Deccan Education Society's

FERGUSSON COLLEGE, PUNE (AUTONOMOUS)

SYLLABUS FOR M. Sc. - I

Effective from Academic Year 2016

Preamble:

Fergusson College is awarded academic autonomy by the UGC beginning the year 2016-17. This autonomy is for a period of six years. We shall be following the semester pattern for academic transactions and the Credit Based Assessment System. The curriculum for the graduate programme in Physics is designed to cater to the requirements of the Autonomy and the Credit system following the UGC guidelines.

The Post graduate programme in Physics is spread over two years with two semesters per year.

The programme is aimed to be more learning centric than teaching centric. The courses are designed so that a student progressively develops a deeper understanding of various aspects of physics and at the end of the programme a student is a well trained with the basic understanding of physics as a discipline of science.

Emphasis will be given on practical based experience. Research component at the PG level is brought in through the projects students will be working on.

Continuous assessment is an integral part of the credit system. This will help students learn their subjects systematically and thoroughly.

Objectives:

1. To help student develop the scientific attitude and to understand various physical phenomena in nature.
2. To help student learn various mathematical and experimental tools used to study physical phenomena.
3. To help student develop analytical mind and face real world challenges.
4. To expose student to the latest developments in physics.
5. To develop an aptitude for research in physics.

Course Structure for M. Sc. - I (Physics)

Semester	Course Code	Title of the Course	Core / Elective	No. of Credits
I	PHY4101	Classical Mechanics	CORE	4
	PHY4102	Mathematical Methods in Physics	CORE	4
	PHY4103	Atoms, Molecules and Solids	CORE	4
	PHY4104	Electronics	CORE	4
	PHY4105	Physics Practical Laboratory - I	CORE	4
	PHY4106	Physics Practical Laboratory - II	CORE	4
	PHY4107	Self Learning: Lasers		1
II	PHY4201	Electrodynamics	CORE	4
	PHY4202	Solid State Physics	CORE	4
	PHY4203	Quantum Mechanics	CORE	4
	PHY4204	Statistical Mechanics	CORE	4
	PHY4205	Physics Practical Laboratory - III	CORE	4
	PHY4206	Physics Practical Laboratory - IV	CORE	4
	PHY4207	Self Learning: Energy Studies		1

Post Graduate Extra Credits in M. Sc. - I (Physics)

Semester	Course Code	Title of the Course	No. of Credits
I	XHR0001	Human Rights - I	1
	XCS0002	Introduction to Cyber Security - I / Information Security - I	1
	XSD0003	Skill Development - I	1
II	XHR0004	Human Rights - II	1
	XCS0005	Introduction to Cyber Security - II / Information Security - II	1
	XSD0006	Skill Development - II	1

Course Structure for M. Sc. - II (Physics)

Semester	Course Code	Title of the Course	Core / Elective	No. of Credits
III	PHY5301	Experimental Techniques in Physics	CORE	4
	PHY5302	Basic Material Science	CORE	4
	* PHY5303	Physics of Semiconductor Devices	ELECTIVE	4
	* PHY5304	Thin Film Physics and Technology	ELECTIVE	4
	* PHY5305	Astronomy and Astrophysics - I	ELECTIVE	4
	* PHY5306	Vacuum Science and Technology	ELECTIVE	4
	PHY5307	Physics Practical Laboratory - V	CORE	4
	PHY5308	Physics Practical Laboratory - VI	CORE	4
	PHY5309	Self Learning: Biomedical Instrumentation	CORE	1
	* Students should select either PHY5303 **OR** PHY5304 **&** PHY5305 **OR** PHY5306 for Semester III			
IV	PHY5401	Nuclear Physics	CORE	4
	PHY5402	Materials Synthesis, Processing and Applications	CORE	4
	* PHY5403	Physics of Nanomaterials	ELECTIVE	4
	* PHY5404	Instrumentation Techniques	ELECTIVE	4
	* PHY5405	Atmospheric Science	ELECTIVE	4
	* PHY5406	Astronomy and Astrophysics - II	ELECTIVE	4
	PHY5407	Physics Practical Laboratory - VII	CORE	4
	PHY5408	Physics Practical Laboratory - VIII	CORE	4
	PHY5409	Self Learning: Astronomical Instrumentation Techniques	CORE	1
	* Students should select either PHY5403 **OR** PHY5404 **&** PHY5405 **OR** PHY5406 for Semester IV.			

