Davangere University
Shivagangotri, Davangere- 577007

Department of Studies in Physics

Syllabus for M.Sc.

PHYSICS

Choice Based Credit System (CBCS)
With effective from 2020-21

DAVANGERE UNIVERSITY
DEPARTMENT OF PHYSICS
PROCEEDINGS OF THE BoS MEETING

The Board of Studies (BoS) in Physics (P.G.) met on 25th February, 2020 at 11.00 a.m. in the Department of Physics, Davangere University, Shivagangothri, Davangere. The following are the members.

1.	Prof. M.N. KALASAD	-Chairman, BoS
2.	Prof. S.R. INAMDAR	- Member
3.	Prof. H.S. JAYANNA	- Member
4.	Prof. K.M. ESHWARAPPA	- Member
5.	Ms. SHASHIKALA YALAGI	- Member
6.	Ms. SOUMYA S BULLA	- Member

Sl. No.	Points for the Deliberation in the BoS Meeting
1	Revision and updation of P.G. Physics Syllabus (2020-21).
2	Question paper pattern P. G.
3	Ph. D. Guideship.

Resolution:

* The members have discussed the revision and updation of P. G. Physics Syllabus (2020- 21) as per CBCS, question paper pattern (P. G.).

* The syllabus is revised as per the scheme provided by the University.

* Question paper pattern P. G. is discussed and approved for the academic year 2020-2021.

* The board has gone through the details of Dr. Prasanna G. D (Assistant Professor), Dept. of Physics, Davangere University and found that he fulfils the norms of the University to become a research guide. Therefore, board resolved to give a research Guideship to Dr. Prasanna G. D.

Signature of the Committee Members:

1. Prof. M.N. KALASAD
2. Prof. H.S. JAYANNA
3. Prof. K.M. ESHWARAPPA
4. Ms. SHASHIKALA YALAGI
5. Ms. SOUMYA S BULLA

Dr. M. N. Kalasad
Chairman, BoS (P. G.)
Chairman
Board of Studies
Department of Physics
Davangere University
Shivagangotri, Davangere-07

Programme - M. Sc. Physics

Programme Specific Objectives

- To enable students to understand basic and advanced concepts of Physics.
- To impart professional knowledge and practical skills which includes, advanced experiments and computational techniques.
- To develop an ability to analyze and apply the concepts of Physics for solving real life problems.
- To create a conducive environment to sharpen the research skills and thus produce competent and professionally sound graduates.

Program Outcomes

The Master of Science in Physics program enables the students with knowledge, general competence and analytical skills that are essential for education, research, industry and consultancy.

On completion of the programme the student will be able to:

- Think critically and acquire skills through logical reasoning and inculcate the habit of self-learning through principles of Physics.
- Apply the knowledge and comprehend the fundamental theory and experimental concepts of Physics to real life situation.
- Demonstrate highest standards of ethical conduct and professional behavior, critical, interpersonal and communication skills as well as a commitment to life-long learning.
- Take up research to predict cause and effects of physics principles.

Programme Specific Outcomes

On completion of the programme the student will be able to:

- Understand the concepts of Physics and appreciate the diverse phenomenon observed in nature from a small set of fundamental laws.
- Acquire hands on experience to work in applied areas of physical sciences by gaining the knowledge of Physics through theory and practical with good laboratory practices and safety.
- Demonstrate the skills to communicate the acquired knowledge and also, explore the possible applications by research.

Semester	Subject/ Paper Code	Title of the Paper	Instruction Hrs./week	Examination	Internal Assessment	Total Marks	Credits	Examination duration (Hrs.)
				Marks				
SEMESTER-I		**THEORY PAPERS**						
	20PHYC 1.1	Mathematical Methods of Physics-I	4	70	30	100	4	3
	20PHYC 1.2	Classical Mechanics	4	70	30	100	4	3
	20PHYC 1.3	Electrodynamics, Plasma Physics and Optics	4	70	30	100	4	3
	20PHYC 1.4	Electronics	4	70	30	100	4	3
		PRACTICAL PAPERS						
	20PHYL 1.5	Electronics Lab	8	80	20	100	4	4
	20PHYL 1.6	General Physics Lab	8	80	20	100	4	4
	Mandatory Credits: English Language Communication Skill		2	---	---	---	2	---
SEMESTER-II		**THEORY PAPERS**						
	20PHYC 2.1	Mathematical Methods of Physics-II	4	70	30	100	4	3
	20PHYC 2.2	Statistical Mechanics	4	70	30	100	4	3
	20PHYC 2.3	Quantum Mechanics-I	4	70	30	100	4	3
	20PHYC 2.4	Atomic and Molecular Physics	4	70	30	100	4	3
		PRACTICAL PAPERS						
	20PHYL 2.5	Computational Physics lab	8	80	20	100	4	4
	20PHYL 2.6	Optics lab	8	80	20	100	4	4
	Mandatory Credits: Computer Skill		2	---	---	---	2	---
SEMESTER-III		**THEORY PAPERS**						
	20PHYC 3.1	Quantum Mechanics -II	4	70	30	100	4	3
	20PHYC 3.2	General Nuclear Physics	4	70	30	100	4	3
	20PHYC 3.3	General Condensed Matter Physics	4	70	30	100	4	3
	20PHYE 3.4a **20PHYE 3.4b** **20PHYE 3.4c**	Lasers and Optoelectronics Devices. Astrophysics Atmospheric Physics	4	70	30	100	4	3
	20PHYOE 3.5a **20PHYOE 3.5b**	Nanomaterials Introduction to Energy Science	2	40	10	50	2	2
		PRACTICAL PAPERS						
	20PHYL 3.6	General Nuclear Physics Lab	8	80	20	100	4	4
	20PHYL 3.7	General Condensed Matter Physics lab	8	80	20	100	4	4
SEMESTER-IV		**THEORY PAPERS & PROJECT WORK/DISSERTATION**						
	20PHYC 4.1	Experimental Techniques	4	70	30	100	4	3
	20PHYC 4.2a **20PHYC 4.2b**	Condensed Matter Physics (CMP)- I Nuclear Physics (NP)-I	4	70	30	100	4	3
	20PHYC 4.3a **20PHYC 4.3b**	Condensed Matter Physics (CMP)- II Nuclear Physics (NP)-II	4	70	30	100	4	3
	CMP 20PHYE 4.4a Nanophysics 20PHYE 4.4b Solar& Hydrogen Energy 20PHYE 4.4c Polymer Composites 20PHYE 4.4d Biophysics	**NP** 20PHYE 4.4e Accelerating Physics 20PHYE 4.4e Radiation Physics and Dosimetry 20PHYE 4.4e Nuclear Spectroscopy Methods 20PHYE 4.4d Biophysics	4	70	30	100	4	3
		PRACTICAL PAPERS & STUDY TOUR/FIELD VISIT						
	20PHYL 4.5a **20PHYL 4.5b**	Condensed Matter Physics lab Nuclear Physics lab	8	80	20	100	4	4
	20PHYP 4.6	Project Work	8	80	20	100	4	4
	Mandatory Credits: Personality Development		2	---	---	---	2	---
	Total Credits for the Course		136	---	---	2400	104	---

Programme - M. Sc. Physics

Courses having focus on employability/ entrepreneurship/ Skill development

Paper Code	Title of the Paper	Activities with direct bearing on employability/ entrepreneurship/ Skill development
20PHYC 1.1	Mathematical Methods of Physics-I	The knowledge of tensor analysis helps the students with skills to implement stress & strain related forces acting in civil engineering works. Further the understanding of materials helps in coding vector related problems.
20PHYC 1.2	Classical Mechanics	The knowledge of Keppler's law helps the students to develop a skill to calculate the relative distance between the plants. Further the knowledge of Coriolis force helps them in implementing weather forecasting skills.
20PHYC 1.3	Electrodynamics, Plasma Physics and Optics	Felids of Moving charges, radiating systems propagation and interactions of electromagnetic waves, behaviors plasma and interferometer and interference filters.
20PHYC 1.4	Electronics	Student with Op Amp and digital electronics circuits handling skills enables them getting employability in functioning hardware industries.
20PHYL 1.5	Electronics Lab	With the help of the practical skills students can obtain employability in hardware industries.
20PHYL 1.6	General Physics Lab	Students will develop the skills of observing and developing optical devices for practical purpose by gaining employability in Telescope and Microscope designing industries.
Mandatory Credits: English Language Communication Skill		
20PHYC 2.1	Mathematical Methods of Physics-II	Working out the solution of partial differential equations. Group representation, identifying boundary conditions, errors analysis and Monte Carlo Calculations.
20PHYC 2.2	Statistical Mechanics	The knowledge of statistical mechanics helps students develop skills that can infer for the statistical data obtained from various sample sizes.
20PHYC 2.3	Quantum Mechanics-I	Wave function, working out the solution of Schrodinger, wave equation and Operator algebra.
20PHYC 2.4	Atomic and Molecular Physics	The students will develop IR & Raman spectra recording skills and the knowledge of lasers and optical fibers helps them to get employability.
20PHYL 2.5	Computational Physics lab	The knowledge of latex helps students with a skill to compute large documents with ease of access. The understanding of octave helps students in developing coding skills that can give results in short span of time.
20PHYL 2.6	Optics lab	Space dynamics, remotes sensing, concepts stellar interferometer, H-R diagram and Solar system.
Mandatory Credits: Computer Skill		
20PHYC 3.1	Quantum Mechanics -II	Employing approximation methods to various systems and Dirac's Concepts.
20PHYC 3.2	General Nuclear Physics	Magnetic moment by molecular beam experiment, nuclear spin, nuclear reactions -Q values, threshold energy, working neutrons, nuclear forces and particle

