Fergusson College (Autonomous)

Pune

Learning Outcomes-Based Curriculum

for

M.Sc. Physics

With effect from June 2019

Learning Outcomes

The key learning outcomes of our course are: knowledge and understanding of the concepts, logical as well as abstract thinking and analytical approach, experimental and computational skills, research methodology, values and positive attitude.

Post Graduates should have developed following qualities	
1	Understanding of basic and advanced concepts in Physics
2	Theoretical and practical skills along with problem solving ability
3	Logical and abstract thinking and analytical approach
4	Ability to apply acquired knowledge and skills to the new and unknown situations in order to develop new theories, experiments and technology
5	Understand the nature in a better way
6	Understand and appreciate the nuances and beauties in science education
7	Tenacity, hardworking and ability to work against odds
8	A new perspective to look at everything from 'Physics' point of view
9	Get introduced to work environment at industrial scale and at research level
10	Awareness of the impact of Physics in social, economical and environmental issues
11	Willingness to take up responsibility in study and work; confidence in his/her capabilities; and motivation for life-long learning.

Programme Structure

M. Sc. - I

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	Quantum Mechanics	CORE	4
	PHY4104	Electronics	CORE	4
	PHY4105	Physics Practical Laboratory – I (General Lab)	CORE	4
II	PHY4201	Atoms, Molecules and Solids	CORE	4
	PHY4202	Electrodynamics	CORE	4
	PHY4203	Statistical Mechanics	CORE	4
	PHY4204	Basic Materials Science	Special-1	4
	PHY4205	Physics Practical Laboratory – II (Electronics Lab)	CORE	4

M. Sc. – II

Semester	Course Code	Title of the Course	Core / Elective	No. of Credits
III	PHY5301	Solid State Physics	CORE	4
	PHY5302	Experimental Techniques in Physics	Special-2	4
	*PHY5303	Materials Synthesis, Processing and Applications	G Elective	4
	*PHY5304	Astronomy and Astrophysics - I	D Elective/ M/**	4
	*PHY5305	Physics of Semiconductor Devices	D Elective/ M/**	4
	*PHY5306	Vacuum Science and Technology	D Elective/ M/**	4
	PHY5307	Physics Practical Laboratory –III (Materials Science)	Special Lab-1	4
*Students should select any two courses for Semester III, from PHY5303, PHY5304, PHY5305 and PHY5306				
IV	PHY5401	Nuclear Physics	CORE	4
	PHY5402	Physics of Nanomaterials	G Elective	4
	PHY5403	Atmospheric Science	D Elective/ M**	4
	PHY5404	Astronomy and Astrophysics – II	D Elective/ M/**	4
	PHY5405	Thin Film Physics and Technology	D Elective/ M/**	4
	PHY5406	Physics Practical Laboratory –IV (Astrophysics + Atmospheric Science + MATLAB)	Special Lab-2	4
	PHY5407	Physics Practical Laboratory –V (Project)	CORE	4
*Students should select any two courses for Semester IV, from PHY5402, PHY5403, PHY5404 and PHY5405				

*D = Departmental Elective, G = General Elective (from other departments),
M = MOOCs (Massive Open Online Course): **: Courses will be decided by the Chairman, BOS.

Extra Credit Courses 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

Extra Credit Courses 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

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

Objectives:

1. Students should understand the drawbacks of Newtonian approach and necessity of new approaches to solve advanced problems involving the dynamic motion of classical mechanical systems.
2. The students will introduce about the forces, angular momentum and knowledge about the constraint.
3. The course provides the students about the knowledge of hollow cylinder and solid cylinder.
4. How to use differential equations and other advanced mathematics in the solution of the problems considered in item 1.
5. How to useconservation of energy and linear and angular momentum to solve dynamics problems.
6. How to represent the equations of motion for complicated mechanical systems using the Lagrangian and Hamiltonian formulations of classical mechanics.
7. Students should understand the forces in non inertial systems.