Post Graduate Extra Credits in M. Sc. - II (Physics)

Semester	Course Code	Title of the Course	No. of Credits
III	XCS0007	Introduction to Cyber Security - III / Information Security - III	1
	XSD0008	Skill Development - III	1
IV	XCS0009	Introduction to Cyber Security - IV / Information Security - IV	1
	XSD0010	Skill Development - IV	1

Syllabus of M. Sc. - I (Physics)

Semester I

PAPER CODE: PHY4101
PAPER – I: CLASSICAL MECHANICS
No. of Credits: 4 **No. of Lectures: 48**

	Title and Contents	No. of Lectures
Unit-I	**Constrained motion and Lagrangian formulation:** Constraints and their types. Generalized coordinates, Lagrange's equations of motion, including velocity dependent potentials. properties of kinetic energy function, theorem on total energy, generalized momenta, cyclic-coordinates, integrals of motion, Jacobi integrals and energy conservation, Concept of symmetry, invariance under Galilean transformation.	**12**
Unit-II	**Variational principle and Hamiltonian formulation:** Variational principle, Euler's equation, applications of variational principle, shortest distance problem, Brachistrochrone, Geodesics of a Sphere. Hamilton's function and Hamilton's equation of motion, configuration space, phase space and state space, Lagrangian and Hamiltonian of relativistic particles.	**12**
Unit-III	**Canonical transformations and Poisson brackets:** Legendre transformations, Generating function, Conditions for canonical transformation and problem. Definition, Identities, Poisson theorem, Jacobi-Poisson theorem, Jacobi identity, (statement only), invariance of PB under canonical transformation.	**12**
Unit-IV	**Non inertial frames of references, central force:** Rotating frames of reference, inertial forces in rotating frames, Larmour precision, electromagnetic analogy of inertial forces, effects of Coriolis force, Foucault's pendulum.	**12**

References:

1. Classical Mechanics by H. Goldstein, Narosa Publishing Home, New Delhi.
2. Classical Dynamics of Particles and Systems by Marion and Thomtron, Third Edition, Horoloma Book Jovanovich College Publisher.
3. Classical Mechanics by P. V. Panat, Narosa Publishing Home,, New Delhi.
4. Classical Mechanics by N. C. Rana and P. S. Joag, Tata Mc-Graw Hill Publishing Company Limited, New Delhi.
5. Introduction to Classical Mechanics by R. G. Takawale and P. S. Puranik, Tata Mc-Graw Hill Publishing Company Limited, New Delhi.
6. Classical Mechanics by J. C. Upadhyaya, Himalaya Publishing House.
7. Analytical Dynamics E. T. Whittaker, Cambridge University Press.

PAPER CODE: PHY4102
PAPER –II: MATHEMATICAL METHODS IN PHYSICS
No. of Credits: 4 **No. of Lectures: 48**

	Title and Contents	No. of Lectures
Unit-I	**Linear spaces and operators:** Vector spaces and subspaces, Linear dependence and independence, Basis and Dimensions, linear operators, Inverses. *References*: 3-4	**12**
Unit-II	**Matrix algebra:** Matrix representation, Similarity transformations, Eigenvalues and eigenvectors, Inner product, Orthogonality, Introduction only to Gramm-Schmidt orthogonalization procedure, Self adjoint and Unitary transformations, Eigenvalues & eigenvectors of Hermitian & Unitary transformations, Diagonalization. *References*: 3-4	**12**
Unit-III	**Special functions:** Legendre, Hermite and Laguerre function – Generating function, Recurrence relations and their differential equations, Orthogonality properties, Bessels's function of first kind, Spherical Bessel function, Associated Legendre function, Spherical harmonics. *References*: 5-6	**12**
Unit-IV	**Fourier series and integral transforms:** Fourier Series : Definition, Dirichlet's condition, Convergence, Fourier Integral and Fourier transform, Convolution theorem, Parseval's identity, Applications to the solution of differential equations, Laplace transform and its properties, Applications to the solution of differential equations, Fourier transform & Laplace transform of Dirac Delta function. *References*: 1, 2, 5-9	**12**