		interactions.
20PHYC 3.3	**General Condensed Matter Physics**	The understanding of crystal structure, the behavior of solids helps in developing materials that has high withstanding capacity in its respective practical fields. This in turn helps students' employability in the respective manufacturing industries.
20PHYE 3.4a	**Lasers and Optoelectronics Devices.**	With skills of laser properties and optoelectronic devices students will have employability in the field of developing sensors and security devices.
20PHYE 3.4b	**Astrophysics**	Space dynamics, remote Sensing, concepts stellar interferometer H-R diagram and Solar system.
20PHYE 3.4c	**Atmospheric Physics**	The skills of developing atmospheric models to study the pollution in the atmosphere helps them in getting employability in various instrument and radar systems.
20PHYOE 3.5a	**Introduction to Energy Science**	Students can develop the skills of preparing models to transfer energy. With the knowledge of different energy sources, the students can get employability in various energy harnessing plants.
20PHYOE 3.5b	**Nanomaterials**	The skill of designing materials helps them in developing materials that have practical application which intern helps them with employability in respective industries. Further with good professional experience students can work on entrepreneurship in this field as well.
20PHYL 3.6	**General Nuclear Physics Lab**	The skills of handling Nuclear detector and counter helps them in employing in various energy related jop opportunities.
20PHYL 3.7	**General Condensed Matter Physics lab**	With the skills of determining fermi energy, energy gap and hall coefficients of a material, students can obtain employability in the field of chip manufacturing and material synthesis.
20PHYC 4.1	**Experimental Techniques**	With the understanding of various experimental techniques students can obtain employability in scientific instruments manufacturing units.
20PHYC 4.2a	**Condensed Matter Physics (CMP)- I**	With the understanding of semiconductor properties and optical properties of solids students can obtain employability in the field of semiconductor industries.
20PHYC 4.2b	**Nuclear Physics (NP)-I**	With the knowledge of nuclear detectors students develop the skills of developing and constructing simple pulse shaping circuits.
20PHYC 4.3a	**Condensed Matter Physics (CMP)-II**	Dielectric, ferroelectric properties of Solids, growth of nanomaterials, and studies on imperfections & dislocations.
20PHYC 4.3b	**Nuclear Physics (NP)-II**	Nuclear fission, neutron transport studies, analysis of nuclear rection mechanisms, & nuclear decay.
20PHYE 4.4a	**Nanophysics**	Growth & Characterization techniques and studies of applications.
20PHYE 4.4b	**Solar& Hydrogen Energy**	With the knowledge of solar photovoltaic cells students can gain employability in various industries that are focusing on harnessing solar energy efficiently. Further the understanding of hydrogen power helps them

		getting employability in its respective fields.
20PHYE 4.4c	**Polymer Composites**	On understanding various properties related to the polymer composite materials students can actively engage in an R & D field of material synthesis companies.
20PHYE 4.4d	**Biophysics**	With the understanding of various concepts of biophysics helps students in getting employability in various medical instrumentation and devices manufacturing units.
20PHYE 4.4e	**Accelerating Physics**	With the understanding of construction and working of particle accelerator students can get employed in the field of respective accelerator developing companies.
20PHYE 4.4f	**Radiation Physics and Dosimetry**	On understanding interaction of radiation with matter students develop skills to further their career in the field of research.
20PHYE 4.4g	**Nuclear Spectroscopy Methods**	Ion implantation concepts& experimental methods of positron annellation spectroscopy.
20PHYL 4.5a	**Condensed Matter Physics lab**	Four probe technique, Guy balance handling Measurement of magnetic Susceptibility, coercivity, retentivity, energy loss of ferromagnetic materials V-I Characteristics, magnetoresistance activation energy.
20PHYL 4.5b	**Nuclear Physics lab**	Handling of GRS, GM Counter, Measurement of point energy & randomicity of radioactive decay. Design and implementation of nuclear electronic circuits.
20PHYP 4.6	**Project Work**	Working on specific projects students gain the skills to further their interest in the field of research and in solving various scientific problems.
Mandatory Credits: Personality Development		

DAVANGERE UNIVERSITY

Shivagangothri, Davangere-577 007

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

Master of Science (M.Sc.) in Physics

SYLLABUS: 2020-2021 onwards

Structure, Course Titles, Workload & Credits

Course Number	Theory /Practical's	Workload per Week	*Honors' Degree*		*Master's Degree*			
			Semester-I	Semester-II	Semester-III	Semester-IV		
I	Theory-1	T-4	Mathematical Methods of Physics-I	Mathematical Methods of Physics-II	Quantum Mechanics-II	Experimental Techniques		
II	Theory-2	T-4	Classical Mechanics	Statistical Mechanics	General Nuclear Physics	Condensed Matter Physics (CMP) -I / Nuclear Physics (NP) -I		
III	Theory-3	T-4	Electrodynamics, Plasma Physics and Optics	Quantum Mechanics-I	General Condensed Matter Physics	Condensed Matter Physics (CMP)-II/ Nuclear Physics (NP)-II		
IV	Theory-4	T-4	Electronics	Atomic and Molecular Physics	Elective-I	Elective-II (Student can opt anyone of the following)		
						(For those students who opted for CMP-I and II)		(For those students who opted for NP-I and II)
					3.4a Lasers and Optoelectronic Devices	4.4a Nanophysics		4.4e Accelerator Physics
					3.4b Astrophysics	4.4b Solar and Hydrogen Energy		4.4f Radiation Physics and Dosimetry
					3.4c Atmospheric Physics	4.4c Polymer Composites		4.4g Nuclear Spectroscopy Methods
						4.4d Biophysics		4.4d Biophysics
Course Related Practical's for 100 Marks each	Practical-1	P-8	I-1: Electronics Lab	II-1: Computational Physics Lab	III-1: General Nuclear Physics Lab	*IV.1: Condensed Matter Physics Lab / Nuclear Physics Lab*		
	Practical-2	P-8	I-2: General Physics Lab	II-2: Optics	III-2: General Condensed Matter Physics Lab	*IV.2: Project Work* (Instead of Practical's- for 4 Credits in 4th Sem)*		
TOTAL NO OF HOURS/CREDITS	T-16+ P-16 = 32 Hours		*T-16 Credits + P-16 (8 Credits) = 24 Credits*	*T-16 Credits + P-16 (8 Credits) = 24 Credits*	*T-16 Credits + P-16 (8 Credits) = 24 Credits*	*T-16 Credits + P-16 (8 Credits) = 24 Credits*		

*Project Work - 100 Marks (of Which, 70 Marks for Dissertation and 30 Marks for Presentation at the Viva-Voce Exam)

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

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

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

T-Theory P-Practical

Semester-I
20PHYC 1.1: Mathematical Methods of Physics - I

<u>Course Objectives:</u>

- To demonstrate and understand how to formulate and solve Physics problems using mathematical concepts viz: Vectors, Tensors, Matrices, Special functions and Fourier and Laplace Integral Transforms.

<u>Course Outcomes:</u>

After successful completion of this course, students will be able to:

CO 1. Demonstrate the usage of vectors, coordinate system and tensors.
CO 2. Identify the need of special functions to formulate Physics problems and acquire the ability to solve them.
CO 3. Recognize the type of matrices, their properties and applications, also understand the calculus of residues.
CO 4. Obtain Fourier and Laplace integral transform of given functions and their physical significance.

Semester-I
20PHYC 1.1: Mathematical Methods of Physics - I

Unit-I (16Hrs.)

Vector Analysis in curved coordinates and Tensors: Review of Vector Algebra and Vector Calculus, line integral, volume integral, divergence of a vector function, curl of a vector function & Physical significance. Some important vector functions, Gauss and Strokes theorems, orthogonal coordinates, differential vector operators, special coordinate systems. Circular cylindrical coordinates, Spherical polar coordinates, Application.

Tensors analysis: Algebraic operations of Tensors, Symmetric and anti-symmetric Tensors, (contraction, Direct product, quotient rule), Non-Cartesian tensors. Metric Tensors, Christoffel symbol, covariant differentiation, Tensor differential operator. Applications: Tensors in dynamics of particles, Lagrange equation

Unit-II (16Hrs.)

Special Functions: Series solutions Second order differential equations: power series, Review of Second order differential Equation, Frobenius methods for solving second order linear ODE's. Legendre Function: Legendre equation Legendre Polynomials and their properties, Bessel's Function: Bessel's equation, Bessel's functions and their properties. Laguerre's Function: Laguerre's equation – its properties. Hermite Function: Hermite equation and its solutions. Hermite polynomials and their properties. Beta and Gamma functions.

Unit-III (16Hrs.)

