-independent Schrodinger equation, Stationary states, Energy quantization, Properties of the energy Eigen functions, General solution for a Time-independent potential, Schrodinger equation in momentum space.

Unit-2: **(13 HOURS)**

One–dimensional problems: The free particle, Momentum Eigen functions, the Potential step, Reflection co-efficient, the potential barrier, Transmission and reflection coefficients, the Infinite square well, Finite square well, Linear harmonic oscillator - Energy levels and Eigen functions, the Periodic potential.

Unit-3: **(13 HOURS)**

The General Formalism: State of a system, Dynamical variables and operators, Expansions in Eigen functions, Commuting observables, Compatibility and Heisenberg uncertainty relations, Unitary transformations, Matrix representations of wave functions and operators, Linear harmonic oscillator by Operator method, Time evolution of a system, The Virial theorem, Schrodinger equation for a Two-body system, Schrodinger and Heisenberg pictures.

Unit-4: **(13 HOURS)**

Angular Momentum: Orbital angular momentum, Spatial rotations, Eigen functions and Eigen values of L^2 and L_Z operators, Particle on a sphere and the rigid rotator, General angular momentum, the spectrum of J^2 and J_Z, Matrix representation of angular momentum operators, Spin angular momentum, Total angular momentum, Addition of angular momenta, Addition of orbital angular momentum and Spin of a particle, Addition of Two Spin ½, CG co-efficients.

References:

1. Agarwal and Hariprakash, **Quantum Mechanics**, PHI.
2. Biswas S. N., (2010) **Quantum Mechanics**, Books and Allied.
3. Bransden B. H. and Joachain C.J., (2004) **Quantum Mechanics**, 2nd Edition, Pearson Education.
4. David J. Griffiths (2005) **Introduction to Quantum Mechanics**, 2nd Edition, Pearson Education.
5. Ghatak and Lokanathan, (2004) **Principles of Quantum Mechanics**, Macmillan.
6. Merzbacher E., (1999) **Quantum Mechanics**, John Wiley.
7. Powell and Crasemann, (1964) **Quantum Mechanics**, IBH.
8. Sakurai J. J., (2000) **Modern Quantum Mechanics**, Pearson Education.

M.Sc. PHYSICS

SEMESTER – II

Course Code: (**Phy.Core: II-4**)

ATOMIC AND MOLECULAR PHYSICS

(4 hours teaching per week)

Unit-1: **(16 HOURS)**

Atomic Physics: Brief review of Atomic models of Bohr and Sommerfeld, One electron atom: Quantum states, Atomic orbitals, Spectrum of hydrogen, Rydberg atoms (brief treatment), Relativistic corrections to spectra of alkali atoms: Spin-orbit Interaction and fine structure in alkali spectra. Two electron atom: Ortho and para states and role of Pauli principle, Level schemes of Two electron atoms. Perturbations in the spectra of One and Two electron atoms: Zeeman effect, Paschen-Back effect, Stark effect in hydrogen spectra, Hyperfine interactions and 21cm line of hydrogen. Many electron atoms: Central field approximation. LS and JJ coupling schemes.

Unit-2: **(16 HOURS)**

Molecular Spectra and Microwave Spectroscopy: Electromagnetic radiations from molecules, Basic elements of practical spectroscopy, Widths and intensities of spectral lines, Fourier transform spectroscopy, Microwave spectroscopy - rotation of molecules, Rotational spectra of diatomic molecules, Rigid rotator, Intensities of spectral lines, Isotopic substitution, Non-rigid rotator, Spectrum of a non-rigid Rotator, Polyatomic molecules, Linear molecules, Symmetric top molecule, Experimental techniques and instrumentation.

Unit-3: **(16 HOURS)**

Infrared and Raman spectroscopy: Diatomic molecule as a simple harmonic oscillator, Anharmonicity, Diatomic vibrationg rotator, Vibration rotation spectrum of carbon monoxide, Vibrations of polyatomic molecules, Influence of rotation on the spectra of polyatomic molecules, Linear molecules, Symmetric top molecules, Experimental technique and IR spectrometer, Fourier transform spectroscopy. Raman spectroscopy: Quantum theory of Raman effect, Pure rotational Raman spectra. Vibrational Raman spectra, Polarization of light and Raman effect, Structure determination from Raman and Infrared spectroscopy.

Unit-4: Laser and fiber optics **(16 HOURS)**

Coherence of light, Spatial and temporal coherence, Einstein's co-efficients: Spontaneous and stimulated emission, Idea of light amplification, Characteristics of a laser beam, Threshold condition for laser oscillation, Role of resonant cavity, He-Ne lasers, Applications of lasers, Holography: Fundamentals of 3D-mapping of images, Recording and reconstruction, Applications in Microscopy and Interferometry, Fiber Optics: Mechanism of light propagation in a fiber wave guide, Numerical aperture, Types of optical fibers, Transmission characteristics of optical fibers - Attenuation and Dispersion in fibers.

References:

1. Atkins P. W., and Friedman R.S., (2004) **Molecular Quantum Mechanics**, 3rd Edition, Oxford Press, (Indian Edition)
2. Banwell and McCash, (1998) **Fundamentals of Molecular Spectroscopy**, Tata McGraw Hill.
3. Bransden and Joachain, (2004) **Physics of Atoms and Molecules**, 2nd Edition, Pearson Education.
4. Ghatak and Tyagarjan, (2004) **Optical Electronics**, Cambridge, Press.
5. Herzberg G., (1950) **Spectra of Diatomic Molecules**, Van Nostrand.
6. Hollas J. M., (1998) **Modern Spectroscopy**, John Wiley.

7. Kar R. K., (2008) **Optics (Classical and Quantum),** Books and Allied.
8. Klein M. V., and Furtak T.E., (1986) **Optics,** John Wiley.
9. Laud B. B., (1991) **Lasers and Nonlinear Optics**, Wiley- Eastern Ltd.
10. Nambiar, (2004) **Lasers**, New Age International.
11. Silfvast (1998) **Lasers**, Cambridge Press.
12. White H. E., **Introduction to Atomic Spectra**, McGraw Hill.