References:

1. Mathematics for Physical Sciences – Mary Boas, John Wiley & Sons.
2. Mathematical methods in Physics – B. D. Gupta.
3. Linear Algebra – Seymour Lipschutz, Schaum Outlines Series- Mc-Graw Hill Edition.
4. Matrices and Tensors in Physics, A. W. Joshi, 3rd Edition, New Age International.
5. Mathematical Methods for Physicists – Arfken & Weber – 6th Edition-Academic Press, N.Y.
6. Mathematical Methods in Physics – Satyaprakash.
7. Fourier Series - Seymour Lipschutz, Schaum Outlines Series.
8. Laplace Transform - Seymour Lipschutz, Schaum Outlines Series.
9. Fourier Series and Boundary value problems - R. V. Churchill, McGraw Hill.

PAPER CODE: PHY4103
PAPER – III: ATOMS, MOLECULES AND SOLIDS
No. of Credits: 4 **No. of Lectures: 48**

	Title and Contents	No. of Lectures
Unit-I	**Atoms:** Atomic structure and atomic spectra, quantum numbers, Pauli's exclusion principle, electron configuration, Trems for equivqlemnt and non-equivalent electrons, Hund's rules, origin of spectral lines, selection rules, spectra of one electron atoms, spectra of two electron atoms, fine structure and hyperfine structure, Normal Zeeman effect and Anomalous Zeeman effect , Paschen- Back effect ***Reference*****:** Banwell, Articles 5.1, 5.2, 5.3, 5.4, 5.6	**12**
Unit-II	**Molecules:** Molecular Spectra: Rotational and vibrational spectra for diatomic molecules, Electronics spectra of diatomic molecules, vibration course structure, vibrational analysis of band structure, Frank – Condon principle, Dissociation energy and dissociation products, rotational fine structure of electronic vibrational transitions, electronic angular momentum in diatomic molecules. ***Reference*****:** Aruldhas, Articles 9.1 to 9.11	**12**
Unit-III	**Resonance Spectroscopy:** ESR: Principles of ESR, ESR spectrometer, total Hamiltonian, hyperfine structure. ***Reference*****:** Aruldhas, Articles 11.1 to 11.5 NMR: Magnetic properties of nucleus, resonance condition, NMR instrumentation, relaxation process, chemical shift, applications of NMR. ***Reference*****:** Aruldhas 10.1 to 10.4, 10.7	**12**
Unit-IV	**Crystal Diffraction & Lattice Vibrations of Solids:** Laue theory of X-ray diffraction, Geometrical structure factor, Atomic scattering factor, calculations for sc, bcc, fcc, hcp and diamond structure. Vibrational modes of monoatomic linear lattice & diatomic linear lattice, Acoustic and optical modes of vibration, Brillouin zone, Phonon. Lattice heat capacity, Einstein model and Debye model of lattice heat capacity, Normal and Umklapp processes. ***Reference*****:** Kittle, Ch.2, Ch. 4, Ch.5 and Ref.5: Ch.2	**12**

References:

1. Fundamentals of Molecular spectroscopy, C. N. Banwell and Elaine M. Mc Cash
2. Molecular structure and Spectroscopy, G. Aruldhas.
3. Quantum Physics, Robert Eiesberg and Robert Resnik
4. Introduction to solid states Physics, Charles, Kittle 7th Edition
5. Solid States Physics, A. J. Dekkar

PAPER CODE: PHY4104
PAPER – IV: ELECTRONICS
No. of Credits: 4 **No. of Lectures: 48**

