Fergusson College (Autonomous)
Pune

Learning Outcomes-Based Curriculum

for
M. Sc. Physics
With effect from June 2019

Programme Structure

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Programme Structure

Year	Paper	Paper code	Title of Paper	Type of Paper	No. of Credits
S. Y. M.Sc.	**Semester III**				
	Paper- 1	PHY5301	Experimental Techniques in Physics	Special-2	4
	Paper - 2	PHY5302	Solid State Physics	CORE	4
	Paper - 3	*PHY5303	Physics of Semiconductor Devices	D Elective / M**	4
	Paper -4	*PHY5304	Materials Synthesis, Processing and Applications	G Elective	4
	Paper– 5	*PHY5305	Astronomy and Astrophysics - I	D Elective / M**	4
	Paper – 6	*PHY5306	Vacuum Science and Technology	D Elective / M**	4
	Paper -7	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**				
	Semester IV				
	Paper- 1	PHY5401	Nuclear Physics	CORE	4
	Paper - 2	*PHY5402	Astronomy and Astrophysics – II	D Elective / M**	4
	Paper - 3	*PHY5403	Physics of Nanomaterials	G Elective	4
	Paper -4	*PHY5404	Thin Film Physics and Technology	D Elective / M**	4
	Paper– 5	*PHY5405	Atmospheric Science	D Elective / M**	4
	Paper – 6	PHY5406	Physics Practical Laboratory –IV (Astrophysics + Atmospheric Science + MATLAB)	Special Lab-2	4
	Paper -7	PHY5407	Physics Practical Laboratory –V (Project)	CORE	4
*** 1 P** ***Students should select any two courses for Semester IV, from PHY5402, PHY5403, PHY5404 and PHY5405**					
*D = Departmental Elective					
M = MOOCs (Massive Open Online Course): **: Courses will be decided by the Chairman					

Extra Credit Courses for M. Sc.

Structure of Compulsory Add-on Credits for all PG courses					
Year	**Semester**	**Human Rights**	**Cyber Security**	**Skill Development**	**Total Credits**
First Year	I	2 Credits	--	--	2 Credits
	II	--	2 Credits	2 Credits	4 Credits
Second Year	III	--	2 Credits	2 Credits	4 Credits
	IV	--	--	--	--
		2 Credits	4 Credits	4 Credits	**10 Credits**

Note: Only Course Grade must be printed for add-on courses and marks will not be counted for SGPA or CGPA calculations. Student must pass in all add-on courses to get the degree.

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

Program Outcomes (POs) for M. Sc. Programme	
PO1	**Disciplinary Knowledge:** Demonstrate comprehensive knowledge of the discipline that form a part of an postgraduate programme. Execute strong theoretical and practical understanding generated from the specific programme in the area of work.
PO2	**Critical Thinking and Problem solving:** Exhibit the skill of critical thinking and understand scientific texts and place scientific statements and themes in contexts and also evaluate them in terms of generic conventions. Identify the problem by observing the situation closely, take actions and apply lateral thinking and analytical skills to design the solutions.
PO3	**Social competence:** Exhibit thoughts and ideas effectively in writing and orally; communicate with others using appropriate media, build effective interactive and presenting skills to meet global competencies. Elicit views of others, present complex information in a clear and concise and help reach conclusion in group settings.
PO4	**Research-related skills and Scientific temper:** Infer scientific literature, build sense of enquiry and able to formulate, test, analyse, interpret and establish hypothesis and research questions; and to identify and consult relevant sources to find answers. Plan and write a research paper/project while emphasizing on academics and research ethics, scientific conduct and creating awareness about intellectual property rights and issues of plagiarism.
PO5	**Trans-disciplinary knowledge**: Create new conceptual, theoretical and methodological understanding that integrates and transcends beyond discipline-specific approaches to address a common problem.
PO6	**Personal and professional competence**: Perform independently and also collaboratively as a part of team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	**Effective Citizenship and Ethics** : Demonstrate empathetic social concern and equity centred national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	**Environment and Sustainability**: Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
PO9	**Self-directed and Life-long learning:** Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