M.Sc. PHYSICS

SEMESTER - II

Course Code: (**Phy.Pra: II-1**)

OPTICS AND COMPUTATIONAL LABS

List of Experiments

(Any Eight of the following to be performed)

1. Bisection method for solving equations.
2. Euler method for solving differential equations.
3. Least square fit method (Linear Regression) for data.
4. Newton-Raphson method for solving equations.
5. Simpon is 1/3rd rule method for Integrating a function.
6. Runge-Kutta 2nd order method for Integration.
7. Interference and diffraction experiments with laser.
8. Edser-Butler fringes.
9. Absorption coefficient of a solution.
10. Study of ellptically polarized light.
11. Jamin interferometer.
12. Rotatory dispersion.
13. Experiments with Michelson interferometer.

(Experiments may be added with BOS approval whenever new experiments are setup and tested)

M.Sc. PHYSICS

SEMESTER - II

Course Code: (**Phy.Pra: II-2**)

GENERAL PHYSICS LAB - II

List of Experiments/Computer Exercises
(Any Eight of the following to be performed)

1. Variation of Surface Tension with temperature.
2. Ultrasonic interferometer.
3. Thermocouple charcteristics.
4. Mode constants of steel rod.
5. Thermal conductivity of a poor conductor.
6. Energy Gap of a thermistor.
7. Measurements of low resistances using Kelvin bridge.
8. Verifications of the law for thermo Emf's.
9. Thermal expansion of solids by optical methods.
10. Thermionic emission
11. Dielectric constant of solids.
12. Analysis of Rotation-vibration spectrum of a diatomic molecule.
13. Experiments with photocells.

(Experiments may be added with BOS approval whenever new experiments are set up and listed)

References:

1. Gupta and Kumar, (1976) **Practical Physics**, Pragati Prakashan.
2. Misra and Misra, (2000) **Physics Lab Manual**, South Asian Publishers.
3. Sing and Chauhan, (1976) **Advanced Practical Physics**, 2 Volumes, Pragati Prakashan.
4. Worsnop and Flint, (1979) **Advanced Practical Physics for Students**, Asia Publication.

M.Sc. PHYSICS

SEMESTER – III

Course Code: (**Phy.Core: III-1**)

ASTROPHYSICS

(4 hours teaching per week)

Unit-1: **(13 HOURS)**

Orbital motion and Space dynamics: Coordinate and time systems, Elements of orbits in space, Elements of reduction of observational data, Review of Two body problem: Kepler's Law of orbital motion, Newton's laws of motion and gravitation, Solution to Two body problem: Elliptical, Parabolic and Hyperbolic orbits, Orbits in space: f and g series Many body problem: Equations of motion, Lagrange's solutions, Lagrange's planetary equations(qualitative), Artificial satellites, Types of orbits-Geostationary and Geosynchronous orbits, Sun Synchronous orbits and satellites, Weightlessness and Artificial gravity. Forces acting on Artificial satellites, Atmospheric drag. Rocket motion: Motion of a rocket in a gravitational field and in atmosphere, Multi stage rockets.

Unit-2: **(13 HOURS)**

Remote Sensing: Definition, Historic perspective, Concepts of remote sensing, Electromagnetic spectrum, Source of electromagnetic radiation for remote sensing, Fundamentals of radiometry and radiometric measurements, Energy interaction with earth's surface features, Signatures of vegetation, soil and water bodies of the earth's surface (general discussion), Classification of remote sensors, Spectral, spatial and temporal resolution, IR and microwave sensors (qualitative), Data reception and products (qualitative), Application of remote sensing for earth's resource management (general discussion). Indian Remote Sensing Programme.

Unit-3: **(13 HOURS)**

Basic concepts: Trigonometric Parallaxes, Parsec, Apparent and absolute magnitudes, Atmospheric extinction, Angular radii of stars, Michelson's stellar interferometer, Binary stars and their masses, Radial and transverse velocities, Types of optical telescopes and their characteristics

Properties of Stars: Spectra of stars spectral sequence - temperature and luminosity classifications, H-R diagram, Stellar structure equations, Star formation and Main sequence evolution, Mass luminosity relation, White dwarfs, Pulsars, Neutron stars and Black holes.

Unit-4: **(13 HOURS)**

The Solar System: The surface of the Sun, Solar interior structure, Solar rotation, Sun sports the active Sun, Properties of interior planets and exterior planets, Satellites of planets, Comets, Asteroids, Meteorites.

Stars Clusters, Galaxies and the Universe: Open and Global clusters, the structure and contents of Milky way galaxy, Hubble's classification of galaxies, Galactic structure and dark matter, Hubble's law, Big bang origin of the universe, Cosmic microwave background radiation and evolution of the universe.

References:

1. Abhyankar K. D., (2001) **Start and Galaxies,** University Press
2. Baidyanath Basu, (2003) **An Introduction to Astrophysics, PHI**
3. Bhatia V. B., (2001) **A Textbook of Astrophysics and Cosmology,** New Age
4. Bohm Vitense E.,(1989)**Introduction to Stellar Astrophysics,** 3rd Volume, Cambridge University Press.
5. Brandt J. C. And Hodge, (1964) **Solar System Astrophysics,** McGraw-Hill.
6. George Joseph, (2002)**Fundamentals of Remote Sensing,** University Press Pvt. Ltd. Hyderabad
7. Herwit M., (1990) **Astrophysics Concepts,** John Wiley.
8. Iribrine J. V. and H.R. Cho, (1980) **Atmospheric Physics,** D. Reidel Publishing Co,.
9. Krishnaswamy (ed), (2010) **Astrophysics,** 3rd World Scientific Publishing Company
10. Lyne A. G.and G.Smith. **Pulsar Astronomy,** Cambridge University Press.

11. Narlikar J. V., (1993) **Introduction to Cosmology,** Cambridge University Press.
12. Olesen H. L., (1966) **Radiation effects on Electronic Systems,** Plenum Press, New York.
13. Ostlie and Carrol, (1997) **Introduction to Modern Astrophysics** Addison Wesley.
14. Peebles P. J. E., (1993) **Principles of Physical Cosmology,** Princeton University Press.
15. Rana etc, (1992) **Our Solar System,** New Age Publishers.
16. Roy A. E., (2002) **Orbital Motion,** Adam Hinglar Ltd.
17. Schunk R. W. and A. F. Nagy, (2000) **Ionospheres, Physics, Plasam Physics and Chemistry,** Cambridge University Press
18. Shu F., (1987) **The Physical University,** Sopress.
19. Singh and Sharma, (2004) **Introduction to Remote Sensing,** Rawath Publications, New Delhi.
20. Swihart T. L.,(1968) **Astrophysics and Strllar Astronomy,** Wiley
21. Taylor R. J., (1993) **Galaxies; their Structure and Evolution**, Cambridge University Press.
22. Taylor R. J., (1994) **The Stars; their Structure and Evolution**, Cambridge University Press.
23. Unsold A., (1977) **the New Cosmos,** Springer Verlag.