	Title and Contents	No. of Lectures
Unit-I	**Applications of special function ICs:** 1.1 Study of Timer IC 555: Block diagram, Astable and monostable multivibrator circuits. 1.2 Study of VCO IC 566 and its applications. 1.3 Study of PLL IC 565: Block diagram, applications like frequency multiplier, FSK, FM demodulator. 1.4 Function generator using two OPAMPs with variable controls, Astable and monostable multivibrators using OPAMP. ***References*:** 1 to 5	**12**
Unit-II	**Regulated power supply** 2.1 Concept of Voltage Regulator using discrete components. 2.2 Types of power supplies: series and shunt regulators, CVCC, SMPS. 2.3 Three pin regulators. (IC 78XX/79XX, IC LM 317). 2.4 Basic low and high voltage regulator and foldback current limiting using IC 723. 2.5 Concept and applications of DC - DC converter. ***References*:** 4, 5, 6	**12**
Unit-III	**A. Digital Logic circuits I: Combinational Logic:** 3.1 Review of Boolean identities and its use to minimize Boolean expressions. 3.2 Minimization of Boolean expressions using Karnaugh map (up to 4 variables). **B. Digital Logic circuits II: Sequential Logic:** 3.3 Review of synchronous, asynchronous and combinational counters (4-bit). 3.4 Decade counter IC 7490 with applications. 3.5 Shift registers using IC 7495: applications as SISO, SIPO, PISO and PIPO. 3.6 Up-down counter ***References*:** 7, 8	**12**
Unit-IV	**Data Converters:** 4.1 Analog to digital converters: Binary weighted type, R-2R ladder type, Study of IC 0808 4.2 Digital to analog converters: Single slope, Dual slope, Flash, Counter type, Continuous type, Simultaneous type, Successive approximation type, Study of IC 7106 ***References*:** 7, 8, 9	**12**

References:

1. Operational Amplifiers: G. B. Clayton (5th edition)
2. OPAMPS and Linear Integrated Circuits: Ramakant Gayakwad, Prentice Hall
3. Linear Integrated Circuits: D. Roy Choudhary, Shail Jain
4. Electronic Principles: A. P. Malvino, TMH
5. Power Supplies: B. S. Sonde

6. SMPS, Inverters, Converters: Gottlieb
7. Digital Principles and Applications: Leach and Malvino
8. Digital Electronics: R. P. Jain
9. Data Converters: B. S. Sonde

PAPER CODE: PHY4105
PAPER – V: PHYSICS PRACTICAL LABORATORY - I: General Physics Lab - I
No. of Credits: 4 **No. of experiments: 12**

Sr. No.	Title of Experiment
1	Michelson Interferometer.
2	Characteristics of G. M. tube
3	Magnetic susceptibility: Gouy method.
4	Resistivity of semiconductor by Four Probe method
5	Absorption coefficient of Al and dead time
6	Skin depth in Al
7	Thermionic emission
8	End point energy of G. M. tube.
9	Electron Spin Resonance. (ESR)
10	Franck – Hertz Experiment
11	Band gap of a semiconductor
12	Measurement of thickness of wire

PAPER CODE: PHY4106
PAPER –VI: PHYSICS PRACTICAL LABORATORY - II: C - Programming Lab
No. of Credits: 4 **No. of experiments: 12**

Sr. No.	Title of Experiment
1	Legendre polynomials using the standard recurrence relation.
2	Bessel functions of the first kind using the standard recurrence relation
3	To generate random numbers.
4	Lagrangian Interpolation
5	Differential Equation of a charged particle in a uniform magnetic field.
6	Gauss – Elimination method (Whetstone's bridge)
7	Differential equation for charging /discharging of a capacitor
8	Runge – Kutta method
9	Find out the value of 'π' using Monte-Carlo methods. Obtain your result correct up to five decimal positions.
10	Free falling body
11	Differential equation for discharging of a capacitor
12	Simple Harmonic Oscillator