PSO No.	Program Specific Outcomes(PSOs) Upon completion of this programme the student will be able to
PSO1	**Academic competence**: (i) **Associate** the universal applications of physics in all disciplines. **Articulate** fundamental and advance concepts, principles and processes underlying physical phenomena in different branches ranging from classical mechanics to quantum mechanics and extended to electrodynamics, statistical mechanics, atomic, molecular and solid state physics, nanomaterials and electronic science. (ii) **Demonstrate** mathematical, statistical and computational ability in problem solving. **Demonstrate** and **explain** various mathematical techniques, numerical methods, experimental techniques to broaden independent thinking and scientific temper.
PSO2	**Personal and Professional Competence:** (i) Execute experimental and project work independently. (ii) Carry out laboratory oriented numerical calculations and experimental data interpretation. Analyse self-generated data through experiments as well as archival data (iii) Formulation of physics concepts, effective presentation and communication skills through seminars and group discussions. Develop skills of technical report writing along with precise presentation with effective communication. Apply appropriate concepts and various methods to solve wide range of problems. Incorporate the hands-on training of soldering to connect electronic components for designing circuits for device applications.
PSO3	**Research Competence:** (i) Use of in-house laboratory setup for building instrumentation. Integrate and interpret data. Evaluate the research findings in materials sciences and astrophysics. Apply experimental skills for interdisciplinary research work. Review of research papers, books for publications in journals. Apply experimental skills for projects / research and need for interdisciplinary research Carry out projects in basic, applied and interdisciplinary science to develop conceptual understanding and an orientation towards research. Interpret and analyse the results of the research project. Integrate mathematical / statistical and computational data to analyse and formulate theories. Implement Projects and research paper writing and book reviews.
PSO4	**Entrepreneurial and Social competence:** Enhance analytical skills and research aptitude in specific areas related to physics including materials science, thin film technology, solar energy, radiation dosimetry, astrophysics, atmospheric science, energy generation and storage for academic research and industrial applications. Develop job oriented analytical skills on an advanced level needed in industry, consultancy, education, research or public administration. **(i)** Employ and develop skills in specific areas related to physics and engineering for industrial application, production and technology development and transfer. **(ii)** Develop social awareness through internships and science popularization programs. Execute awareness of ethical issues: emphasis on academic and research ethics, need and value of lifelong learning, international perspective, importance of academic and research ethics, human rights, scientific misconduct, intellectual property rights and issues related to cyber laws and plagiarism.

F.Y. M.Sc. Semester I		
Title of the Course and Course Code	**CLASSICAL MECHANICS (PHY4101)**	**Number of Credits : 04**

Course Outcomes (COs) **On completion of the course, the students will be able to:**	
CO1	Describe various approaches for finding solutions of equations of motions.
CO2	Discuss and give examples of constraints and methods of eliminating them.
CO3	Apply different mathematical tools and techniques to find solutions of problems in Mechanics.
CO4	Compare and contrast different approaches of solving equations of motion.
CO5	Evaluate the generating functions and assess different mathematical transformations.
CO6	Develop the techniques to analyze motions in accelerated, frames of references.

Unit No.	Title of Unit and Contents	No. of Lectures
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**
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**
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**
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.

Title of the Course and Course Code	**Mathematical Methods in Physics (PHY4102)**	**Number of Credits : 04**
On completion of the course, the students will be able to:		
CO1	Describe the concepts of Complex analysis, Fourier and Laplace Transformations.	
CO2	Discuss basic theory of Linear Algebra, Matrix algebra and special functions.	
CO3	Apply mathematical tools, special functions on polynomials to solve physical problems and identify mathematical concepts related to physics to generate solutions.	
CO4	Outline the basic elements of complex analysis and formulate the important integral theorems. Determine the residues of a complex function and use the residue theorem to compute certain types of integrals.	
CO5	Analyze concepts of vector space, matrix algebra and inner product spaces.	
CO6	Construct Fourier series, Fourier and Laplace transforms to solve mathematical problems relevant to the physical sciences.	