M.Sc. PHYSICS

SEMESTER – III

Course Code: (**Phy.Core: III-2**)

NUCLEAR AND PARTICLE PHYSICS

(4 hours teaching per week)

Unit-1: **(13 HOURS)**

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 cycle in a thermal reactor and Four factor formula.

Unit-2: **(13 HOURS)**

Nuclear Forces and Nuclear Detectors:

Nuclear Forces: Characteristics of nuclear forces - Short range, saturation, charge independence and exchange characteristics, Ground state of the Deuteron using square-well potential, Relation between the Range and Depth of the potential, Yukawa's theory of nuclear forces (qualitative only).
Nuclear Detectors: Scintillation Detectors - NaI(TI), Plastic Scintillator - 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, Position sensitive detector.

Unit-3: **(13 HOURS)**

Nuclear Models and Nuclear Decay:

Liquid drop model: Semi-empirical mass formula, Stability of nuclei against Beta decay, Mass parabola, Fermi gas model: Kinetic energy for 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.
Beta Decay: Fermi's theory of Beta decay, Curie plots and "ft" Values, Selection rules,
Gamma Decay: Multipolarity of gamma rays, Selection rules, Internal conversion (qualitative only).

Unit-4: **(13 HOURS)**

Elementary Particle Physics: Types of interaction between elementary particles, Hadrons and Leptons, Detection of 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, Lepton family and Three generations of neutrinos. Charge conjugation symmetry, CP violation in weak interactions, 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, Standard model (qualitative only).

References:

1. DeBenedetti S.,**(1964) Nuclear Interaction,** John Wiley, New York.
2. Enge H., (1971) **Introduction to Nuclear Physics,** Addison wesley.
3. Evans R. D., (1955) **The Atomic Nucleus,** Tata McGraw Hill.
4. Ghoshal S. N., (2000) Atomic and Nuclear Physics, Vol. II.
5. Griffiths D., (1987) **Introduction to Elementary Particles,** Jhon Wiley.
6. Kapoor S.S. and V.S. Ramamurthy, (1986) **Nuclear Radiation Detectors,** Wiley-Eastern, New Delhi.

7. Kenneth S. Krane, (1987) Introductory Nuclear Physics, John Wiley and Sons.
8. Knoll G. F., (2000) **Radiation Detection and Measurements,** 3rd Edition, Jhon Wiley and Sons.
9. Longo J. M., (1973) **Elementary Particles,** II Edition, McGraw-Hill, New York.
10. Patel S. B., (1991) **Nuclear Physics-An Introduction,** New Age International (P) Limited.
11. Perkins D. H., (2000) **Introduction to High Energy Physics,** 4th Edition, Addison Wesley, London.
12. Price W. J., (1964) **Nuclear Radiation Detection,** McGraw-Hill, New York.
13. Roy R. R. and B. P. Nigam,(1983) **Nuclear Physics,** Wiley- Eastern Ltd.
14. Tait W. H.,(1980) **Radiation Detection,** Butterworths, London.
15. Wong, (1998) **Introductory to Nuclear Physics,** PHI

M.Sc. PHYSICS

SEMESTER – III

Course Code: (**Phy.Core: III-3**)

QUANTUM MECHANICS - II

(4 hours teaching per week)

Unit-1: **(13 HOURS)**

The Schrodinger Equation in Three Dimensions: Separation of Schrodinger equation in cartesian coordinates, Three-dimensional box, Three-dimensional Harmonic oscillator, Central potential, Separation of the Schrodinger equation in Spherical polar coordinates, the Free particle, Three-dimensional Square well potential, the Hydrogen 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.

Unit-2: **(13 HOURS)**

Approximation methods I: 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, Quasi- degenerate states, The Variational method, Particle in a one-dimensional Infinite square well, the WKB approximation, the Connection formulae, Energy levels in a potential well, Penetration of a potential barrier, Alpha particle decay of nuclei.

Unit-3: **(13 HOURS)**

Approximation Methods II: Time - dependent perturbation theory - General features, Time-independent perturbation, Two-level system with Time-independent perturbation, the Golden rule, Periodic perturbation, the Adiabatic approximation, Charged harmonic oscillator in a Time-dependent electric field, Scattering experiment and Cross sections, Potential scattering, the method of partial waves, scattering by a square well, the Integral equation of potential scattering, the Born approximation.

Unit-4: **(13 HOURS)**

Relativistic Quantum Mechanics: The Klein-Gordon equation for a free particle; Charged particle in an electromagnetic field, Stationary state solution, 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, Covariant formulation of the Dirac theory, Plane wave solutions of the Dirac equation, Spin and Helicity operators, Solutions of the Dirac equation for a Central potential, The Hydrogenic atom, Non-relativistic limit of the Dirac equation, Negative energy states.

References:

1. Aruldas, (2002) Quantum Mechanics, PHI.
2. Bransden B. H. and Joachain, (2004) **Quantum Mechanics,** 2^{nd} Edition, Pearson Education.
3. David J. Griffiths, (2005) **Intriduction to Quantum Mechanics,** 2^{nd} Edition, Pearson Education.
4. Fields, J. D. Bjorken and S.D. Drell, (1968) **Relativistic Quantum Mechanics and Relativisitic Quantum,** McGraw-Hill, New York.
5. Sakurai J. J.,(2000) **Modern Quantum Mechanics,** Pearson Education.
6. Schiff L. I.,(1955) **Quantum Mechanics,** McGraw-Hill.
7. Srivastava, (2007) **Quantum Mechanics,** PHI.
8. Stephen Gasiorowicz, (2003) **Quantum Physics,** John Wiley.
9. Thankappan V. K., (2004) **Quantum Mechanics,** 2^{nd} Edition.

M.Sc. PHYSICS

SEMESTER – III

Course Code: (**Phy.Core: III-4**)

GENERAL CONDENSED MATTER PHYSICS

(4 hours teaching per week)

Unit-1: **(13 HOURS)**

Crystal Physics: Crystalline state - periodic arrangement of atoms - Lattice translation vectors and Lattice - Basis and the Crystal structure - primitive and non-primitive lattice cell, 2-D and 3-D Bravias lattices and Crystal systems. Elements of symmetry operations - points and space groups, Crystal direction and Crystal planes - Miller indices. Simple crystal structures - NaCl, CsCl, Diamond, ZnS.