PAPER CODE: PHY4107 **PAPER – VII: SELF LEARNING: LASERS** **No. of Credits: 1** **No. of Lectures: 15**	
	Brief outline of the course
	Laser systems and Applications: **Fundamentals of Lasers:** Interaction of radiation with Matter: Absorption, Spontaneous emission, Thermal equilibrium and Maxwell Boltzmann distribution, balancing of rate equation at thermal equilibrium, Spontaneous emission, Significance of Einstein's coefficients, population inversion Components of lasing system: Active medium, Optical pump and Resonating cavity **Lasing Systems:** He-Ne laser, CO_2 Laser, Nd: YAG Laser, Semiconductor Lasers **Applications of Lasers:** Length measurement, Velocity measurement(Laser Doppler Velocity meter), Holography, *Laser in spectroscopy*: High resolution spectroscopy, Multi Photon spectroscopy, *Laser in Medicine*: diagnosis and detection of Cancer, *lasers in Ophthalmology*, *Laser isotope separation*, *Lasers in Non linear Optics* : Harmonic generation and self focusing effect Laser printers, Laser CD writer, Laser barcode scanner
	Reference Books: 1. O. Svelto, Principles of Lasers, (Plenum, New York, 1982). 2. K. Thyagrajan and A. K. Ghatak, Laser: Theory and Applications. (McMillan India, New Delhi, 1984). 3. A. K. Ghatak and K. Thyagrajan, Optical Electronics,(Cambridge Univ. Press, 1989). 4. Laser Fundamentals, W. T. Silfvast (Cambridge University Press 1999). 5. Laser Spectroscopy by Demtröder. 6. A. Yariv, Quantum Electronics, 2nd edition (Wiley, New York, 1975). 7. An introduction to Lasers – theory and applications, M. N. Avadhanulu, S. Chand and Co. New Delhi 8. Lasers and Nonlinear Optics by B. B. Laud, Wiley Eastern Limited, New Delhi.

Additional courses for grade.

	PAPER CODE: XHR0001 **Name of the Course: Human Rights - I** **No. of Credits: 1** **No. of Lectures: 15**
	Brief outline of the course
	This course is as per the guidelines of the SPPU

	PAPER CODE: XCS0002 **Name of the Course: Introduction to Cyber Security - I / Information Security - I** **No. of Credits: 1** **No. of Lectures: 15**
	Brief outline of the course
	This course is as per the guidelines of the SPPU

	PAPER CODE: XSD0003 **Name of the Course: Skill Development - I** **No. of Credits: 1** **No. of Lectures: 15**
	Brief outline of the course
	This course is designed to develop subject specific skills expected of a PG student.

Semester II

PAPER CODE: PHY4201
PAPER – I: ELECTRODYNAMICS
No. of Credits: 4 **No. of Lectures: 48**

	Title and Contents	No. of Lectures
Unit-I	**Multipole expansions and time varying fields:** Multipole expansions for a localized charge distribution in free space, linear quadrapole potential and field, static electric and magnetic fields in material media, boundary conditions, Time dependent fields, Faraday's law for stationary and moving media, Maxwell's displacement current, differential and integral forms of Maxwell's equations, Maxwell's equations for moving medium. ***Reference*****:** 1, 2, 3, 4, 10.	**12**
Unit-II	**Energy, force, momentum relations and electromagnetic wave equations:** Energy relations in quasi-stationary current systems, Magnetic interaction between two current loops, Energy stored in electric and magnetic fields, Poynting's theorem, General expression for electromagnetic energy, Electromagnetic wave equations, Electromagnetic plane waves in stationary medium, Reflection and refraction of electromagnetic waves at plane boundaries (Oblique incidence), Electromagnetic waves in conducting medium, Skin effect and skin depth. ***Reference*****:** 1, 2, 4, 5, 6,8,10.	**12**
Unit-III	**Inhomogeneous wave equations:** Inhomogeneous wave equations, Lorentz's and Coulomb's gauges, Gauge transformations, Wave equations in terms of electromagnetic potentials, D'Alembertian operator, Hertz potential and its use in computation of radiation fields. ***Reference*****:** 1, 2, 4, 5,8,10.	**12**
Unit-IV	**Relativistic Mechanics and Covariance:** Experimental basis for special theory of relativity (Michelson – Morley experiment), Lorentz transformations, Relativistic velocity addition, Minkowski's space time diagram, Four vector potential, electromagnetic field tensor, Lorentz force on a charged particle. ***Reference*****:** 1,2,3,6,9,10	**12**

References:

1. Introduction to Electrodynamics, (3rd Edition) by David J. Griffith Publication: Prentice-Hall of India, New Delhi.
2. Introduction to Electrodynamics, by A. Z. Capri and P. V. Panat Narosa Publishing House.
3. Classical electricity & Magnetism, by Panofsky and Phillips, Addison Wesley.
4. Foundations of Electromagnetic theory, by Reitz & Milford, World student series Edition.
5. Classical Electrodynamics, by J. D. Jackson, 3rd Edition John Wiley.
6. Electromagnetic theory and Electrodynamics, by Satya Prakash, Kedar Nath and Co. Meerut.
7. Special theory of Relativity, by Robert Resnick.
8. Electromagnetics by B. B. Laud, Willey Eastern.