Matrices and Calculus of Residues: Different types of Matrices –Orthogonal, Hermitian, Skew Hermitian, Periodic matrix, Idempotent matrix, Unitary and Normal. Eigen values and Eigen vectors of Matrices. Diagonalization of Matrices. Elements of Complex analysis, Analytic functions, Cauchy – Riemann equations, Cauchy – Riemann equations (polar form), Cauchy' s Integral theorem, Cauchy Integral formula, Taylor expansion, Laurent's expansion, Singularities, Cauchy's Residue Theorem.

Unit-IV (16Hrs.)

Fourier Integral Transforms: Review of Fourier series, Generalized expansion of Fourier series. Fourier integrals, Fourier sine and cosine integrals, properties of Fourier transform, Fourier transform of derivatives. Convolution theorem. Applications of Fourier Transform.

Laplace transforms and their properties, Laplace transforms of derivatives, Convolution theorem, Laplace transform of Integral of f(t), t f(t), Exponential Integral function, f(t)/t, error function, unit step function, impulse function. Inverse Laplace transforms.

References:

1. H.K. DASS and Dr. Rama Verma, **"Mathematical Physics"** 6th Edition S. Chand & Company
2. Sathya Prakash, **"Mathematical Physics"** 6th Revised Edition Sultan Chand and Sons
3. Arfken G.B. and Weber H J (1995), **"Mathematical Methods of Physics"**, 4th Edition, Books Pvt Ltd., India.
4. B. D. Gupta, **"Fundamentals of Mathematical Physics"** 6th Edition Books and Allied (p) Ltd.
5. Chattopadhyay P.K, **"Mathematical Physics"** Wiley Eastern
6. Sharma, **"Matrix methods and vector Spaces in Physics"** PHI
7. G Ramachandran, MS Vidya and Venkataraya, Vijayalakshmi, **"Introduction to vectors, axial vectors, tensors and spinors",** Prakashana Mysuru, 2017.

Semester-I
20PHYC 1.2: Classical Mechanics

Course Objectives:

- To understand the dynamics of system of particles.
- To illustrate the Lagrangian and Hamiltonian formulation.
- To demonstrate the motion of a rigid body.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Understand the concepts of Newtonian Mechanics, Central force field.
CO 2. Apply the Lagrangian equations to simple practical situations.
CO 3. Understand and apply the Hamilton's equations to simple practical situations.
CO 4. Describe Euler's theorem, Euler's angles and Coriolis force.

Semester-I
20PHYC 1.2: Classical Mechanics

Unit-I (16Hrs.)

Newtonian Mechanics: Single and many particle systems - Conservation laws of linear momentum, angular momentum and energy; Motion in central force field: Reduction to one-body problem; equations of motion and first integrals; the Virial theorem; Kepler's laws of planetary motion; Scattering in a central force field: Scattering cross-section; the Rutherford scattering problem.

Unit-II (16Hrs.)

Lagrangian Formulation: Constraints in motion; Generalized co-ordinates; Virtual work and D'Alembert's principle; Lagrangian equations of motion; Velocity dependent potentials and dissipation function; symmetry and conservation theorems; simple applications of Lagrangian formulation. Hamilton variational principle; Lagrangian equations of motion from variational principle; Simple applications; energy function and conservation of energy.

Unit-III (16Hrs.)

Hamiltonian Formalism: Hamilton's equations of motion from Legendre transformations; conservation theorems; Derivation of Hamilton equation from Variational principle; Principle of least action; Simple applications.
Canonical transformations: Poisson brackets - Canonical equations of motion in Poisson bracket notation; Hamilton - Jacobi Equations; Harmonic oscillator problem as an example of the Hamilton-Jacobi method.
Relativistic mechanics: Four-dimensional formulation: four-vectors, four-velocity, four-momentum and four-acceleration; Lorentz co-variant form of equation of motion.

Unit-IV (16Hrs.)

Motion of a Rigid Body and Continuum Mechanics: Moving coordinate systems: rotating coordinate systems; the Coriolis force; effect of Coriolis force on a freely falling particle; Euler's theorem; angular momentum and kinetic energy; the inertia tensor; Euler's equations of motion; Euler's angles; motion of a symmetric top.
Continuum Mechanics: Basic Concepts**,** Equations of continuity and motion - Navier-Stokes equations; Simple applications.

References

1. Classical Mechanics: **H. Goldstein**, (Addison-Wesley, 1950)
2. Introduction to Classical Mechanics: **R.G. Takawale** and **P. S. Puranik** (TMH, 1979)
3. Classical Mechanics: **N. C. Rana** and **P. S. Joag** (Tata McGraw, 1991)
4. Mechanics: **Landau L. D.** and **Lifshitz E. M.** (Addition-Wesley, 1960)
5. Classical Mechanics: **Dr. J.C. Upadhyaya** (Himalaya Publishing House, 2009)

Semester-I
20PHYC 1.3: Electrodynamics, Plasma Physics and Optics

<u>Course Objectives:</u>

- To setup and examine Maxwell's equations and their applicability to electromagnetic field. Understand the Radiating systems.
- To identify and analyze the interaction mechanism of electromagnetic waves and Plasma. Demonstrate and understand the advanced theory and application of interference and diffraction phenomena.

<u>Course Outcomes:</u>

After successful completion of this course, students will be able to:

CO 1. Identify the various system of charges, formulate Maxwell equations in terms of electromagnetic potential and understand the theory of radiation.

CO 2. Illustrate various radiating systems and identify the need of tensor formulation and represent electromagnetic field vectors in tensor form.

CO 3. Understand the interaction mechanism of electromagnetic waves in different media and relate to practical situation.

CO 4. Understand the advanced concepts of interference and diffraction phenomena and their applications.

Semester-I
20PHYC 1.3: Electrodynamics, Plasma Physics and Optics

Unit-I (16Hrs.)

Electric Multipole Moments: The electric dipole and multipole moments of a system of charges. Multipole expansion of the scalar potential of an arbitrary charge distribution.
Potential formulation: Maxwell equations in terms of electromagnetic potentials. Gauge transformations. The Lorentz, Coulomb and radiation gauges.
Fields of moving charges and radiation: The retarded potentials. The Lienard-Wiechert potentials. Fields due to an arbitrarily moving point charge. The special case of a charge moving with constant velocity.

Unit-II (16Hrs.)

Radiating systems: Radiation from an oscillating dipole. Power radiated by a point charge—Larmor formula. Lienard's generalization of Larmor formula. Energy loss in bremsstrahlung and linear accelerators. Radiation reaction—Abraham-Lorentz formula.
Relativistic electrodynamics: Charge and fields as observed in different frames. Covariant formulation of electrodynamics-Electromagnetic field tensor-Transformation of fields - Field due to a point charge in uniform motion-Lagrangian formulation of the motion of charged particle in an electromagnetic field.

Unit-III (16Hrs.)

Electromagnetic waves: Monochromatic plane waves- velocity, phase and polarization. Propagation of plane electromagnetic waves in (a) conducting media (b) non conducting medium and (c) ionized gases. Reflection and refraction of electromagnetic waves—Fresnel formulae for parallel and perpendicular components. Brewster law. Normal and anomalous dispersion—Clausius-Mossotti relation. Poynting theorem.
Plasma physics: Quasi neutrality of a plasma-plasma behavior in magnetic fields, Plasma as a conducting fluid, magneto hydrodynamics, magnetic confinement, Pinch effect, instabilities, Plasma waves.

Unit-IV (16Hrs.)

Interference: General theory of interference of two monochromatic waves. Two-beam and Multiple-beam interference with a plane-parallel plate. Fabry-Perot interferometer—etalon construction, resolving power and its application. Interference filters.
Diffraction: Integral theorem of Helmholtz and Kirchoff. Fresnel-Kirchoff diffraction formula—conditions for Fraunhofer and Fresnel diffraction. Fraunhofer diffraction due to a circular aperture.

References:

1. Griffiths D.J., **"Introduction to electrodynamics",** 5th Edn., Prentice-Hall of India, New Delhi,2006.
2. Jackson J.D., **"Classical electrodynamics"**, 2nd Edn., Wiley-Eastern Ltd, India, 1998.
3. Born M. and Wolf E., **"Principles of optics"**, 6th Edn., Pergamon Press, Oxford, 1980.
4. Laud B.B., **"Electromagnetics",** Wiley Eastern Limited, India, 2000.
5. Matveev A.N., **"Optics",** Mir Publishers, Moscow, 1988.
6. Grant I.S. and Phillips W.R., (1975) **"Electromagnetism"**, John Wiley and Sons Ltd.
7. Lorrain P. and D. Corson, (1986) **"Electromagnetic Fields and Waves"**, CBS.
8. Paul Bellan, (2006) **"Fundamentals of Plasma Physics"**, CUP.
9. Pramanik, **"Electromagnetism"**, PHI.
10. Bittencourt J. A., (2004) **"Fundamentals of Plasma Physics",** Springer.
11. Choudhuri A. R., (1998) **"The Physics of Fluids and Plasmas",** Cambridge, UP.