X-ray diffraction in crystals: Scattering from atom, Concept of reciprocal lattice, Bragg's law, Analysis of X-ray diffraction pattern from crystals, Structure factor, Atomic scattering factor, Multiplicity factor-R-factor (definitions only)

Unit-2: **(13 HOURS)**

Point Defects: Schottky and Frenkel - expression for equilibrium concentrations, line defects-dislocations, Planar defects, Grain boundaries.

Superconductivity: 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.

Unit-3: **(13 HOURS)**

Crystal Physics:

Electronic properties of solids- Review of free electron theory of metals, Electronic motion in periodic lattice, Band theory, Bloch theorem (statement only), Kronig Penny model - E-K Curves, Number of allowed states in bands, Motion of electrons in one dimension , Effective mass, Concept of hole, Solids classification into Conductors, Semiconductors and Insulators.

Semiconductors: Intrinsic and extrinsic semiconductors, Expression for carrier concentration, Position of Fermi level (in intrinsic cases only), Electrical conductivity, Mobility and their temperature dependence, Hall effect in semiconductors.

Unit-4: **(13 HOURS)**

Dielectric and Ferro Electricity:- Review of basic formulae, Dielectric constant, Polarizibility, Different kinds of polarizibility, Expression for orientational polarizibilty, Lorents field, Clausius-Mossatti relation- Dielectric loss and optical phenomenon. Ferroelectricity.

Magnetism: Review of basic formulae, Magnetic susceptibility, Classification of magnetic materials, Langevins theory of Dia and Para, Ferromagnetism, Wiess molecular field theory, Exchange interaction forces, Anti ferromagnetism (qualitative)

References:

1. Ali Omar, (2000) **Elementary Solid State Physic,** Adison Wiesly.
2. Asckroft F. W. and N. D. Mermin, (1976) **Solid State Physics,** Saunders College.
3. Dekkar A. J., (2000) **Solid State Physics,** MacMillan India Ltd.
4. Kittle C., (1996) **Solid State Physics,** Wiely Eastern.
5. Srivastava J. P., (2008) **Elementary Solid State Physic,** PHI.
6. Wahab M. A., (2009**) Essential of Crystallography,** Narosa Publications.

M.Sc. PHYSICS

SEMESTER - III

Course Code: (**Phy.Pra: III-1**)

NUCLEAR PHYSICS LAB

List of Experiments

(Any Eight of the following to be performed)

1. Statistics of Counting.
2. Dead Time of a G.M. Counter by Single Source Method.
3. Z-Dependence of Beta Absorption Co-Efficient.
4. Half-life of In-116m state by Beta Measurement.
5. Gamma Ray Spectrometer (SCA).
6. Gamma Ray Spectrometer (MCA).
7. Absorption of Gamma Rays.
8. Two Stage Amplifier.
9. Schmitt Trigger as a Discriminator.
10. Transistor Coincidence Circuit and Anti Coincidence Circuit.
11. Study of Beta Absorption.
12. Experiments with Geiger Canting System (GCS).
13. Voltage Multipliers.

(Experiments may be added with BOS approval whenever new experiments are setup and tested)

References:

1. Gupta and Kumar, (1976) **Practical Physics,** Pragati Prakashan.
2. Misra and Misra, (2000) **Physics Lab Manual,** South Asian Publishers.
3. Singh and Chauhan, (1976) **Advanced Practical Physics,** 2 vols., Pragati Prakashan.
4. Worsnop and Flint, (1979) **Advanced Practical for Students,** Asia Pub.

M.Sc. PHYSICS

SEMESTER - III

Course Code: (**Phy.Pra: III-2**)

GENERAL CONDENSED MATTER PHYSICS LAB

List of Experiments

(Any Eight of the following to be performed)

1. Analysis of X-ray Diffractogram.
2. Analysis of Single Crystal Rotation Photograph.
3. Analysis of X-ray Powder Photograph-Cu, Au, Ag.,
4. Analysis of X-ray powder Photograph-W, Mo.
5. Calibration of Electromagnet and Magnetic Susceptibility Determination of Magnetic Salts-$MnSO_4$, $Mncl_2$ by Quinke's Method
6. Fermi Energy of Copper and Related Parameter using Constant Current Source and Multiplier.
7. Experiments with pn-Junction a) Determination of n, E_g and dv/dt of pn Junction Material b) Determination of Junction Capacitance (C_D).
8. Ionic Conductivity of NaCl, Study of the Temperature Variation of and Estimation of Activation Energy.
9. Indexing of Rotation Photograph Using Bernal Chart.
10. Analysis of X-ray Diffraction of Si and Estimation of R factor.
11. Determination of Curie Temperature for Ferromagnetic Material-Ni-Fe alloy)
12. Thermal Expansion-Determination of Coefficients of Thermal Expansion of Materials at Temperature (AL, Cu, Brass, NaCl, KCl).

(Experiments may be added with BOS approval whenever new experiments are setup and tested)

References:

1. Gupta and Kumar, (1976) **Practical Physics,** Pragati Prakashan.
2. Misra and Misra, (2000) **Physics Lab Manual,** South Asian Publishers.
3. Singh and Chauhan, (1976) **Advanced Practical Physics,** 2 vols., Pragati Prakashan.
4. Worsnop and Flint, (1979) **Advanced Practical for Students,** Asia Pub.

M.Sc. PHYSICS

SEMESTER – IV

Course Code: (**Phy.Core: IV-I-1.1**)

CONDENSED MATTER PHYSICS - I

(4 hours teaching per week)

Unit-1 **(13 HOURS)**

Energy bands in solids: Consequences of periodicity, Bloch theorem and proof, Bloch function and their Eigen values, Kronig Penny model, Nearly free electron model, Zone scheme, Energy band in general periodie potential, Tight binding approximation, Weigner Sitz cellular method.

Fermi Surfaces:

Concept of hole- Effective mass, Construction of Fermi surfaces, Electrons uniform magnetic field, Anomalous skin effect, Cyclotron resonance, Closed orbits and open orbits, De-Hass-Van Alphen effect

Unit-2 **(13 HOURS)**

Atomic cohesion and crystal binding: Primary and secondary bonds, Expression for cohesion energy in ionic, Calculation of repulsive exponent from compressibility data and Noble gas crystals, Born Haber cycle, Atomic radii v/s Lattice constant, Properties of covalent, ionic, metallic and hydrogen bonds.