Unit No.	Title of Unit and Contents	No. of Lectures
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**
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**
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: 3, 6)*	**12**

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, 7th Edition, Mc-Graw Hill.
2. Complex Variables – Schaum's Outlines Series, 2nd 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- 3rd Edition, Tata Mc-Graw Hill Edition.
5. Matrices and Tensors in Physics, A. W. Joshi, 3rd Edition, New Age International.
6. Mathematical Methods for Physicists – Arfken & Weber – 6th 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.

Title of the Course and Course Code	**Quantum Mechanics (PHY4103)**	**Number of Credits : 04**
On completion of the course, the students will be able to:		
CO1	Recall and outline basic postulates of Quantum Mechanics and Simple stationary state problem.	
CO2	Explain theory of angular momentum, spin matrices and compute Clebsh-Gordan Coefficient.	
CO3	Demonstrate and interpret solutions of Schrodinger equation for stationary state problems.	
CO4	Categorize different applications of approximation methods to solve time dependent and time independent Hamiltonian systems.	
CO5	Compare different approximation methods in terms of validity.	
CO6	Specify problems based on concepts of stationary states, angular momentum and approximation method.	

Unit No.	Title of Unit and Contents	No. of Lectures
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	**12**

	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.	
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**
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. 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).	**12**
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 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, Liboff, 4th Edition, Pearson Education Ltd
10. Principles of Quantum Mechanics, Shankar R. IInd Edition (Plenum, 1994)

Title of the Course and Course Code	**Electronics (PHY4104)**	**Number of Credits : 04**
On completion of the course, the students will be able to:		
CO1	List special and general purpose integrated circuit chips.	
CO2	Explain internal block diagram and working of the ICs.	
CO3	Illustrate the use of dedicated ICs in different circuits.	
CO4	Explain working of circuits using operational amplifiers, timers, PLLs and SMPS.	
CO5	Compare performance parameters of Op-amps and discrete circuits.	
CO6	Design different circuits for dedicated applications.	

Unit No.	Title of unit and Contents	No. of Lectures
I	**Applications of special function ICs:** Study of Timer IC 555: Block diagram, Astable and monostable multivibrator 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 monostable multivibrators are using OPAMP. ***References*:** 1 to 5	**12**
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**
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**
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: 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. SondeSMPS, Inverters, Converters: Gottlieb
6. Digital Principles and Applications: Leach and Malvino
7. Digital Electronics: R. P. Jain
8. Data Converters: B. S. Sonde

Title of the Course and Course Code	**Physics Practical Laboratory - I (General Lab) (PHY4105)**	**Number of Credits : 04**
On completion of the course, the students will be able to:		
CO1	Tabulate the appropriate experimental data accurately and keep systematic record of general laboratory experiments.	
CO2	Discuss the results, findings using the physical scientific framework and learn experimental tools.	
CO3	Interpret professional quality of textual and graphical presentations of laboratory data and computational results.	
CO4	Analyze various experimental results by developing analytical abilities to address real applications.	
CO5	Evaluate possible causes of discrepancy in practical experimental observations and results in comparison to theoretical results.	
CO6	Develop the skills related to betterment in education and research.	

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.

F.Y. M.Sc. Semester II		
Title of the Course and Course Code	**Atoms, Molecules and Solids (PHY4201)**	**Number of Credits : 04**
Course Outcomes(COs) **On completion of the course, the students will be able to:**		
CO1	Describe the theories explaining the structure of atoms and the origin of observed spectra.	
CO2	Explain different types of spectra.	
CO3	Calculate quantities associated with different types of spectra exhibited by atoms, molecules and solids, heat capacities using different models and structural properties.	
CO4	Analyze spectra and identify the effect of magnetic and electric fields on it.	
CO5	Determine the observed dependence of atomic spectral lines on externally applied electric and magnetic fields.	
CO6	Associate electromagnetic spectrum with the rotational, vibrational and electronic spectra of diatomic molecules, and specify the types of transitions based on selection rules. Compare different structures exhibited by materials.	