Semester-I
20PHYC 1.4: Electronics

<u>Course Objectives:</u>

- To impart fundamental knowledge of operational amplifier and their application in various electrical circuits and devices,
- To demonstrate the designing of various circuits using linear ICs to use them in various application.
- To understand the basics of digital electronics and then design combinational and Sequential logic circuits.

<u>Course Outcomes:</u>

After successful completion of this course, students will be able to:

CO 1. Describe the characteristics of an ideal and practical operational amplifier.

CO 2. Design and demonstrate the linear and non-linear applications of an operational amplifier like differentiator, integrator, amplifier, comparators, multivibrator and rectifiers.

CO 3. Design filters and interface circuits using linear ICs.

CO 4. Understand the different building blocks in digital electronics using logic gates and their applications in adders, Multiplexers, flip flops, shift registers, counters, as combinational and sequential logic control circuits.

Semester-I
20PHYC 1.4: Electronics

Unit-I (16Hrs.)

Operational Amplifier: Basic Information of Op-Amp, Characteristics of an ideal operational amplifier - comparison with 741, IC Op-Amp 741, open loop Op-Amp configurations – Differential, inverting and non-inverting amplifiers (qualitative).

Op-Amp as a feedback amplifier – negative feedback, feedback configurations, voltage-series feedback amplifiers – closed loop voltage gain, input & output impedance, bandwidth and voltage follower, differential amplifiers.

Unit-II (16Hrs.)

Applications of an Operational Amplifier:

Linear Applications – DC & AC amplifiers, Summing, Scaling, Averaging amplifiers, Ideal and Practical Differentiator, Integrator, V-I and I-V convertors.

Non- Linear Applications- Comparators, Wave generators, 555 timer - Astable & Monostable Multivibrator, Schmitt Trigger – IC 741 & 555 timer, Positive and negative clippers, Positive and negative clampers.

Unit-III (16Hrs.)

Filters and Interface Circuits: Active Filters: First order Low-Pass & High-Pass filters, Second order Low-Pass & High-Pass filters, First order Band –Pass Filters, Second order Band-Pass Filters, Narrow Band and Wide Band-Pass Filters, All pass filters.

Interface Circuits: D/A Converters R-2R Ladder Converter, Weighted Register DAC, Accuracy & Resolution, A/D Converters- Successive Approximation A/D Converter, Dual Slope A/D Converter, Accuracy & Resolution.

Unit-IV (16Hrs.)

Boolean algebra and Logic Gates: Definitions, Review of Gates, Boolean laws and theorems, Boolean functions, canonical and standard forms, the Karnaugh map method of simplification of Boolean functions. Two-Three-Four variable k-maps, SOP & POS simplification, NAND and NOR implementation, don't care conditions, The Tabulation Method, determination and selection of prime implicates.

Combinational and Sequential logic: Introduction, design procedure, Adders – binary parallel adder, decimal adder, Subtractor, Code conversion, decoders and multiplexers; Flip Flops, types-SR, JK, D & T, triggering of Flip Flops, Flip flop excitation tables,

Registers and types, Counters, Synchronous and Asynchronous Counters

References:

1. Ramakanth A Goyakwad, **"Op-Amp and Linear Integrated Circuits"**: PHI
2. M. Morris Mono, **"Digital Logic and Computer Design"**, PHI
3. Albert Malvino, David J Bates, **"Electronics Principals"**
4. Floyd T L, **"Digital Fundamentals"**, 7th edn. (Pearson Education Asia 2002)
5. S L Kakani, K C Bhandari, **"Electronic Devices and Circuits"**
6. A P Malvino and D P Leach, **"Digital Principles and Applications"**, TATA McGraw Hill,
7. Robert F. Coughlin and Fredericks, Driscoll, **"Operational Amplifiers and Linear Integrated Circuits"**: PHI
8. D Chattopadhya, **"Electronics-Fundamentals and Applications"**,

Semester-I
20PHYL 1.5: Electronics Lab

List of Experiments

(At least Eight of the following to be performed)

1. Study the performance Op-Amp in differential mode and common mode and hence find CMRR and Slew rate.
2. Design and construct the practical differentiator and study its performance and compare the given capacitance value.
3. Design and construct the practical integrator and study its performance and compare the given capacitance value.
4. Construct second order High Pass filter and to determine cut-off frequency.
5. Construct second order Low Pass filter and to determine cut-off frequency.
6. Construct Astable Multivibrator and hence find its duty cycle using (IC-741/555).
7. Study of Op-Amp as an inverting and non-inverting amplifier.
8. Design and construct summing and log amplifier using Op-Amp.
9. Design and construct scaling and averaging using Op-Amp.
10. Design and construct comparator and subtractor using Op-Amp.
11. Realization of all gates using NAND gates (IC-7400).
12. Realization of all gates using NOR gates (IC-7402).
13. Verification of Half and Full adder.
14. Verification of coding and decoding.
15. Verification of flip-flops (JK, D, T).

(Additional Experiments may be added with BOS approval)

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

Semester-I
20PHYL 1.6: General Physics Lab

List of Experiments

(At least Eight of the following to be performed)

1. Determination of inversion temperature of Cu-Fe thermocouple.
2. Determine the velocity of ultrasonic sound though liquid media and determining the Vander walls constant.
3. Determination of mode constant of vibration of fixed free bar.
4. Frank-Hertz experiment- determine the excitation potential of Ar gas.
5. Thermal conductivity of good conductor by Forbes method.
6. Determination of filament work-function in vacuum and verification of Richard and Dushman equation.
7. Measurement of low resistance using Kelvin Double bridge.
8. Analysis of rotation vibration spectrum of a diatomic molecule (HCl/HBr).
9. Determination of Plank constant using photocell.
10. Determination of energy gap of thermistor.
11. Determination of Hartmann's constants and hence to verify the Hartmann's formula.
12. Determination of absorption coefficient of $KMnO4$ solution by transmission method.
13. Verification of law of intermediate metals for thermo emf.

(Additional Experiments may be added with BOS approval)

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

Semester-II
20PHYC 2.1: Mathematical Methods of Physics - II

Course Objectives:

- To demonstrate how to setup and solve Partial Differential Equations (PDE) for a given problem. Identify the necessity of groups and their representation. Classify and trace the sources of errors and evaluate the errors. Illustrate the Monte Carlo Method of calculations.

- To make the students familiar with the applications of Partial Differential Equations, Green functions, Error Analysis and Monte Carlo Method of Calculations and group theory.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Classify PDEs, apply analytical methods and physically interpret the solutions.

CO 2. Demonstrate the representation of groups.

CO 3. Use of Green functions to solve partial differential equations.

CO 4. Classify the types of errors and perform algebra of errors, identify the given problem has stochastic nature or not and perform Monte Carlo calculations of simple problems.

Semester-II
20PHYC 2.1: Mathematical Methods of Physics - II

Unit-I (16Hrs.)

Partial Differential Equations: Classification of PDE's. System of surface and characteristics, Examples of Hyperbolic, Parabola and Elliptic Equations. Solution by the direct integration, method of separation of variables. The wave equation, Laplace equation, Heat conduction equations and their solutions in Cartesian coordinate system in one, two and three dimensions, Plane Polar coordinates, Cylindrical polar and Spherical polar coordinates, Spherical harmonics and their properties.

Unit-II (16Hrs.)

Group Theory: Definition and examples of Groups. Symmetry Group of squares, Multiplication table, Classes and subgroups, Cyclic Groups, Direct product of Groups, Isomorphism and Homomorphism, Permutation Group, Reducible and irreducible Group representations. Schur's Lemmas., Topological and Lie Groups, Connectedness and Compactness, Group generators. Representation of a continuous Group. SO (2), SO (3) and SU (2) Groups and their representation, The Lorentz Group.

Unit-III (16Hrs.)

Green's functions and Integral equations: Boundary value problems, Sturm-Liouville theory. Green functions for one, Two- and Three-dimensional equations, Eigen function expansion of Green's functions, Fred Holm and Volterra type integral equations. Solution of equation with separable Kernals, Neumann series method – examples, Non – homogeneous integral equations.

Unit-IV (16Hrs.)

Theory of Errors and Curve Fitting:

Error Analysis: Definition, Classification of errors, Propagation of errors – addition, subtraction, multiplication, division, exponentials, logarithm. Deviation from mean value, standard deviation. **Least Square Fitting:** Principle of least square, method of least squares, change of origin and scale, to fit up the parabola.

Monte Carlo Method of Calculations: Random variables, discrete random variables, continuous random variables, probability density function, discrete probability density function, continuous probability distributions, cumulative distribution function, accuracy and precision, law of large number, central limit theorem, random numbers and their generation, tests for randomness, inversion random sampling technique including worked examples, integration of simple 1-D integrals including worked examples.