Lattice vibrations: Vibration Modes of 1-D lattice - mono and diatomic linear lattice, Disppersion relation, Acoustical and optical modes, Phase and group velocity, Brillouin zone, Derivation of force constant, Quantization of elastic waves.

Unit-3 **(13 HOURS)**

Thermal properties of solids: Specific heat of solids, Classical, Einstein, Debye models, Density of states. 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.

Optical properties of solids: Classical Model, Ionic conduction, Refractive index, Optical absorption, Photoconduvtivity, Photoelectric and Photovoltaic effect, Optical properties of fibers, Optical properties of semiconductors.

Unit-4 **(13 HOURS)**

Superconductivity: Review of experimental survey - Mechanism of superconductivity, Properties dependent on energy gap, Thermodynamics of superconductivity, Flux quantization, London equations, Penetration depth, Ginzberg-Landau theory, BCS theory - Qualitative Approach, Important predictions of BCS theory, Tunnelling – DC and AC Josehpson effect – SQIUDS - Applications.

References :

1. Ali Omar, (2000) **Elementary Solid State Physics**, Addison Wiesly.
2. Asckroft F. W. and N. D. Mermin, (1976) **Solid State Physics**, Saunders College.
3. Dekkar A. J., (2000) **Solid State Physics**, MacMillan India Ltd.
4. Kittle C., (1996) **Solid State Phy**sics, Wiely Eastern.
5. Pillai S. O., (2001) **Solid State physic**s, New Age int. Publishers.
6. Srivastava J. P., (2008) **Elementary Solid State Physics**, PHI.
7. Wahab M. A. (2009) **Essential of Crystallography**, Narosa Publications.

M.Sc. PHYSICS

SEMESTER – IV

Course Code: (**Phy.Core: IV-II-2.1**)

CONDENSED MATTER PHYSICS - II

(4 hours teaching per week)

Unit-1 **(13 HOURS)**

Crystal Physics – Elementary 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, Wisenbrg and Rotating method, Determination of relative structures, Amplitudes from measured intensities, Lorentz polarization factors.

Unit-2 **(13 HOURS)**

Ferromagnetism: Weiss rheory of Ferromagnetism, Weiss field, Spontaneous magnetization, Curie-Weiss Law, Heisenberg exchange interaction, Ising Model, Ferromagnetic domains, Anisotropy energy , Bloch wall, Spin waves, Magnons, Bloch 3/2 law, High temperature properties: Corrections to Curie law, Analysis of critical point, Mean field theory, Effect of dipolar interactions, Demagnetization factors.

Antiferromagnetism: Two Sub-Lattice model, Molecular field theory, Neel temperature. Ferrimagnetism, Structure of Ferrites, Saturation magnetization, Curie temperature, Susceptibility of Ferrimagnets, GMR and CMR materials.

Unit-3 **(13 HOURS)**

Ferroelectrics: Classification and properties, Crystal types of ferroelectrics, Properties of Roshelle salt and $BaTiO_3$, Dipole theory- Dielectric constant near Curie temperature, Microscopic Sourse of Ferroelectricity, Thermodynamics of ferroelectric Phase transition, second and First order Ferroelectric domanis. Piezoelectricity - Properties, structure and applications.

Unit-4 **(13 HOURS)**

Electrical transport in metals: Boltzmann equation, Relaxation time approximation, Electrical conductivity, Thermal conductivity, Thermoelectric effect, Calculation of Relaxation time, Scattering due to Impurities and Lattice, Mattheisen Rule, Temperature dependence of resistivity.

Elastic properties of solids: Stress Strain Tensor, Elastic constant, Hooks law, Strian energy, Reduction of elastic constant from symmentry, Isotropy for cubic crystals, Experimental determination of elastic constant by Ultrasonic interferometer.

References :

1. Ali Omar, (2000) **Elementary Solid State Physic**, Addison Wiesly.
2. Asckroft F. W. and N. D. Mermin, (1976) **Solid State Physics**, Saunders College.
3. Dekkar A. J. , (2000) **Solid State Physics**, MacMillan india Ltd.
4. Kittle C., (1996) **Solid State Physics**, Wiely Eastern.
5. Pillai S. O., (2001) **Solid State physics**, New Age int. Publishers.
6. Srivastava J. P., (2008) **Elementary Solid State Physics**, PHI.
7. Wahab M. A. (2009) **Essential of Crystallography**, Narosa Publications.

M.Sc. PHYSICS

SEMESTER – IV

Course Code: (**Phy.Core: IV-III-3.1**)

(Any one of the following Elective courses to be chosen)

LASER PHYSICS

(4 hours teaching per week)

Unit-1 **(13 HOURS)**

Laser characteristics: Review of fundamentals of lasers, Population inversion, Pumping techniques and types, Characteristics of laser beams, Gaussian and its properties, Modes of laser oscillations of a laser cavity - Longitudinal and transverse. An expression for the number of modes of oscillation in terms of frequency and cavity length, Three and 4 level laser systems, Mode locking, Pulse shortening. Line-broadening mechanism, Spectral narrowing and stabilization. Continuous lasers and Pulsed lasers.

Unit-2 **(13 HOURS)**

Laser systems: High powered lasers and low powered lasers, Pumping techiques for Population inversion mechanism and energy levels of the following lasers - Ruby laser, Nd:YAG laser. Semiconductor lasers. Diode Pumped Solid State Laser, Homogeneous and heterogeneous, double heterogeneous lasers. Carbon Dioxide laser, Excimer laser, Dye laser, Argon Ion laser. Engineering and medical applications of lasers.

Unit-3 **(13 HOURS)**

Laser spectroscopic techiques: Spectral characteristics of laser emission - Active resonators, Gain saturation, Spatial hole burning. Laser fluorescence and Raman scattering and their application in pollution studies. Non-linear spectroscopy - Non-linear interaction of light with matter. Laser induced multiphoton processes and their applications. Ultragigh resolution spectroscopy and its applications.

Unit-4 **(13 HOURS)**

Lasers in fiber optics: Review of propagation of Light through optical fiber, Modes of fiber and charactcistics, Optical Switches, Optical Couplers. Types of Losses - Attenuation Loss, Dispersion Loss, Splice Loss, Intermodal dispersion and Material dispersion. EDOF as an amplifier, Optical fiber communications using lasers, WDM optical fibers.