PAPER CODE: PHY4202
PAPER – II: SOLID STATE PHYSICS
No. of Credits: 4 **No. of Lectures: 48**

	Title and Contents	No. of Lectures
Unit-I	**Band Theory of Solids:** Nearly free electron model, DC and AC electrical conductivity of metals. Bloch theorem (with proof), Kronig-Penney model, Motion of electron in 1-D according to band theory, Distinction between metals, insulators and intrinsic semiconductors, Reduced, periodic and extended zone schemes, Cyclotron resonance, Quantization of electronic orbit in a magnetic field. ***Reference*:** Kittel, Ch. 7 and 9	**12**
Unit-II	**Diamagnetism and Paramagnetism:** Classical theory of diamagnetism, Langevin theory of Paramagnetism, Quantum theory of Paramagnetism, Paramagnetic susceptibility of conduction electron, Magnetic properties of rare earth ions & iron group ions with graphical representation, Crystal field splitting, Quenching of orbital angular momentum. ***Reference*:** Kittel, Ch. 14	**12**
Unit-III	**Ferromagnetism, Antiferromagnetism and Ferrimagnetism:** *Ferromagnetism*: Wiess theory, Curie point, Exchange integral, saturation magnetization and its temperature dependence, Saturation magnetization at absolute zero, ferromagnetic domains, Anisotropy energy, Bloch wall, *Antiferromagnetism*: Neel temperature, *Ferrimagnetism*: Curie temperature, susceptibility of ferrimagnets. ***Reference*:** Kittel, Ch 15	**12**
Unit-IV	**Superconductivity:** Occurrence of superconductivity, Meissner effect, Heat capacity, Energy gap, Microwave and IR properties, Isotope effect, Type I and II superconductors, Thermodynamics of superconductivity, London equation, London penetration depth, BCS theory, Quantization in a superconductivity ring, Qualitative discussion of Josephson superconductor tunnelling. ***Reference*:** Kittel, Ch.12	**12**

References:

1. Introduction to solid states Physics - Charles, Kittle 7th Edition.
2. Solid States Physics - S. O. Pillai (Current edition).
3. Elementary Solid States Physics- M. Ali Omar.
4. Problem in Solid State Physics – S.O. Pillai.
5. Solid States Physics – A. J. Dekkar.
6. Solid States Physics – Wahab.
7. Solid State Physics: Neil W. Ashcroft, N. David Mermin.
8. Solid States Physics – C. M. Kacchawa

PAPER CODE: PHY4203
PAPER – III: QUANTUM MECHANICS
No. of Credits: 4 **No. of Lectures: 48**

	Title and Contents	No. of Lectures
Unit-I	**Introduction, Basic postulates of Quantum Mechanics, Simple stationary state problem:** Inadequacy of classical Physics, Formation of wave packet and uncertainty principle, Schrodinger's wave equation and probability interpretation. Basic Postulates of Quantum mechanics: i) The state of the system: probability density, superposition principle, ii) Observable and operators: self adjoint operator, commutation iii) Measurement in Quantum mechanics: Expectation value, complete sets of commutating operator, eigen value and eigen function. iv) Time evolution of system's state: time evolution operator, stationary states time independent potentials Simple stationary state problem: particle in a rigid box and a non rigid box, potential barrier, hydrogen atom.	**12**
Unit-II	Set of discrete and continuous eigenvalues, completeness and closure property, physical interpretation of eigen value and eigen function and expansion coefficient. Dirac notation: Hilbert space, Dirac's bra and ket notation, dynamical variables and linear operators, projection operators, unit operator, unitary operator, matrix representation of an operator, change of basis, unitary transformation. Eigen values and eigen functions of simple harmonic oscillator by operator method.	**12**
Unit-III	**Angular Momentum:** General formalism of angular momentum, matrix representation of angular momentum, geometrical representation of angular momentum, Orbital angular momentum: Eigen value equation of L^2 and L_z operator. funnctions of L Spin angular momentum, General theory of spin,, Pauli theory of spins(Pauli's matrices) Addition of angular momenta, Computation of Clebsch-Gordon coefficients in case (J_1=1/2, J_2=1/2).	**12**
Unit-IV	**Approximation Methods:** Approximation methods for stationary states: Time-independent perturbation theory: Non degenerate and Degenerate perturbation theory. Variational method: Time-dependent Perturbation theory: Transition amplitude 1^{st} and 2^{nd} order, transition probability Approximation Methods for constant and Harmonic perturbation, Fermi's golden rule.	**12**