References:

1. H.K. DASS and Dr. Rama Verma, **"Mathematical Physics"** 6th Edition S. Chand & Company
2. Sathya Prakash, **"Mathematical Physics"** 6th Revised Edition Sultan Chand and Sons
3. Arfken G.B. and Weber H J (1995), **"Mathematical Methods of Physics"**, 4th Edition, Books Pvt Ltd., India.
4. B. D. Gupta, **"Fundamentals of Mathematical Physics"** 6th Edition Books and Allied (p) Ltd.
5. Chattopadhyay P.K, **"Mathematical Physics"** Wiley Eastern
6. Sharma, **"Matrix methods and vector Spaces in Physics"** PHI
7. G Ramachandran, MS Vidya and Venkataraya, Vijayalakshmi, **"Introduction to vectors, axial vectors, tensors and spinors"**, Prakashana Mysuru, 2017.
8. Athanasios Papoulis and S. Unnikrishna Pillai, **"Probability, Random Variables, and and Stochastic Processes"**, FOuth Edition, McGraw Hill.
9. Malvin H. Kalos and Paula A. Whitelock, **"Monte Carlo Methods"**, Second edition, Wiley-VCH, Verlag GmbH & Co. KGaA.

Semester-II
20PHYC 2.2: Statistical Mechanics

<u>Course Objectives:</u>

- To understand the need of statistical approach in Physics.
- To identify the application of statistical approach in various branches of Physics. Understand the nature and characteristics of various statistical laws. Comprehend on how statistical mechanics deals with randomness problems in physics.

<u>Course Outcomes:</u>

After successful completion of this course, students will be able to:

CO 1. Understanding the need of statistical approach in physics by formulation and interpretation of various statistical laws.

CO 2. Explore statistical ideas in classical field and its applications.

CO 3. Solve Quantum Physics problems employing statistical ideas.

CO 4. Apply statistics in more complex randomness problems in Physics viz; Transition probability, Brownian motion and Fluctuating forces.

Semester-II
20PHYC 2.2: Statistical Mechanics

Unit-I (16Hrs.)

Thermodynamic Preliminaries: Introduction, some definitions, Zeroth law, First Law, Thermodynamic process, Molar specific heat C_p and C_v, Reversible and Irreversible process, Second law, Entropy, Thermodynamic function and Maxwell relation, thermodynamic potentials, Thermodynamic equilibria.

Statistical Mechanics: Statistics and probability, Microstate and Macrostate, phase space, Liouville's theorem, Ensemble Density distribution in phase space, Basic postulates, probability calculations, density of states, Quasi static work done by pressure, Equilibrium condition and constraints, Reversible and Irreversible process, Distribution of energy between system in equilibrium.

Unit-II (16Hrs.)

Classical Statistics: Thermal interaction, Heat reservoir, Microcanonical ensemble, System in contact with heat reservoir, Application of canonical distribution, Calculation of mean values, Connection with thermodynamics, Grand canonical ensemble.

Application of Classical Statistical Mechanics: Partition function and their properties, Thermodynamic quantities of ideal monoatomic gas, Gibbs paradox, Validity of the classical approximation, The Equi-partition theorem and its applications, Specific heats of solids, Paramagnetic susceptibility, Maxwell velocity distribution.

Unit-III (16Hrs.)

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

Unit-IV (16Hrs.)

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

References:
1. Satya Prakash., (2020) **"Statistical Mechanics"**, KNRN.
2. Reif F., (1985) "**Fundamentals of Statistical and Thermal Physics"**, McGraw Hill.
3. Gopal E. S. R., (1976) "**Statistical mechanics and properties of Matter"**, Macmillan, Indian.
4. Patria R. K., (1972) "**Statistical mechanics"**, 2nd Edition, Pergamon Press.
5. Salinas S. R. A., (2009) "**Introduction to statistical Physics"**, Springer International.
6. Laud B.B., (2007) "**Fundamental of Statistical Mechanics"**, NAI publisher
7. Landau and Lifshitz, (1974) "**Statistical Physics"**, Pergamon Press, Oxford.
8. Srivastava and Ashok, "**Statistical Mechanics"**, PHI.

Semester-II
20PHYC 2.3: Quantum Mechanics - I

Course Objectives:

- To understand the concepts in quantum mechanics. Formulate Quantum Physics laws. Illustrate the applications of quantum mechanics in various one-dimensional problems of different potential field. Demonstrate the construction and solving the quantum mechanical models.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Understand de-Broglie hypothesis, uncertainty principle and derive Schrödinger time dependent and time independent equation along with solving the problems.

CO 2. Setup the Schrödinger equation to the various potential field and able to solve by various approach.

CO 3. Illustrate operator algebra in Quantum Mechanics.

CO 4. Explain the concepts of angular momentum and distinguish the identical particles.

Semester-II
20PHYC 2.3: Quantum Mechanics - I

Unit I   **(16Hrs.)**
Fundamentals of Quantum Mechanics: Failures of Classical mechanics and origin of Quantum Mechanics. Wave Aspect of Particle: de Broglie's hypothesis, Quantum and classical views of particle and waves, wave particle duality, Quantization rules, Gaussian Wave packets, phase velocity and group velocity. Uncertainty: Principle, Mathematical proof of uncertainty relation, application and illustrative examples. Complementarity Principle. superposition principle, Observables and operators, The state of system: Expectation values, Equation of motion of matter waves: time evolution of a system, time dependent and time independent Schrodinger equation, Schrodinger equation in momentum space. The Ehrenfest's Theorem.

Unit II   **(16Hrs.)**
One Dimensional Problem :The Free Particle, Particle in a Box: Energy eigen value and Eigen functions, Potential Step: Reflectance and Transmittance Co-efficient for $E>V_0$ and $E<V_0$ cases, Rectangular Potential Barrier: Reflectance and Transmittance Co-efficient, Quantum tunneling effect, application of Barrier Penetration (α-decay), Infinite and finite square well potential: Energy eigen value and Eigen functions, Harmonic Oscillator: Energy eigenvalues, Energy eigen states, Recurrence relation, Uncertainty relation, matrix representation of Linear Harmonic Oscillator (LHO) in operator method.

Unit III   **(16Hrs.)**
General Formalism: The Hilbert space, Dimension and basis of a vector space, Dirac's notation, Operators: Hermitian Adjoint, Commutator algebra, Uncertainty relation between two operators, Eigen values and eigen vectors of an operator, Unitary transformation, Schwarz inequality, Matrix representation of Kets, Bras and Operators. Basic postulates of Quantum Mechanics, Position Representation, momentum Representation, parity operator and matrix and wave mechanics. Virial theorem.

Unit IV   **(16Hrs.)**
Angular Momentum: Orbital Angular Momentum: general formalism and matrix representation, Eigen functions of $\hat{L}^2$ and $\hat{L}_z^2$. Spin Angular Momentum: General theory of Spin, Spin ½ and Pauli matrices. Total Angular Momentum: Eigen values of $\hat{J}^2$ and $\hat{J}_z$, Eigen value of $\hat{J}_+$ and $\hat{J}_-$, Eigen functions of $\hat{J}_x$ and $\hat{J}_y$, Addition of Angular Momenta: Clebsch- Gordan Coefficients for $j_1 = \frac{1}{2}$ and $j_2 = \frac{1}{2}$. Identical Particles and Spin: Symmetric and antisymmetric wave functions, Pauli exclusion Principle, Distinguishability of identical Particles. Commutation relation.

Reference Books:
1. N. Zettili, **"Quantum Mechanics, Concepts and Applications"** John Wiley and Sons, Ltd. 2nd ed. 2009.
2. Satya Prakash, **"Advanced Quantum Mechanics"** KNRN, 5th ed. 2019.
3. David j. Griffiths, **"Introduction to Quantum Mechanics"** Pearson Education,2nd ed.2005.
4. Ghathak and Lokanathan, **"Principles of Quantum Mechanics"**, Macmillan,2004.
5. Merzbacher E, "**Quantum Mechanics"** John Wiley and Sons,1999.
6. P. M. Mathews and K. Venkatesan, **"A Textbook of Quantum Mechanics"**, McGraw Hill Education Pri. Ltd. New Delhi,2nd ed.2010.

Semester-II
20PHYC 2.4: Atomic and Molecular Physics

Course Objectives:

- To examine the validity and applicability of various atomic models to understand the atomic spectra.
- To understand the IR and Raman spectroscopic techniques.
- To explain the construction and working of different type of lasers.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Understand the concepts of atomic models, Coupling schemes, Stark and Zeeman effect.

CO 2. Explain different diatomic rotors, oscillators with their rotational and vibrational spectra.

CO 3. Demonstrate the IR, Raman spectroscopy techniques to determine the various molecular structures. Also, analyze the electronic coarse structure of molecules.

CO 4. Outline the properties and applications of lasers and optical fibers.

Semester-II
20PHYC 2.4: Atomic and Molecular Physics

Unit-I (16Hrs.)

Atomic Physics: Brief review of atomic models of Bohr and Sommerfeld; Determination of spectral terms; LS and JJ coupling schemes: derivation of interaction energies, Lande interval rule; One electron atom: energy shifts due to relativistic corrections to kinetic energy, Spin-orbit Interaction, Darwin term; fine structure splitting in hydrogen atom, fine structure of spectral lines, intensities of structure lines, Lamb shift; Hyperfine structure of spectral lines: Isotope effects, Nuclear spin and hyperfine splitting, Intensity ratio and determination of Nuclear spin. Interaction with the external fields: Zeeman effect (Normal and anomalous); Paschen-Back effect; Stark effect.

Unit-II (16Hrs.)