References:

1. Thyagarajan K., A. K. Ghatak, (1981) **Lasers: Theory and Applications**, McMillan India.
2. swelto O., (1998) **Principles of Lasers**, Springer.
3. Sigman A. E., (1986) **Lasers**, University Press.
4. Koechner W., (1992) **Solid State Laser engineering**, Springer verlag.
5. Demtroder W., (2002) **Laser Spectroscopy**, Springer International.
6. Laud B. B., (1991) **Laser & Nonlinear Optics**, Wiley Eastern Limited.
7. Amn, Yariv on., (1985) **Optical Electronics**, Holt Rineheart and Winstion.
8. Fiber Djafar K. Myubaev, And Lowell L. Scheiner, **Optic Copmmunication**.
9. Ghatak A. K., K. Thyagarajan, (1997) **Introduction to Fiber Optics**, Cambridge University Press.
10. Ghatak A. K., K. Thyagarajan, (1997) **Optical Electronics,** Cambridge University Press.

M.Sc. PHYSICS

SEMESTER – IV

Course Code: (**Phy.Core: IV-III-3.2**)

NANOPHYSICS

(4 hours teaching per week)

Unit-1 **(13 HOURS)**

Topics in condensed matter: Density of states – variation with energy. Variation of density of states and band structture with size of crystal. Density of states for different dimensions.

Introduction to Nanomaterials: (Definition, reason for interest in nanomaterials, Classification of nanostructures – 1-D, 2-D and 3-D confinement, Effect of nanostructure on structural and mechanical properties, Chemical reactivity and stablity, Thermal, magnetic, optical and electronic properties, nano processes in bio-systems) - overview.

Mechanical behaviour of Nanostructured systems: Effect of grain size on elasticity and hardness, Empirical hall, Petch equation - Models to explain it, Modification for small grain sizes.

Gas reactive applications of Nanostructured materials: Catalysis: Electrocatalysis processes, Impact of Nanostructure, **Gas sensors:** Physical princioples of semiconductor sensors and nanostructure design, **Hydrogen storge:** Properties of hydrogen storage compounds and nanostructure design.

Nanomagnetic materials and applications: Domain and domain walls, Bulk and nanostructures, Magnetization processes in particulate nanomagntes and layered nanomagnets, Applications, Magnetoresistance, Giant magnetorsistance, Spin valves and tunnelling magnetoresistance.

Unit-2 **(13 HOURS)**

Overview of Semiconductors: Electronic band structure, Concept of the effective mass, Optical processes, Direct and indirect band gap Semiconductors, Exaction formation, Superlattice - Heterostructure.

Quantum size effect: Quantum confinement in 1 dimension: Quantum wells: Electron confinement in infinitely deep square well, Square well of finite depth, Optical absorption in quantum well in the case of Heterostructure consisting of thin layer of Glass sandwitched between thick layers of a glass.

Quantum confinement in 2 dimension: Quantum wires
Quantum confinement in 3 dimension: Quantum dots
Applications of wires and dots

Tunnelling Transport T Matrices for potential step and square barrier, Current and conductance.

Resonant tunnelling, Charging eEffects, Coulomb blockade and Coulomb blockade devices.

Unit-3 **(13 HOURS)**

Methods for preparation of Nano-material
Bottom Up: Nanoparticles (Metal and semiconductor), Nucleation, Growth, Chemical bath deposition, Capping techiques.

Nanostructures: Quantum dots, Quantum well structures, Thin film deposition techiques, Molecular beam epiaxy, MOVPE, MOCVD, Cluster beam evaporation, Cluster nucleation, Theory of condensation from super saturated vapor, Cluster formation.

Top Down: Ball Milling: Details, Shaker mills, Lithography – Electron Beam/Ion Beam.
Self-assembled molecular materials: Principles of self assembly, Micellar and vesicular polymerization, Colloidal nanoparticle crystals, Self organizing inorganic nanoparticles.

Thin organic films: Spin coating of polymers: Multilayers, Layer by layer deposition, Langmuir and structural analysis

Unit-4 **(13 HOURS)**

Characterization of Nanomaterials

Diffraction techniques: X-ray diffraction (XRD) – Crystallinity, Particle/crystallite size determination and structural analysis**.**

Microscopic techniques: Scanning Electron Microscopy (SEM) – Morphology, Grain size and EDX; Transmission Electron Microscopy (TEM) – Morphology, Particle size and Electron diffraction.

Scanning probe techniques: Scanning Tunneling Microscopy (STM) – Surface imaging and Roughness; Atomic Force Microscopy (AFM) – Surface imaging and Roughness; other Scanning probe techiques.

Spectroscopy techniques: Photoluminescence – Emission (PL) and Excitation (PLE) spectroscopy; Infrared (IR) and Raman spectroscopy; X-ray Absorption (XAS) and X-ray Photoelectron (XPS) Spectroscopy with Depth profiling.

References:

1. Charles kittel, (1996) **introduction to solid state physics**, VII edition.
2. Carl. C. Koch, (Ed) (2004) **Nanostructured Materials-Processing, Properties & Applications**, William Andrew Publishing, Norwich, New York, USA.
3. Robert W. Kersall, Ian W. Hamley & Mark Geoghegan, (Ed) (2005) **Nanoscale Science & Technology**, John Wiley & Sons, Uk.
4. Jain K. P., (1997) **Physics of Semiconductor Nanostructures**, Narosa.
5. Crandall B. C., (1996) **Nanotechnology : Molecular Speculations on Global Abundabce**, MIT Press.
6. John H. Davies, (1997) **Physics of Low Dimensional Semiconductor Nanostructures**, Cambridge University Press.
7. Edelsteins A. S., R. C. Cammarata, (Ed) (1996) **Nano Materials : Synthesis, Properties and Applications,** Institute of Physics Publishing, Bristol & Philadelphia.
8. Fendler J. H., (Ed) (1998) **Nano Particles and Nano Structured Films: Preparation, Characterzation and Applications**, John Wiley & Sons.
9. Bimerg, D. M. Grundmann & N. N. Ledentsoy, **Quantum Dot Heterostructures**, John Wiley and Sons.

M.Sc. PHYSICS

SEMESTER – IV

Course Code: (**Phy.Core: IV-III-3.3**)

ATMOSPHERIC PHYSICS

(4 hours teaching per week)

Unit-1 **(13 HOURS)**

Physical Meteorology: Atmospheric compostion, Laws of thermodyamics of the atmosphere. Adiabatic process, Potential temperature, the Clausis Clapyeron equation, Laws of Black body radiation, Solar and Terrestrial radiation, Albedo, Green house effect, Heat balance of earth-atmosphere system.