Course Outcomes:

After successfully completing the course, student will be able to:

1. Define and understand basic mechanical concepts related to advanced problems involving the dynamic motion of classical mechanical systems.
2. Describe and understand the differential equations and other advanced mathematics in the solution of the problems of mechanical systems.
3. Describe and understand the motion of a mechanical system using Lagrange-Hamilton formalism.
4. Describe and understand the motion of the forces in non inertial systems.

Suggested Pedagogical Processes:

- ICT based learning
- Demonstration of models and experiments
- Group discussion
- Problem solving methods
- Open book tests
- Seminars on different topics
- Pre-recorded lectures

	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 Poisson Bracket under canonical transformation.	**12**

Unit-IV	**Non inertial frames of references, central force:** Rotating frames of reference, inertial forces in rotating frames, Larmour precession, 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 PublishingCompany 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

Learning Objectives:

1. Student should be able to understand basic theory of Complex Analysis, Linear Algebra, Matrix algebra, Special functions, Fourier series and integral transforms.
2. To learn mathematical tools required to solve physical problem.
3. To understand mathematical concepts related to physics.

Course Outcomes:
After successfully completing the course, student will be able to:

1. Have a good grasp of the basic elements of complex analysis, including the important integral theorems. Students will be able to determine the residues of a complex function and use the residue theorem to compute certain types of integrals.
2. Students will understand the applications of vector space, matrix algebra and special functions.
3. Have learned how to expand a function in a Fourier series, and under what conditions such an expansion is valid. Students will be aware of the connection between this and integral transforms (Fourier and Laplace) and be able to use the latter to solve mathematical problems relevant to the physical sciences.
4. Have practiced formulating good questions and explaining to others.

Suggested Pedagogical Processes:

- ICT based learning
- Demonstration of models and experiments
- Group discussion
- Problem solving methods
- Open book tests
- Seminars on different topics &Pre-recorded lectures

	Title and Contents	**No. of Lectures**
Unit-I	**Complex Analysis:** Complex variable, Function of a complex variable, Limit of a function of a complex variable, Continuity, Differentiability, Analytic functions, Cauchy-Riemann Equations, Harmonic Functions, Complex Integration, Cauchy integral theorem, Cauchy integral formula, Derivatives of analytic functions, Power Series-Taylor's theorem, Laurent's theorem, Calculus of Residues, Cauchy's Residue theorem, Evaluation of real definite integrals. *(References: 1-3)*	**12**
Unit-II	**Linear Algebra:** **Vector Spaces and Operators:** Vector spaces and subspaces, Linear Spans, Linear dependence and independence, Basis and Dimensions. **Matrix algebra:** Matrix representation of a linear operator, Change of basis, Polynomials of matrices, Characteristic polynomial, Cauchy-Hamilton theorem, Diagonalization, Eigenvalues and Eigenvectors. **Inner Product Spaces, Orthogonality:** Inner product spaces, Orthogonality, Orthogonal sets and basis, Gram-Schmidt orthogonalization process. *(References: 4, 5)*	**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	**12**

	function, Spherical harmonics. *(References: 3, 6)*	
Unit-IV	**Fourier series and integral transforms:** Fourier Series: Definition, Dirichlet's condition, Convergence, Parseval's identity, Fourier Integral and Fourier transform, Convolution theorem, Applications of Fourier Transform to solve differential equations, Laplace transform and its properties, Applications of Laplace transform to solve differential equations, Laplace transform of Dirac Delta function. *(References: 3, 6-10)*	**12**

References:

1. Complex Variables and Applications – J.W.Brown, R.V.Churchill, 7^{th}Edition, Mc-Graw Hill.
2. Complex Variables – Schaum's Outlines Series, 2^{nd}Edition, Tata Mc-GrawHill Edition.
3. Higher Mathematical Physics- H.K.Dass& Dr. Rama Verma-S. Chand. & Co. Pvt. Ltd
4. Linear Algebra – Schaum's Outlines Series- 3^{rd}Edition, Tata Mc-Graw Hill Edition.
5. Matrices and Tensors in Physics, A. W. Joshi, 3^{rd}Edition, New Age International.
6. Mathematical Methods for Physicists – Arfken& Weber – 6^{th}Edition-AcademicPress, N.Y.
7. Mathematical Methods in the Physical Sciences – Mary Boas, John Wiley & Sons.
8. Fourier series - Seymour Lipschutz, Schaum's Outlines Series. Tata Mc-Graw Hill Edition
9. Laplace Transform - Seymour Lipschutz, Schaum's Outlines Series. Tata Mc-Graw Hill Edition
10. Mathematical Methods in Physics – B. D. Gupta.

PAPER CODE: PHY4103
PAPER – III: QUANTUM MECHANICS
No. of Credits: 4

Learning Objectives:

1. To acquire mathematical skills require to develop theory of quantum mechanics
2. To develop understanding of postulates of quantum mechanics and to learn to apply them to solve some quantum mechanical systems.
3. To offer systematic methodology for the application of approximation methods to solve complicated quantum mechanical systems

Course Outcomes:

After successfully completing the course, student will be able to:

1. Understand historical aspects of development of quantum mechanics.
2. Understand and explain the differences between classical and quantum mechanics.
3. Understand the central concepts and principles in quantum mechanics, such as the Schrodinger equation, the wave function and its statistical interpretation, the uncertainty principle, stationary and non-stationary states, time evolution of solutions, as well as the relation between quantum mechanics and linear algebra including understanding of elementary concepts in statistics, such as expectation values and variance. They will master the concepts of angular momentum and spin, as well as the rules for quantization and addition of these. Hence they will be able to solve the complex systems by approximation method.

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Suggested Pedagogical Processes:

- ICT based learning
- Demonstration of models and experiments
- Group discussion
- Problem solving methods
- Open book tests
- Seminars on different topics
  Pre-recorded lectures

	Title and Contents	
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	**12**

	momentum, Orbital angular momentum: Eigen value equation of L^2 and $L_z$operator. Functions of Orbital and 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).	
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 1st and 2nd 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 NouredineZettili, 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, Liboff, 4th Edition, Pearson Education Ltd
10. Principles of Quantum Mechanics, Shankar R. IInd Edition (Plenum, 1994)

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

Objectives:
Students should understand the concepts of:
1. Special function ICs
2. Regulated power supply
3. Digital Logic circuits
4. Data Converters

Course Outcomes:
After the completion of the course, students will be able to:
1. Use special function ICs for different applications.
2. Built and design regulated power supply.
3. Develop logic circuits for various applications in real life.
4. Design and develop data convertors.

Suggested Pedagogical Processes:
- Lecture cum demonstration methods
- ICT based learning&Pre-recorded lectures
- Demonstration experiments
- Group discussion & Open book tests
- Problem solving methods
- Hands on experiments related to courses.
- Study visits at Science Park, universities and national research institutes.
- Seminars on different topics

	Title and Contents	**No. of Lectures**
Unit-I	**Applications of special function ICs:** Study of Timer IC 555: Block diagram, Astable and monostablemultivibrator circuits. Study of VCO IC 566 and its applications. Study of PLL IC 565: Block diagram, applications like frequency multiplier, FSK, FM demodulator. Function generator using two OPAMPs with variable controls, Astable and monostablemultivibrators using OPAMP. ***References*:** 1 to 5	**12**
Unit-II	**Regulated power supply** Concept of Voltage Regulator using discrete components. Types of power supplies: series and shunt regulators, CVCC, SMPS. Three pin regulators. (IC 78XX/79XX, IC LM 317). Basic low and high voltage regulator and foldback current limiting using IC 723.Concept and applications of DC - DC converter. ***References*:** 4, 5, 6	**12**
Unit-III	**A. Digital Logic circuits I: Combinational Logic:** Review of Boolean identities and its use to minimize Boolean expressions. Minimization of Boolean expressions using Karnaugh map (up to 4 variables). **B. Digital Logic circuits II: Sequential Logic:** Review of synchronous, asynchronous and combinational counters (4-bit). Decade counter IC 7490 with applications. Shift registers using IC 7495: applications as SISO, SIPO, PISO and PIPO. Up-down counter ***References*:** 7, 8	**12**
Unit-IV	**Data Converters:** Analog to digital converters: Binary weighted type, R-2R ladder type, Study of IC 0808. 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 (5^{th} edition)