Rotational and Vibrational Spectra of Diatomic Models: General features of IR and Raman spectra of diatomics; classical and quantum theory of Raman scattering; Diatomic molecule as a rigid rotator: Energy levels, eigen functions, selection rules, intensities of spectral lines, effect of isotopic substitution, IR and Raman spectra; Diatomic molecule as a non-rigid rotator: Energy levels, eigen functions, selection rules, IR and Raman spectra.
Energy levels, eigen functions, selection rules, IR and Raman spectra of a diatomic molecule as a (a) harmonic oscillator, (b) anharmonic oscillator, (c) vibrating rotator.

Unit-III (16Hrs.)

Vibrational IR, Raman and Electronic Spectrometry
Types of molecular vibrations; Fourier Transform instruments; Dispersive instruments; advantages of FT spectrometers; Raman Spectroscopy: Intensity of Raman bands; depolarization ratio; Instrumentation, dispersive and FT-Raman spectrometes; applications.
The Born-Oppenheimer approximation; Vibrational Coarse Structure of electronic spectra: Intensity of Vibrational-Electronic Spectra, The Frank-Condon Principle; Dissociation energy; Rotational Coarse Structure of electronic spectra; The Fortrait Diagram; Predissociation.

Unit-IV (16Hrs.)

Laser and Fiber Optics: Coherence of light, Spatial and temporal coherence, Einstein's co-efficient: Spontaneous and stimulated emission, Idea of light amplification, Characteristics of a laser beam, Threshold condition for laser oscillation; He-Ne lasers, Ruby laser: construction and working, energy level diagram; Applications of lasers
Fiber Optics: Mechanism of light propagation in a fiber wave guide - Numerical aperture, acceptance angle, total internal reflection; Types of optical fibers – single and multimode fibers; Transmission characteristics of optical fibers - Attenuation and Dispersion in fibers.

References:

1. Atkins P. W., and Friedman R.S., (2004) **"Molecular Quantum Mechanics"**, 3rd Edition, Oxford Press, (Indian Edition)
2. Banwell and McCash, (1998) **"Fundamentals of Molecular Spectroscopy"**, Tata McGraw Hill.
3. Bransden and Joachain, (2004) **"Physics of Atoms and Molecules"**, 2nd Edition, Pearson Education.
4. Ghatak and Tyagarjan, (2004) **"Optical Electronics"**, Cambridge, Press.
5. Herzberg G., (1950) **"Spectra of Diatomic Molecules"**, Van Nostrand.
6. Hollas J. M., (1998) **"Modern Spectroscopy"**, John Wiley.
7. Kar R. K., (2008) **"Optics (Classical and Quantum) "**, Books and Allied.
8. Klein M. V., and Furtak T.E., (1986) **"Optics"**, John Wiley.
9. Laud B. B., (1991) **"Lasers and Nonlinear Optics"**, Wiley- Eastern Ltd.
10. Nambiar, (2004) **"Lasers"**, New Age International.
11. Silfvast (1998) **"Lasers"**, Cambridge Press.
12. White H. E., **"Introduction to Atomic Spectra"**, McGraw Hill.
13. Rajkumar., **2014 "Atomic and molecular spectra, lasers", 5th Edition**

Semester-II
20PHYL 2.5: Computational Physics Lab

List of Experiments

1. **Linux operating system basics (4 sessions):**
   Login procedure; creating, deleting directories; copy, delete, renaming files; absolute and relative paths; Permissions—setting, changing; Using text editor.
2. **Scientific text processing with LATEX.**
   Typeset text using text effects, special symbols, lists, table, mathematics and including figures in documents.
3. **Using the plotting program GNUPLOT (2 sessions):**
   Plotting commands; To plot data from an experiment and applying least-squares fit to the data points. Including a plot in a LATEX file.
4. **Using the mathematics package OCTAVE (2 sessions):** To compute functions, matrices, eigenvalues, inverse, roots.
5. **Programming in C**
   a. Compute the roots of a quadratic equation.
   b. Generate Pascal's triangle.
   c. To add two m× n matrices.
   d. To find the sum and average of a data stored in a file.
   e. Linear least-squares fitting to data in a file.
   f. To find the trajectory of a projectile shot with an initial velocity at an angle. Also, find the maximum height travelled and distance travelled. Write the trajectory data to a file specified and plot using Gnu plot.

(Additional Experiments may be added with BOS approval)

Semester-II
20PHYL 2.6: Optics Lab

List of Experiments

(At least Eight of the following to be performed)

1. Determination of the Size of the Lycopodium Particles by Diffraction Haloes.
2. Verification of Fresnel's Law of Reflection from plane dielectric surface.
3. Determination of Bire fringes using Babinet Compensator.
4. Verification of Brewster's law by polarisation.
5. Study of elliptically polarized light.
6. Determination of thickness of mica sheet using Edser Butler method.
7. Determination of wavelength by using Fabry-Perot Etalon.
8. Determination of divergence of laser beam.
9. Determination of slit width using young's single slit interference method.
10. Verification of Malus law.
11. Determination of wavelength of sodium light by Michelson's Interferometer.
12. Determination of Elastic Constant of a Material of Glass plate by Cornu's Interference method.

(Additional Experiments may be added with BOS approval)

Semester-III
20PHYC 3.1: Quantum Mechanics - II

Course Objectives:

- To understanding of advanced concepts in quantum mechanics by solving relevant physical problems.
- To illustrate the approximation methods for solving Quantum mechanical problems and their applications to physical situations.
- To understand the basics concepts in relativistic Quantum mechanics.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Apply the advanced concepts to solve three dimensional problems of Quantum mechanics.

CO 2. Identify the need and use of approximation methods (time independent).

CO 3. Employ the approximation methods to solve the Quantum mechanical problems (time dependent).

CO 4. Derive the Klein Gordan equation and explain the Dirac's concepts on spin of electron and negative energy states.

Semester-III
20PHYC 3.1: Quantum Mechanics - II

Unit I **(16Hrs.)**

Three- Dimensional Problems: Three- Dimensional Problems in Cartesian Coordinates: Free Particle, Box Potential, Harmonic Oscillator. Three- Dimensional Problems in Spherical Coordinates: Central potential, Free Particle, Square well Potential, Rigid rotator: Energy eigen value and Eigen functions. Isotropic Harmonic Oscillator: Energy eigen value and Eigen functions. The Hydrogen atom: Energy eigen value and Eigen functions.

Unit II: **(16Hrs.)**

Approximation Methods-I: Time Independent Perturbation Theory: Non-degenerate Perturbation Theory: Perturbed Harmonic Oscillator, First order Zeeman effect. Degenerate Perturbation Theory: First Order Stark Effect. Variation Method: Zero-point energy of 1D Harmonic Oscillator, Ground state of helium. The WKB Method: Connection formulae for barrier penetration, Probability of Penetration of a Barrier, Theory of α- Decay, Potential well.

Unit III: **(16Hrs.)**

Approximation Methods-II: Time Dependent Perturbation Theory, Physical Interpretation, Adiabatic Approximation, sudden Approximation, A Charged particle in an Electromagnetic field, theory of radiation, Einstein transition probabilities and selection rules. Scattering Theory: Scattering and Cross section, scattering amplitude, Born approximation, scattering by coulomb field, Scattering by square well potential, Scattering by Gaussian potential, Partial wave analysis for Plane wave and Spherical wave, Partial wave analysis for elastic scattering. scattering by coulomb field by method of partial waves.

Unit IV: **(16Hrs.)**

Relativistic Quantum Mechanics: Klein Gordan Equation for free particle and limitations of Klein Gordan Equation, Klein Gordan Equation in electromagnetic field, Dirac's Relativistic equation, Properties of Dirac's matrices, Dirac's Relativistic equation and free particle solution of a Dirac particle, Probability density and current density, charged particle in Electromagnetic field, spin of electron in Dirac theory. Dirac hole theory (Negative energy states).

References:
1. N. Zettili, **"Quantum Mechanics, Concepts and Applications"** John Wiley and Sons, Ltd. 2nd ed. 2009.
2. Satya Prakash, **"Advanced Quantum Mechanics"** KNRN, 5th ed. 2019.
3. David j. Griffiths, **"Introduction to Quantum Mechanics"** Pearson Education,2nd ed.2005.
4. Ghathak and Lokanathan, **"Principles of Quantum Mechanics"**, Macmillan,2004.
5. Merzbacher E, "**Quantum Mechanics"** John Wiley and Sons,1999.
6. P. M. Mathews and K. Venkatesan, **"A Textbook of Quantum Mechanics"**, McGraw Hill Education Pri. Ltd. New Delhi,2nd ed.2010.

Semester-III
20PHYC 3.2: General Nuclear Physics

Course Objectives:

- To demonstrate and understanding of basic properties of nuclei and nuclear structure and enable the students to relate theoretical predictions and measurement results.
- To critical evaluation of results in nuclear and particle physics and to understand the fundamentals of nuclear reactors.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Explain the basic properties of nuclei and nuclear structure and relate the theoretical predictions and measurements results

CO 2. Understand various nuclear reactions and decay modes.

CO 3. Demonstrate the knowledge of basics of nuclear reactors and appreciate the role nuclear reactors in nation building.