References:

1. A Text-book of Quantum Mechanics by P. M. Mathews and K. Venkatesan.
2. Quantum Mechanics Nouredine Zettili, , A John Wiley and Sons, Ltd., Publication
3. Quantum mechanics by A. Ghatak and S. Lokanathan
4. Quantum Mechanics by L. I. Schiff
5. Modern Quantum mechanics by J. J. Sakurai
6. Quantum Physics by R. Eisberg and R. Resnick
7. Introduction to Quantum Mechanics by David J. Griffiths

8. Introductory Quantum mechanics by Granier, Springer Publication.
9. Introductory Quantum Mechanics, Li boff, 4th Edition, Pearson Education Ltd
10. Shankar R. Principles of Quantum Mechanics, IInd Edition (Plenum, 1994)

PAPER CODE: PHY4204
PAPER – IV: STATISTICAL MECHANICS
No. of Credits: 4 **No. of Lectures: 48**

	Title and Contents	No. of Lectures
Unit-I	**Statistical Description and Thermodynamics of Particles:** Specification of the state of the system, Macroscopic and Microscopic states, Phase space, Statistical ensemble, Postulate of equal a priori probability, Behaviour of density of states, Liouville's theorem (Classical). Equilibrium conditions and constraints, Distribution of energy between systems in equilibrium, Approach to thermal equilibrium, Sharpness of the probability distribution, Dependence of the density of states on the external parameters, Equilibrium between interacting systems.	**12**
Unit-II	**Classical Statistical Mechanics:** Micro-canonical ensemble, System in contact with heat reservoir, Canonical ensemble, Applications of canonical ensembles (Paramagnetism, Molecule in an ideal gas, Law of atmosphere), System with specified mean energy, Calculation of mean values and fluctuations in a canonical ensemble, Connection with thermodynamics, Grand-canonical ensemble, Physical interpretation of α, Chemical potential in the equilibrium state, Mean values and fluctuations in grand canonical ensemble, Thermodynamic functions in terms of the Grand partition function.	**12**
Unit-III	**Applications of Statistical Mechanics and Quantum Distribution Functions:** Classical partition functions and their properties, Calculations of thermodynamic quantities, Ideal monatomic gas, Gibbs paradox, Equipartition theorem and its Simple applications. i) Mean kinetic energy of a molecule in a gas ii) Brownian motion iii) Harmonic Oscillator iv) Specific heat of solid, Maxwell velocity distribution, Related distributions and mean values. Symmetry of wave functions, Quantum distribution functions, Boltzmann limit of Boson and Fermion gases, Evaluation of the partition function, Partition function for diatomic molecules, Equation of state for an ideal gas, quantum mechanical paramagnetic susceptibility.	**12**
Unit-IV	**Ideal Bose and Fermi Systems:** Photon gas – i) Radiation pressure, ii) Radiation density, iii) Emissivity, iv) Equilibrium number of photons in the cavity. Einstein derivation of Planck's law, Bose- Einstein Condensation, Specific heat, Photon gas – Einstein and Debye's model of solids Fermi energy, Mean energy of fermions at absolute zero, Fermi energy as a function of temperature, Electronic specific heat, White – Dwarfs (without derivation).	**12**

References:

1. Fundamentals of Statistical and Thermal Physics, F. Reif, McGraw-Hill International Edition (1985).

2. Fundamentals of Statistical Mechanics, B. B. Laud, New Age International Publication (2003).
3. Statistical Mechanics, R. K. Pathria, Bufferworgh Heinemann (2nd Edition).
4. Statistical Mechanics, K. Huang, John Willey and Sons (2nd Edition).
5. Statistical Mechanics, Satya Prakash and Kedar Nath Ram, Nath Publication (2008).
6. Statistical Mechanics by Loknathan and Gambhir.