Dynamic Meteorology: Fundamental forces, Non-inertial reference frames and Apparent forces, Structure of static atmosphere. Momentum, Continuity and Energy equations, Thermodynamics of the Dry atmosphere, Elementary applications of the basic equations the Circulation theorem, Vorticity, Potential vorticity, Vorticity and Potential vorticity equations.

Unit-2 **(13 HOURS)**

Monsoon Dynamics: Wind, temperature and pressure distribution over India in the lower, middle and upper atmosphere during pre, post and mid-monsoon season. Monsoon circulation in the Meridonal (Y-Z) and Zonal (X-Y) planes, Energy cycle of monsoon. Dynamics of monsoon depressions and Easterly waves. Intra seasonal and Internal variability of monsoon. Quasi-Be weekly and 30-60 day Oscillations. ENSO and Dynamical mechanism for their existence.

Unit-3 **(13 HOURS)**

Numerical methods for Atmospheric models: Filtering of sound and gravity waves, Filtered forecast equations, Basic concepts of Quasigeostrophic and primitive equation models, One level and Multi-level models. Basic concepts of initialization and objective analysis for wave equation, Advection equation and Diffusion equation.

Atmospheric Pollution: Role of Meteorology on Atmospheric pollution, Atmospheric boundary layer, Air stability, Local wind structure, Ekman spiral, Turbulence boundry layer scaling. Residence time and reaction rates of pollutants, Sulphur compounds, Nitrogen compounds, Carbon compounds, Organic compounds, Aerosols, Toxic gases and Radio active particles trace gases.

Unit-4 **(13 HOURS)**

Atmospheric Instrumentation systems: Ground based instruments for the measurement of Temperature, Pressure, Humidity, Wind and Rainfall rate. Air borne instruments – Radisonde, Rawinsonde, Rockestsonde, Satellie Instrumentation (Space borne instruments)

Radar Meteorology : Basic meteorology - Radar principles and technology, Radar signal processing and display, Weather Radar - Observation of precipitating systems, Estimation of Precipitation, Radar observation of Tropical Cyclones, Use of Weather Radar in Aviation, Clear Air Radars – Observation of Clear Air phenomena - Other Radar systems and applications.

References

1. Frederick K . Lutgens and Edward K. Tarbuk (1992) **The Atmosphere** (for chapter I and VI) Dynamic Meteorology by Holton, J R., 3rd edition, Academic Press N Y.
2. Haltiner G J and R T villians, (1980) **Numerical weather Prediction**, John wiley and sons, (for chapter 4).
3. Henry Saugageot, **Radar Meteorology**.
4. Keshvamurthy R N and M Shankar Rao, (1992) **The Physics of Monsoons**, Allied Publishers, (for Chapter 3)
5. Tom Lyons and Prillscott, **Principles of Air Pollution Meteorology** by CBS Publishers& Distributors (p) Ltd.

M.Sc. PHYSICS

SEMESTER - IV

Course Code: (**Phy.Core: IV-IV-4.1**)

(Any one of the following Elective courses to be chosen)

CRYSTAL PHYSICS

(4 hours teaching per week)

Unit-1 **(13 HOURS)**

Scattering of X-Ray: General description of the scattering process: Scattering from a pair of points, Scattering from a general distribution of point scatterers, Thomson scattering, Compton scattering, Scattering of X-Ray by atoms. Diffraction from a Crystal: Diffraction from a One dimensional, Two dimensional and Three dimensional array of atoms, Crystal structure factor, Schematic absence due to lattice type and Symmetry elements, Diffraction and Fourier transformation, Electron density equation.

Unit-2 **(13 HOURS**

Determination of Crystal Structure: Trial and error methods, the Patterson function, Isomorphous replacement method, Heavy atom method, Anomalous scattering and applications, Inequality relationships, Sign relationships, a General survey of methods.
Refinement techniques: Cyclic fourier refinement, Difference fourier synthesis, Correction for series termination, least square refinement, Assessment of accuracy, Thermal vibrations.

Unit-3 **(13 HOURS)**

Crystallography of Macro molecules: Crystallization, Preparation of isomorophous heavy atom derivatives, Collection of data, Data processing, Determination of heavy atoms positions, Calculation of phases, interpretation of the electron density maps and refinements.

Unit-4 **(13 HOURS)**

Crystal imperfections and diffusion in solids: Review of Crystalline imperfection – Schottky and Frenkel Defects, Equilibrium concentrations line imperfections, Edge and screw dislocations - interactions of Dislocations. Surface imperfections - Grain Boundary - Tilt and Twin Boundaries, Volume imperfections. Diffusion in solids – Fick's laws of diffusion - Solution to Fick's Second law - Error function. Determination of Diffusion coefficients – Diffusion couple. Applications based on Second law Atomic model of diffusion, Electrical conductivity of ionic crystals.

References:

1. Azaroff L. V., (1968) **Elements of X-ray Crystallography**, Mc Graw Hill, New York.
2. Blundell T. L. and L. N. Johnson, **Protein Crystallography**.
3. Burger M. J. (1952) **X-ray Crystallographyt**, Jhon Wiley, New York.
4. Charles Kittel, (1984) **Solid State Physics**, wiley Eastern.
5. Dennis Sherwood, **Crystals, X-ray and Proteins**.
6. Duncan M. and C. Mike, (1997) **Crystalline Solids**, Nelson, London.
7. Michael M. Wolfen, (1997) **An introduction to Crystallography**, Cambridge University Press.
8. Santhana Raghavan and Ramaswamy, **Crystal Growth Processes and methods**, KRU Publication, Kumbakonam.
9. Verma and Srivastava, (1997) **Crystallography for Solid State Physics**, New Age international Ltd.

M.Sc. PHYSICS

SEMESTER - IV

Course Code: (**Phy.Core: IV-IV-4.2**)

SOLAR AND HYDROGEN ENERGY

(4 hours teaching per week)

Unit-1 **(13 HOURS)**

Solar Energy: Fundamentals of Photovoltaic energy conversion physics and Material properties - Basic to Photovoltaic energy conversion, Optical properties of solids. Direct and indirect transition semiconductors, Interrelationship between Absorption coefficients and Band gap recombination of carriers.

Unit-2 **(13 HOURS)**

Solar Cells: Types of solar cells, P-N junction solar cell, Transport equation, Current density, Open Circuit Voltage and Short Circuit Current, Brief descriptions of Single Crystal Silicon and Amorphous Silicon solar cells, Elementary ideas of advanced solar cells e.g. Tandem solar cells, Solid liquid junction solar cells, Nature of semiconductor, Electrolyte junction, Principles of Photoelectrochemical solar cells.