2. OPAMPS and Linear Integrated Circuits: RamakantGayakwad, 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 Lab)** **No. of Credits: 4**	
Objectives: 1. Acquire the appropriate data accurately and keep systematic record of laboratory activities 2. Interpret findings using the correct physical scientific framework and tools. 3. Prepare professional quality textual and graphical presentations of laboratory data and computational results. 4. Evaluate possible causes of discrepancy in practical experimental observations, results in comparison to theory.	
Course Outcomes: Students will have achieved the ability to: 1. Learn various experimental and computational tools thereby developing analytical abilities to address real world problems. 2. Adopt the skills related to research, education, and industry- academia.	**Suggested Pedagogical Processes:** ➢ Lecture cum demonstration methods ➢ ICT based learning ➢ Demonstration of models and experiments ➢ Group discussion &Problem solving methods ➢ Hands on experiments related to Physics courses.Study visits at Science Park, universities and national research institutes

Sr. No.	Experiment Title
1	**Photoconductivity:** a) To plot the current voltage characteristics of a CdSphotoresistor at constant irradiance. b) To measure the photocurrent as a function of irradiance at constant voltage.
2	**Speed of Light:** To determine the speed of light using transit time of light pulse as a function of a reflecting mirror.
3	**Faraday Effect:** Rotation of the polarization plane Φ and 2Φ as a function of the magnetic field.
4	**Dielectric constant:** a) To Measure the charge Q on a plate capacitor as a function of the applied voltage E. b) To determine the capacitance C as a function of area A of plates. c) To determine the capacitance C with different dielectrics between the plates. d) To determine the capacitance C as a function of the distance *d* between the plates.
5	**Millikan's Oil Drop Method:** To measure the rise and fall times of the oil droplets at different voltages having different charges. a) To determine the radii of droplets. b) To determine the charge '**e**' on the droplets.
6	**Michelson's Interferometer:** To determine the wavelength of He-Ne LASER by using Michelson's Interferometer apparatus.

7	**Specific Heat of Solids:** To determine the specific heat of copper, lead and glass.
8	**Electron Spin Resonance:** To study the Electron Spin Resonance and to determine Lande's g-factor
9	**Frank-Hertz experiment:** To study the discrete energy levels using Frank-Hertz experiment
10	**G. M. Counter:** Characteristics of GM tube and determination of end point energy of β-ray source
11	**G. M. Counter:** Determination of dead time of GM tube by Double source method
12	**Skin depth:** Skin depth in Al using electromagnetic radiation.
13	**Gouy's Method:** Measurement of magnetic susceptibility of $MnSO_4$.
14	**Thermionic emission:** To determine work function of Tungsten filament.
15	**Hall effect:** To determine charge concentration, conductivity of Ge-semiconductor.
16	**Four Probe method:** Temperature variation and Band gap of Ge-semiconductor.

Extra Credit courses

	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.

PAPER CODE: PHY4201
PAPER – I: ATOMS, MOLECULES AND SOLIDS
No. of Credits: 4

Objectives:

1. The subject of Atomic and Molecular Physics has reached a significant advancement in high–precision experimental measurement techniques.
2. This area covers a wide spectrum ranging from conventional to new emerging multi-disciplinary areas like molecular physics, optical science especially spectroscopy.
3. In the present syllabus sequence of articles in each chapter enables the student to understand the gradual development of the subject.