CO 4. Illustrate the nuclear forces with examples and make critical evaluation of particle interactions and families.

Semester-III
20PHYC 3.2: General Nuclear Physics

Unit-I (16Hrs.)

Properties of the Nucleus: Nuclear radius-determination by mirror nuclei, mesic X-rays and electron scattering methods. Nuclear moments-spin, magnetic dipole moment. Relation between J and _ on the basis of single particle model. Determination of nuclear magnetic moment by molecular beam experiment. Electric quadrupole moment.

Nuclear models: Liquid drop model-Weissacker's formula and its application to (i) stability of isobars and (ii) fission process. Shell model-single particle potentials, spin-orbit coupling. Magic numbers. Fermi gas model-well depth, level density and nuclear evaporation.

Unit-II (16Hrs.)

Nuclear Reactions: Nuclear reaction cross section, Q-values. Threshold energy. Reactions induced by proton, deuteron and particles. Photodisintegration.

Nuclear Decay Modes: Beta decay: Beta ray spectrum, Pauli neutrino hypothesis, mass of the neutrino from beta ray spectral shape, Fermi theory of beta decay, Kurie plot, ft-values and forbidden transitions. Methods of excitation of nuclei. Nuclear isomerism. Mossbauer effect (qualitative only). Auger effect.

Unit-III (16Hrs.)

Interaction of Nuclear Radiation with Matter and Detectors: Energy loss due to ionization for proton-like charged particles. Bethe-Bloch formula. Range-energy relations. Ionization and radiation loss of fast electrons (Bremsstrahlung) (qualitative only). Interaction of gamma and X-rays with matter. Brief description of NaI (Tl) gamma ray spectrometer. Boron tri-fluoride counter.

Nuclear Reactors: Condition for controlled chain reactions, slowing down of neutrons, logarithmic decrement in energy, Homogeneous spherical reactor, Critical size. Effect of reflectors. Breeder reactor (Qualitative discussion).

Unit-IV (16Hrs.)

Nuclear Forces and Elementary Particles: General features of nuclear forces: General features of nuclear forces; spin dependence, charge independence, exchange character etc. Meson theory of nuclear forces- Yukawa's theory. Properties of pi mesons, charge, isospin, mass, spin and parity, decay modes, meson resonances.

Particle Interactions and Families: Conservation laws—classification of fundamental forces and elementary particles. Associated particle production, Gellmann-Nishijima scheme, strange particles. CP violation in Kaon decay. Symmetries—Eight-fold way symmetry, quarks and gluons. Elementary ideas of the standard model.

References:

1. Krane K.S., **"Introductory nuclear physics"**, Wiley, New York, 1987. (Unit 1. Chapter 16 page 605-610.)
2. Tayal D.C., **"Nuclear Physics"**, Himalaya Publishing House, New Delhi, 2012 (Unit 1. Chapter 1, Page 6-14. Page 30- 35, 40-49. Chapter 9. Page 355-369. Chapter 10. Page 401-411.)
3. Ghoshal S.N., **"Nuclear physics"**, S.Chand and Company, Delhi, 1994. (Unit 2: Chapter 5 page 137-155, Chapter 6 page 187-204, 222, 262, Chapter 13, page 647-651, chapter 15, page 717-721.)
4. Wong S.S.M., **"Introductory nuclear physics",** Prentice Hall of India, Delhi, 1998.
5. Khanna M.P., **"Introduction to particle physics",** Prentice Hall of India, Delhi, 2008.
6. Kapoor S.S. and Ramamoorthy V., **"Nuclear radiation detectors",** Wiley Eastern, Bangalore,2007.

Semester-III
20PHYC 3.3: General Condensed Matter Physics

Course Objectives:

- To demonstrate and understanding of Crystal Structure, Bragg's law for crystal structure analysis,
- To discuss the nature of Bonding in solids. Understand the lattice vibrations. Illustrate superconductivity. Study the Electronic properties of solids.
- To understand the theory of semiconductors and their properties. Illustrate the dielectric, ferroelectricity and magnetic properties of materials.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Describe the crystal structure, demonstrate and apply Bragg's law for crystal structure analysis from various diffraction experiments.

CO 2. Classify the bonding in solids, understand the concept, theory of superconductivity and lattice vibration.

CO 3. Understand the electronic properties of solids and visualize the energy band structure of semiconductors.

CO 4. Analyze the Electronic, Dielectric, Ferroelectric and Magnetic properties of solids.

Semester-III
20PHYC 3.3: General Condensed Matter Physics

Unit-I (16Hrs.)

Crystal Physics: Lattice Points and space lattice, The Basis and Crystal Structure, Unit Cells and Lattice parameters, Wigner Seitz unit cell, 2-D & 3-D Bravias lattice, Crystal systems, Symmetry elements, point groups & Space groups, Directions-planes-& Miller Indices, The Reciprocal lattice, Reciprocal lattice to SC, BCC and FCC lattice. Simple crystal structures – HCP, NaCl, CsCl, Diamond, ZnS.

Crystal Diffraction: Braggs law, Lanes equation, Equivalence of Bragg & Laue equations, Ewalds construction, Diffraction Experiments: Lane, rotations and powder method. Atomic Scattering factor, structuring factor, Structure facture of simple crystal SC, BCC, FCC.

Unit-II (16Hrs.)

Bonding in Solids: Cohesive Energy, Ionic Bonding, Bond Energy of NaCl molecule, Covalent Bond, Metallic Bond, Hydrogen Bonds

Lattice Vibrations: Dynamics of: -chain of Identical atoms, -Diatomic Linear Chain, -Identical atoms in 3D, Anharmonicity and Thermal expansion

Superconductivity: Zero resistance and persistent current, Isotope effect, Effects of magnetic field, Type I and II Superconductors, Meissner effect, Thermodynamic properties, Heat capacity, Thermal conductivity. BCS theory (qualitative), High temperature Superconductors (qualitative) – Applications.

Unit-III (16Hrs.)

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

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

Unit-IV (16Hrs.)

Dielectric and Ferro Electricity: Review of basic formulae, Microscopic concept of polarisation, Langevin's theory of Polarisation, Clausius-Mosotti relation, Ferroelectricity, Dielectric constant and Dielectric Loss, Dielectrics in Alternating Fields.

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

References:
1. Wahab M. A.,(2009) **"Essential of Crystallography",** Narosa Publications.
2. S O Pillai., (1996) **"Solid State Physics"**, NAI Publishers
3. Ali omar, (2000) **"Elementary Solid State Physics"**, Adison wisely.
4. Ackroft F. W. and N. D.Mermin, (1976) **"Solid State Physics"**, Saunders Collage.
5. Dekkar A. J., (2000) **"Solid State Physics"**, MacMillan India Ltd.
6. Kittle C., (1996) **"Solid state Physics"**, Wiely Eastern.
7. Srivastava J. P., (2008) **"Elementary Solid-State Physics"**, PHI.

Semester-III
20PHYE 3.4a: Lasers and Optoelectronic Devices

Course Objectives:

- To demonstrate and understanding of Laser characteristics and various laser systems.
- To demonstrate the fundamental and applied aspects of optoelectronic device physics and its applications to the design and operation of laser diodes, light-emitting diodes, and photodetectors and to analyze optoelectronic device characteristics in detail using concepts from quantum mechanics and solid-state physics.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Understand the fundamentals of lasers, the characteristics of laser radiation and individual types of lasers.

CO 2. Describe fundamental and applied aspects of semiconductor laser structures.

CO 3. Explain key concepts in quantum and statistical mechanics relevant to physical, electrical and optoelectronic properties of materials and their applications to optoelectronic devices like LED.

CO 4. Describe the operation of optoelectronic devices like photodetector and its characteristics that have to be optimized for new applications by employing their understanding of optoelectronic device physics.

Semester-III
20PHYE 3.4a: Lasers and Optoelectronic Devices

Unit-I **(16Hrs.)**

Laser Characteristics: Population inversion, Pumping techniques, and types, Characteristics of laser beams, Gaussian and its properties, Modes of laser oscillations of a laser cavity - Longitudinal and transverse. An expression for the number of modes of oscillation in terms of frequency and cavity length, Three and 4 level laser systems, Q-Switching, Mode locking, Pulse shortening. Line-broadening mechanisms.

Laser Systems: Pumping techniques for Population inversion mechanism and energy levels of the following lasers: Nd:YAG laser, Carbon Dioxide laser, Dye laser, Argon Ion laser. engineering and medical applications of lasers.

Unit-II **(16Hrs.)**

Semiconductor Laser Structures and Properties: Junction laser operating principles, threshold current density of a semiconductor laser treated as two-level system, Threshold current density from the spontaneous emission rate. Power output of junction laser, Temperature dependence of threshold current, Hetero junction lasers: single and double Heterostructure laser, losses in Heterostructure lasers, Heterostructure laser materials, Quantum well lasers, strained quantum well lasers, Surface emitting lasers, Device fabrication steps. Modulation of lasers: Rate equations, steady state solution or static characteristics.