PAPER CODE: PHY4205
PAPER – V: PHYSICS PRACTICAL LABORATORY - III: General Physics Lab - II
No. of Credits: 4 **No. of experiments: 12**

Sr. No.	Title of Experiment
1	Divergence of a laser beam
2	Pumping speed of vacuum system
3	Conductance of a long tube
4	Ionic conductivity of NaCl
5	Study of creep
6	Phase diagram of Pb-Sn
7	Stress measurement of thin films
8	Hall effect
9	Study of Iodine spectra
10	Core loss in transformer
11	Solar cell characteristics
12	Rydberg's constant

PAPER CODE: PHY4206
PAPER – VI: PHYSICS PRACTICAL LABORATORY - IV: Electronics Lab
No. of Credits: 4 **No. of experiments: 12**

Sr. No.	Title of Experiment
1	Study of voltage controlled oscillator using IC-566.
2	Crystal oscillator- Millar type
3	Diode pump using UJT.
4	Digital to Analogue Converter using R-2R
5	Active filters: Low / High pass / Band pass / Notch filter using Op-Amp
6	Function generator using Op-Amp / IC –8038.
7	Study of opto-coupler, MCT2E and their application.
8	Constant current source using Op-Amp.
9	Digital clock.
10	Fold back power supply
11	Study of multiplexer and Demultiplexer
12	DAC using Binary type for 4-bit

PAPER CODE: PHY4207 **PAPER –VII: SELF LEARNING: ENERGY STUDIES** **No. of Credits: 1** **No. of Lectures: 15**	
	Brief outline of the course
	Role of energy in economic development and social transformation Energy and Gross Domestic Product (GDP), Gross National Product (GNP) and its dynamics Various types of energy sources, availability and overall energy demand Energy consumption in various sectors and its changing pattern, projected energy demands, its impact on environmental and climatic change Depletion of energy sources and impact of exponentional rise in energy consumption on economics of India and International relations. Non renewable energy sources: Coal, Oil, Natural Gas, Nuclear power, Hydroelectricity. Renewable energy sources: Solar, wind, Biomass, Tidal, Ocean wave, Ocean thermal, Geothermal etc. Future energy options, sustainable development, energy crisis, transition from carbon free technologies, parameters of transition.
	References: 1. TEDDY Year Book, (Tata Energy Research Institute (TERI) Publication, New Delhi). 2. World Energy Resources, Charles E. Brown (Springer Publication), 2002. 3. Energy Policy for India, B.V. Desai (Welley Eastern Publication) 4. Handbooks of Solar Radiation, A. Mani (Allied Publishers), 1980. 5. Solar Energy Fundamentals and Applications, H. P. Garg and Satya Prakash, (Tata McGraw Hill), 1977. 6. Treatise on Solar energy, H. P. Garg, Volume 1,2 and 3.(John Wiley and Sons) 1982 7. Principles of Solar Engineering, F. Kreith and J. F. Kreider, McGraw Hill , 1978 8. Climatological and Solar data for India, Seshadri (Sarita Prakashan), 1969. 9. Solar Energy Utilization, G. D. Rai, Khanna Publishers), 1995. Energy technology, S. Rao and B. B. Parulekar (Khanna Publishers), 1995

Additional courses for grade.

	PAPER CODE: XHR0004 **NAME OF THE COURSE: HUMAN RIGHTS - II** **No. of Credits: 1** **No. of Lectures: 15**
	Brief outline of the course
	This course is as per the guidelines of the SPPU

	PAPER CODE: XCS0005 **NAME OF THE COURSE: INTRODUCTION TO CYBER SECURITY – II / INFORMATION SECURITY - II** **No. of Credits: 1** **No. of Lectures: 15**
	Brief outline of the course
	This course is as per the guidelines of the SPPU

	PAPER CODE: XSD0006 **NAME OF THE COURSE: SKILL DEVELOPMENT - II** **No. of Credits: 1** **No. of Lectures: 15**
	Brief outline of the course
	This course is designed to develop subject specific skills expected of a PG student.