Course Outcomes:

After the completion of the course, students will be able to:

1. Describe theories explaining the structure of atoms and the origin of the observed spectra.
2. Identify atomic effect such as Zeeman effect and Stark effect.
3. List different types of atomic spectra.
4. Explain the observed dependence of atomic spectral lines on externally applied electric and magnetic fields.

Suggested Pedagogical Processes:

- Lecture cum demonstration methods
- ICT based learning
- Demonstration experiments
- Group discussion & Problem solving methods
- Hands on experiments related to courses.
- Pre-recorded lectures & Open book tests
- Study visits at Science Park, universities and national research institutes.
- Seminars on different topics

	Title and Contents	No. of Lectures
Unit-I	**Atoms:** Atomic structure and atomic spectra, quantum numbers, Pauli's exclusion principle, electron configuration, Terms for equivalent 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 monatomic 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	**12**

	and Umklapp processes. ***Reference*:** Kittle, Ch.2, Ch. 4, Ch.5 and Ref.5: Ch.2	

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

PAPER CODE: PHY4202
PAPER- II: ELECTRODYNAMICS
No. of Credits: 4

Objectives:
1. To aspire the students regarding the computation of vector potential, electric field of a localized current distribution using multipole expansion problems.
2. To acquaint the students regarding the concepts of electrodynamics and Maxwell equations and apply it in numerous problems.

Course Outcomes:	Suggested Pedagogical Processes:
Students will have achieved the ability to: 1. Use Maxwell equations in analysing the nature of electromagnetic field due to time varying charge and current distribution. 2. Describe the nature of electromagnetic wave and its propagation through different media and interfaces involved in different situations. 3.Simplify charged particle dynamics and radiation from localized time varying electromagnetic sources.	➢ Lectures and ICT based learning • Group discussion & Problem solving methods ➢ Pre-recorded lectures & Open book tests ➢ Seminars on different topics

	Title and Contents	No. of Lectures
Unit-I	**Electrostatics and Dielectrics:** **Electrostatics:** Coulomb's law, Gauss's law and its applications, Laplace equations in two and three dimensions, multipole expansions for a localized charge distribution in free space, linear quadrupole potential and field, energy in electrostatic fields. **Dielectrics:** linear dielectrics, polarisation, electric displacement, Gauss's law in dielectric materials, boundary conditions at the interface of two dielectrics. ***Reference*:** 1, 2, 4, 5, 6, 7, 8,9,10	**12**
Unit-II	**Magnetostatics and Electrodynamics:** **Magnetostatics**: Magnetic forces, The Biot-Savart's law and Ampere's law and its applications, magnetic vector potential, magnetostatics boundary conditions, magnetic fields inside matter. **Electrodynamics:** Electromotive force, Faraday's law of electromagnetic induction, energy in Magnetic fields, Maxwell's correction to Amperes law, differential and integral forms of Maxwell's equations. ***Reference*:**1, 2, 4, 5, 6, 7, 8,9,10	**12**
Unit-III	**Electromagnetic Waves and its Propagation:** Poynting's theorem, Electromagnetic wave equations, Electromagnetic plane waves in free space, non-conducting and conducting media, Polarisation on	**12**

	reflection and refraction of electromagnetic waves, Fresnel's equations, Brewster's law, skin effect and skin depth. ***Reference***: 1, 3, 4, 5, 6,7,8	
Unit-IV	**Electromagnetic Potentials and Fields:** Scalar and vector potentials, Coulomb gauge and Lorentz gauge, Gauge transformations, Wave equations in terms of electromagnetic potentials, the d'Alembertian operator, Hertz potential and its use in computation of radiation fields, Lienard-Wiechert potentials, Fields of moving point charge. ***Reference***: 1, 2, 3, 4, 5, 6,8	**12**

References:

1. Introduction to Electrodynamics, D. J. Griffiths (PrenticeHall, India)
2. Introduction to Electrodynamics, A. Z. Capri and P. V. Panat, (Narosa Publishing House).
3. Classical Electricity & Magnetism, W.K.H. Panofsky and Phillips, (Addison-Wesley)
4. Foundations of Electromagnetic Theory, J. R. Reitz, F. J. Milford and R. W. Christy, (Pearson)
5. Classical Electrodynamics, by J. D. Jackson, (John Wiley)
6. Electromagnetic Theory and Electrodynamics, Satya Prakash, KedarNath Ram Nath, (Meerut)
7. Electromagnetics, B. B. Laud, (Willey Eastern)
8. Classical Theory of Fields, L.D. Landau and E.M. Lifshitz, (Addison-Wesley)
9. Feynman Lectures, Volume II, R.P. Feynman, Leighton, and Sands, (Narosa)
10. Berkley Series, Volume II, E.M. Purcell (Mc-Graw Hill)

PAPER CODE: PHY4203
PAPER – III: STATISTICAL MECHANICS
No. of Credits: 4

Objectives:

1. This course in statistical mechanics provides the basic idea of probability to the students. There are ways of calculating probability for various statistical system of particles.
2. Students will study basic ideology of phase space, microstate, macrostate.
3. The objective is to apply the principles of probability in distribution of particles in various systems and to calculate thermodynamic probability.
4. The course gives the insight of postulates of statistical physics.
5. Students will learn the different types of statistics distribution and particles. They will learn which particles follow which statistics and why.

Course Outcomes:

1. After taking this course students are able to determine the probability of any type of events. They are able to interpret different types of events.
2. Students have understood the concept of phase space and its volume.
3. They can easily distinguish between different types of particles and statistics and can easily distribute bosons, fermions and classical particles among energy levels.
4. After studying Fermi Dirac statistics, students have learnt to deal with much electron system

Suggested Pedagogical Processes:

- ➢ ICT based learning
- Group discussion & Problem solving methods
- ➢ Pre-recorded lectures & Open book tests
- Seminars on different topics

	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,	**12**

	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.	
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, Butterworth Heinemann (2^{nd} Edition).
4. Statistical Mechanics, K. Huang, John Willey and Sons (2^{nd} Edition).
5. Statistical Mechanics, Satya Prakash and KedarNath Ram, Nath Publication (2008).
6. Statistical Mechanics by Loknathan and Gambhir.

PAPER CODE: PHY4204
PAPER –IV: BASIC MATERIALS SCIENCE
No. of Credits: 4

Objectives:

1. To review basic chemistry and physics in the context of basic materials science.
2. To introduce the students to the concept of phases and phase diagrams.

Course Outcomes:

Students will have achieved the ability to:

1. Understand how structure/property/ processing relationships are developed and applied for different type of materials.
2. Interpret the phase diagrams of single component, multi-component systems
3. Select appropriate type of material for specific properties/application.

Suggested Pedagogical Processes:

- Lecture cum demonstration methods
- ICT based learning
- Demonstration experiments
- Group discussion & Problem solving methods
- Hands on experiments related to courses.
- Pre-recorded lectures & Open book tests
- Study visits at Science Park, universities and national research institutes.
- Seminars on different topics

	Title and Contents	No. of Lectures
Unit-I	**Defects in Solids:** Elastic and inelastic behaviour, *Point defects*: vacancies, interstitials, Schottky defects and Frenkel defects, non-stoichiometry. *Line defects*: edge and screw dislocations. Properties of dislocations, force on dislocation, energy of dislocation, dislocation density, interaction between dislocations (cross-slip and climb), Frank-Read source, plastic deformation, motion of dislocation, creep. *Surface defects*: grain boundaries, stacking fault. Volume defect: twin boundary.	**12**
Unit-II	**Solid Solutions:** *Solid solubility*: types of solid solutions, factors governing solid solubility (Hume - Rothery rule), atomic size in solid solutions, size factor, Vegard's law, strain in dislocations, superlattices (Bragg-William theory).	**12**
Unit-III	**Metallurgical Thermodynamics:** Laws of thermodynamics, Auxiliary thermodynamic functions, Measurement of changes in enthalpy and entropy, Richard's rule, Trouton's rule, Chemical reaction equilibrium, Thermodynamic properties of solutions (mixing processes – Rault's law, activity coefficient, regular solution behaviour – Henry's law), Gibb's phase rule: proof, explanation and application to single (mono) component (H_2O) and binary phase diagram.	**12**
Unit-IV	**Phase diagrams:** Thermodynamic origin of phase diagrams, Lever rule, types of phase diagrams. Definition of maxima, minima, miscibility gap. Topology of binary phase diagrams (examples of eutectic, peritectic, monotectic, eutectoid, peritectoid, syntactic reaction, extension rule). Experimental determination of phase diagrams. *Discuss suitable examples wherever necessary.*	**12**