Unit No.	Title of Unit and Contents	No. of Lectures
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**
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**

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**
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 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 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 7^{th} Edition
5. Solid States Physics, A.J. Dekkar

Title of the Course and Course Code	**Electrodynamics (PHY4202)**	**Number of Credits : 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		
CO1	Describe the mathematical description of electromagnetic phenomena based on basic physical quantities.	
CO2	Apply Maxwell equations in analyzing the nature of electromagnetic field due to time varying charge and current distribution.	
CO3	Illustrate vector potential and electric field of a localized current distribution using multipole expansion problems.	
CO4	Analyze the nature of electromagnetic wave and its propagation through different media and interfaces.	
CO5	Determine charged particle dynamics and radiation from localized time varying electromagnetic sources.	
CO6	Compose relative problems in electrodynamics and resolve them through the fundamental equations.	

Unit No.	**Title of Unit and Contents**	**No. of Lectures**
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.	**12**

	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	
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**
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 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	**12**
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 (Prentice Hall, 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)

Title of the Course and Course Code	**Statistical Mechanics (PHY 4203)**	**Number of Credits : 04**
On completion of the course, the students will be able to:		
CO1	Define and describe the concepts of probability, macrostates and microstates and phase space.	
CO2	Compare and distinguish between different types of particles, statistics and distribute bosons, fermions and classical particles among energy levels.	
CO3	Apply the principles of probability in distribution of particles in different systems and calculate thermodynamic probability.	
CO4	Analyze the different types of statistical distribution of particles.	
CO5	Determine and interpret the probability of any type of events.	
CO6	Formulate and apply the distribution functions to Fermi-Dirac system and Bose-Einstein system.	

Unit No.	Title of Unit and Contents	No. of Lectures
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, Lowville'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**
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**
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,	**12**

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

Title of the Course and Course Code	**Basic Material Science (PHY4204)**	**Number of Credits : 04**
On completion of the course, the students will be able to:		
CO1	Describe the mechanisms and factors affecting the solidification process in metals and alloys.	
CO2	Examine critical awareness of the relevance of phenomenon and laws governing solid solution formation.	
CO3	Analyze different concepts of metallurgical thermodynamics.	
CO4	Determine the phase rules, phase diagrams of single and multi-component systems.	
CO5	Evaluate theory of the atomistic and defect structures, to determine the result in the microstructure and influence the properties of metals and alloys.	
CO6	Develop learning skills and systematic understanding of the crystal structure/property/ processing relationships of metals and alloys.	

Unit No.	Title of Unit and Contents	No. of Lectures
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**
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**
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**
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

Title of the Course and Course Code	**Physics Practical Laboratory – II (Electronics Lab) (PHY4205)**	**Number of Credits : 04**
On completion of the course, the students will be able to:		
CO1	Define the objectives of a given electronics-based experiments.	
CO2	Interpret the appropriate tests of measuring equipment for an experiment.	
CO3	Demonstrate proper use of circuit connections of desired experiment.	
CO4	Analyze the electrical/ electronic parameters of a given instrument and the obtained results.	
CO5	Review the observations taken during the experimentation and tabulate the results.	
CO6	Design and construct the electronic circuit and build-up required instrumentations.	

Sr. No.	Title of the Experiment
1	Diode Pump Staircase generator using UJT
2	Fold back Power Supply
3	Crystal Oscillator & Digital Clock
4	Voltage Control Oscillator using IC-566
5	Function generator using IC -8038
6	Opt coupler 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 A stable Multivibrator
16	Phase locked loop (PLL) application using IC565
17	Decade counter/ Shift register
18	OPAMP as logarithmic amplifier