Unit-3 **(13 HOURS)**

Hydrogen Energy: Relevance in relation to depletion of Fossil fuels and Environmental considerations.

Hydrogen Production: Solar hydrogen through Photo lectrolysis and Photocatalytic process. Physics of material characteristics for production of solar hydrogen.

Storage of Hydrogen: Brief discussion of various storage processes, Special features of Solid state hydrogen storage materials, Structural and electronic characteristics of storage materials. New storage modes.

Unit-4 **(13 HOURS)**

Safety and Utilisation of Hydrogen: Various factors relevant to Safety, Use of hydrogen as fuel, Use in vehicular transport, Hydrogen for electricity generation - Fuel cells, Elementary concepts of Other hydrogen based devices such as Air conditioners and Hydride batteries.

Other Renewable Clean Energies: Elements of Solar thermal energy, Wind energy and Ocean Thermal Energy Conversion. Tidal energy.

References:

1. Chandra, **Photo electrochemical Solar Cells**.
2. Fahrenbruch & Bube, **Fundamentals of Solar Cells Photovoltaic Solar Energy**.
3. Fonash, **Solar Cell Devices**, Physics.
4. Winter & Nitch (Eds), **Hydrogen as an Energy Carrier Technologies Systems Economy**.

M.Sc. PHYSICS

SEMESTER - IV

Course Code: (**Phy.Core: IV-IV-4.3**)

SPACE PHYSICS

(4 hours teaching per week)

Unit-1 **(13 HOURS)**

Sun and its emissions: Solar atmosphere, Solar Corona, EM radiation from the Sun, Solar cycles, Solar energy particles, Solar Wind ,Solar Flares, Coronal mass ejections, the Planetary system, Major characteristics of Planets, Bulk atmospheric composition, Planetary magnetism, Magnetic dipole, Tilted dipole models, Spherical harmonic models, Magnetic fields of outer planets.

Unit-2 **(13 HOURS)**

Solar Wind Interactions: MHD equation, Alfven waves, Frozen in field, Planetary bow shocks, Interaction with magnetized planets, Plasma sources in magnetosphere, Plasma acceleration, Jovian magnetosphere; Plasma flow in magnetosphere, Magnetosphere-Ionosphere coupling, Interaction with non-magnetised planets, Magnetised planets, Motion of charged particles in Electromagnetic field.

Unit-3 **(13 HOURS)**

Energy deposition by charged particles: Collision cross section, Fermi Golden rule, Semi empirical electron impact cross sections, Energy deposition techniques, Analytic loss function Montecarlo techniques, Analytical yield spectrum, Charge transfer, Electronic recombination.

Unit-4 **(13 HOURS)**

Planetary Atmospheres: Hydrostatic equation, Eddy and molecular diffusion Eddy diffusion coefficient, Thermal structure, Radiative transfer concepts, Density of radiation, Emission and Absorption coefficients, Equation of transfer, Plane parallel atmosphere, Occultation techniques, Atmospheric gravity waves, Atmospheric temperature of planets, Upper atmospheric composition

References:

1. Clemmow and Dougherty, (1969) **Electrodynamic of Particles and Plasmas,** Addison Wesley.
2. Fundamentals of Aeronomy, (1971) Wiley, NY.
3. Grant Athay R., (1976) **The Solar Chemosphere and Corona,** D Reidel Publishing,
4. Kuiper G. P., (1952) **The Atmospheres Of Earth and Planets,** University of Chicago.
5. Singhal R. P., (2009) Elements of Space Physics, PHL,.

M.Sc. PHYSICS

SEMESTER - IV

Course Code: (**Phy.Pra: IV-1**)

CONDENSED MATTER PHYSICS LAB

List of Experiments

(Any Eight of the following to be performed)

1. Analysis of X-ray diffractogram and estimation of R-factor (Sample: NaCI)
2. Analysis of X-ray diffractogram and estimation of R-factor (Sample: KCI)
3. Analysis of X-ray Powder Photograph (Cu-backward reflection)
4. Analysis of X-ray Powder Photograph (KBr)
5. Analysis of X-ray Powder Photograph (NaCI)
6. Electrical resistivity of thin films by four probe method and its temperature dependence (Cu,AI,Si)
7. Determination of a) optical constants and k b) energy gap using transmission data of $ZnO-B_2O_3-V_2O_5$ thin film
8. Determination of a) optical constants and k b) energy gap using transmission data of $ZnO-P_2O_5-V_2O_5$ thin film
9. Temperature variation of dielectric constant and determination of Curie point of a Ferro electric solid-Lead Ziconate Titanate.
10. Magnetic susceptibility Ferrous ammonium sulphate by Gouy's balance method.
11. Experimental determination of hall coefficient and charge carriers.

(Experiments may be added with BOS approval whenever new experiments are setup and tested)

M.Sc. PHYSICS

SEMESTER - IV

Course Code: (**Phy.Pra: IV-2**)

ATMOSPHERIC AND SPACE PHYSICS LAB

List of Experiments
(Any Eight of the following to be performed)

1. Measurement of temperature by wet and dry buld thermometers and estimation of humidity of the atmosphere.
2. Measurement of relative humidity of the atmosphere using whirling hygrometer and comparison with theoretical values.
3. Measurement and analysis of atmospheric pressure and isobars.
4. Study and plotting of temperature, pressure and humidity contours using the given experimental data.
5. Study of isobaric maps and pressure gradient from the given experimental data.
6. Estimation of saturation vapour pressure, dew point temperature, relative humidity and mixing ratio by measuring temperature and humidity.
7. Measurement and analysis of solar radiation as a function of time using sunshine recorder.
8. Measurement and analysis of wind speed by anemometer and wind direction by wind wane.
9. Estimation of abundance of sodium in solar atmosphere using Fraunhofer absorption lines in solar spectrum.
10. Measurement of absorption spectrum of the earth's atmosphere for O_2,O_3, H_20, CO_2 etc.
11. Determination of extinction coefficient of earth's atmosphere using Beer's law with the help of given data.
12. Analysis and plotting of Meteorological data from sensors.
13. Analysis of satellite data of vegetation, Soil and water bodies of the earth's surface.
14. To study the I-V characteristics of a solar cell.
15. Efficiency of solar cells
16. Solar constant determination

(Experiments may be added with BOS approval whenever new experiments are setup and tested)

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