References:

1. Elements of Materials Science and Engineering (5th edition), Lawrence H. Van Vlack, Addison-Wesley Publishing Co. ISBN: 0-201-08089-3
2. Materials Science and Engineering – A First Course (5th edition), V. Raghvan. PHI Learning Pvt. Ltd, New Delhi, ISBN: 978-81-203-2455-8
3. Physical Metallurgy (Part I) R. W. Cahn and P. Hassen, North Holland Physics Publishing,

New York.
4. Materials Science, G. K. Narula, K. S. Narula and V. K. Gupta, Tata Mc-Graw Hill Publishing Co. Ltd, New Delhi, ISNN: 0-07-451796-1
5. Materials Science and Metallurgy for Engineers, V. D. Kodgire and S. V. Kodgire, Everest Publishing House, ISBN: 81-86314-008
6. Introduction to Materials science for engineers (6th edition)-J. F. Shaekelford and M. K. Murlidhara- Pearson Education.
7. Experiments in Materials Science – Prof. E. C. Subbarao. et.al.
8. Experiments in Materials Science – V. Raghavan

PAPER CODE: PHY4205

PAPER –V: PHYSICS PRACTICAL LABORATORY – II:(Electronics Lab)

No. of Credits: 4

Objectives:

1. To gain practical knowledge by applying the experimental methods to correlate with the physics theory.
2. To learn the usage of electrical and electronic systems for various measurements.
3. Apply the analytical techniques and graphical analysis to the experimental data.
4. To develop intellectual communication skills and discuss the basic principles of scientific concepts in a group.
5. Practice different types of wiring and instruments connections keeping in mind technical, Economical, safety issues.

Course Outcomes:

Students will have achieved the ability to:

1. Understand the behaviour of electronic components and perform analysis and design of bias circuits for diodes, transistors etc.
2. Set up testing strategies and select proper instruments to evaluate performance characteristics of electronic circuit.
3. Choosing testing and experimental procedures on different types of electronic circuit and analyse their operation different operating conditions.

Suggested Pedagogical Processes:

- Lecture cum demonstration methods
- ICT based learning
- Demonstration of models and experiments
- Group discussion &Problem solving methods
- Hands on experiments related to Physics courses. Study visits to Science Park, universities and national research institutes

Sr. No.	Title of the Experiment
1	Diode Pump Staircase generator using UJT
2	Foldback Power Supply
3	Crystal Oscillator & Digital Clock
4	Voltage Control Oscillator using IC-566
5	Function generator using IC -8038
6	Optocoupler using OPAMPs and IC MCT-2E
7	Constant current source using OP-AMP
8	Digital to Analogue Converter (DAC) using R-2R and Binary ladder

9	Active filters using OP-AMP / IC- 8038(Low pass, High pass, Notch type)
10	Study of Multiplexer&Demultiplexer
11	Precision rectifier
12	Design, built and test oscillator – Wien Bridge oscillator
13	Lock-in-amplifier and measurement of low resistance& mutual inductance
14	Analog to digital converter (ADC)
15	IC555-Monosatable and AstableMultivibrator
16	Phase locked loop (PLL) application using IC565
17	Decade counter/ Shift register
18	OPAMP as logarithmic amplifier

Extra Credit courses

	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.