Unit-III **(16Hrs.)**

Light Emitting Diodes: The electroluminescent process, Choice of LED materials, Dive configuration and efficiency: Injection efficiency, recombination efficiency, Extraction efficiency and external conversion efficiency. LED structures: Heterojuction LED, Burros surface emitting LED, Edge emitting LED, Drive circuitry. Device performance characteristics: Spectral response, output power-time characteristics, Light-current characteristics, Diode current voltage characteristics, Frequency response and modulation bandwidth. Manufacturing process and applications.

Unit-IV **(16Hrs.)**

Photo Detectors: photoconductors: quantum efficiency, DC photoconductor, AC photoconductor, gain and bandwidth. Junction photodiodes: p-I-n photodiodes, quantum efficiency and frequency response, Hetero junction photodiodes, avalanche photodiodes, avalanche multiplication: ionization Threshold energies, multiplication and ionization coefficients in p-i-n and p-n junction diodes, Measurement of multiplication factors and impact ionization coefficients. Practical avalanche photodiodes.

References:
1. William T. Silfvast, **"Laser Fundamentals"**, , Cambridge University Press, Second Edition.
2. B.B. laud, **"Lasers and non-linear optics",** New –Age international Publisher.
3. Pallab Bhattacharya, **"Semiconductor Optoelectronic Devices"**, Pearson Education, (Singapore pvt.ltd.), Printed in India by Tan Prints(I), Pvt. Ltd., 2004.
4. Ajoy Ghatak and K. Thayagarajan, **"Introduction to Fiber Optics"**, , Cambridge university press, First South Asian Edition , Rerint 2009.
5. Thyagarajan K., A. K. Ghatak, (1981) **"Lasers: Theory and Applications",** McMillan India.
6. Swelto O., (1998) **"Principles of Lasers"**, Springer.
7. Sigman A. E., (1986) **"Lasers"**, University Press.
8. Ghatak A. K., K. Thyagarajan, (1997) **"Optical Electronics"**, Cambridge University Press.

Semester-III
20PHYE 3.4b: Astrophysics

Course Objectives:

- To introduce the students to the exciting field of Astrophysics.
- To demonstrate and understand the fundamentals of Astrophysics, Astronomical Techniques, Solar system and Stellar Structure.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Demonstrate a basic understanding of various aspects of observational Astronomy.

CO 2. Analyze the basic concepts in Remote Sensing.

CO 3. Explain stellar evolution, including neutron stars, pulsars, white dwarfs and black holes, using evidence and presently accepted theories.

CO 4. Understanding the basic properties of the solar system.

Semester-III
20PHYE 3.4b: Astrophysics

Unit-I (16Hrs.)

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

Unit-II (16Hrs.)

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

Unit-III (16Hrs.)

Basic concepts: Trigonometric Parallaxes, Parsec, Apparent and absolute magnitudes, Atmospheric extinction, Angular radii of stars, Michelson's stellar interferometer, Binary stars and their masses, Radial and transverse velocities, Types of optical telescopes and their characteristics Properties of Stars: Spectra of stars spectral sequence - temperature and luminosity classifications, H-R diagram, Stellar structure equations, Star formation and Main sequence evolution, Mass luminosity relation, White dwarfs, Pulsars, Neutron stars and Black holes.

Unit-IV (16Hrs.)

The Solar System: The surface of the Sun, Solar interior structure, Solar rotation, Sun sports the active Sun, Properties of interior planets and exterior planets, Satellites of planets, Comets, Asteroids, Meteorites. Stars Clusters, Galaxies and the Universe: Open and Global clusters, the structure and contents of Milky way galaxy, Hubble's classification of galaxies, Galactic structure and dark matter, Hubble's law, Big bang origin of the universe, Cosmic microwave background radiation and evolution of the universe.

References:
1. Abhyankar K. D., (2001) **"Start and Galaxies"**, University Press
2. Baidyanath Basu, (2003) **"An Introduction to Astrophysics"**, PHI
3. Bhatia V. B., (2001) **"A Textbook of Astrophysics and Cosmology"**, New Age
4. Bohm Vitense E.,(1989) **"Introduction to Stellar Astrophysics"**, 3rd Volume, Cambridge University Press.
5. George Joseph, (2002) **"Fundamentals of Remote Sensing"**, University Press Pvt. Ltd. Hyderabad
6. Krishnaswamy (ed), (2010) **"Astrophysics"**, 3rd World Scientific Publishing Company
7. Narlikar J. V., (1993) **"Introduction to Cosmology"**, Cambridge University Press.
8. Ostlie and Carrol, (1997) **"Introduction to Modern Astrophysics"** Addison Wesley.
9. Roy A. E., (2002) **"Orbital Motion"**, Adam Hinglar Ltd.

Semester-III
20PHYE 3.4c: Atmospheric Physics

Course Objectives:

- To demonstrate and understand the concept of Physical and Dynamic Meteorology, Monsoon Dynamics, Numerical Methods for Atmospheric Models and Atmospheric Instrumentation Systems.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Identify the applicability and usage of thermodynamics laws with clear emphasis on the atmospheric physics concepts.
CO 2. Explain the monsoon dynamics.
CO 3. Formulate atmospheric models and apply the numerical computational methods for understanding the atmospheric models for pollution studies and meteorology
CO 4. Illustrate the principle and working of various instruments used in atmospheric studies.

Semester-III
20PHYE 3.4c: Atmospheric Physics

Unit-I   **(16Hrs.)**

Physical Meteorology: Atmospheric composition, Laws of thermodynamics of the atmosphere. Adiabatic process, Potential temperature, the Clausius Clapeyron equation, Laws of Black body radiation, Solar and Terrestrial radiation, Albedo, Greenhouse effect, Heat balance of earth atmosphere system.

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

Unit-II   **(16Hrs.)**

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

Unit-III   **(16Hrs.)**

Numerical Methods for Atmospheric Models: Filtering of sound and gravity waves, Filtered forecast equations, Basic concepts of Quasigeostrophic and primitive equation models, One level and Multi-level models. Basic concepts of initialization and objective analysis for wave equation, Advection equation and Diffusion equation. Atmospheric **Pollution:** Role of Meteorology on Atmospheric pollution, Atmospheric boundary layer, Air stability, Local wind structure, Ekman spiral, Turbulence boundary layer scaling. Residence time and reaction rates of pollutants, Sulphur compounds, Nitrogen compounds, Carbon compounds, Organic compounds, Aerosols, Toxic gases and Radioactive particles trace gases.

Unit-IV   **(16Hrs.)**

Atmospheric Instrumentation Systems: Ground based instruments for the measurement of Temperature, Pressure, Humidity, Wind and Rainfall rate. Air borne instruments – Radisonde, Rawinsonde, Rockestsonde, Satellie Instrumentation (Space borne instruments) Radar Meteorology: Basic meteorology - Radar principles and technology, Radar signal processing and display, Weather Radar - Observation of precipitating systems, Estimation of Precipitation, Radar observation of Tropical Cyclones, Use of Weather Radar in Aviation, Clear Air Radars – Observation of Clear Air phenomena - Other Radar systems and applications.

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

Semester-III
20PHYOE 3.5a: Introduction to Energy Science

Course Objectives:

- To understand the concepts of energy sources and processing.
- To acquire the knowledge of utilization and storage of renewable and non-renewable energy sources.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Understand the conventional and non-conventional energy sources
CO 2. Interpret the importance of the generation and utilization of energy from various sources.

Semester-III
20PHYOE 3.5a: Introduction to Energy Sciences

Unit-I   **(16Hrs.)**

Conventional Sources of Energy: Definitions of work and energy, different forms of energy, conversion of energy, power, practical units of energy, fossil fuels and their formation, processing of coal, coal gasification and liquefaction, extraction and refining of oil, biomass energy, combustion of fossil fuels, effects of carbon dioxide and monoxide.

Unit-II   **(16Hrs.)**

Non-conventional Sources of Energy: Sun light and solar energy, solar constant, utilizing heat from sunlight, solar cookers and ovens, solar heating of houses, solar thermal power generation, photovoltaic power generation, wind energy, hydroelectric energy, tidal energy, energy from waves, geothermal energy, Atomic structure, isotopes, radioisotopes, nuclear fission, nuclear reactors, thermal reactors, fast breeder reactors, nuclear fusion, fusion reactors, safety aspects.

References
1. AK Bakshi, **"Energy"**, NBT, 1995
2. SP Sukhatme and J K Nayak, **"Solar Energy"**, TMH, 2008
3. Glasstone, **"Nuclear Energy"**

Semester-III
20PHYOE 3.5b: Nanomaterials

Course Objectives:

- To understand the various concepts of physics of nanomaterials.
- To illustrate different techniques for the of nanomaterials.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Classify the nanomaterials and illustrate size and surface effects.
CO 2. Explain different preparation methods of nanomaterials and carbon nanoclusters.

Semester-III
20PHYOE 3.5b: Nanomaterials

Unit-I   **(16Hrs.)**
Introduction to Nanomaterials: (Definition, reason for interest in nanomaterials, classification of nanostructures. Physics of nanomaterials - size and surface effects. Opto-electronic, chemical, mechanic and thermal properties of nanostructures.
Semiconductor Nanocrystals: Quantum dots, quantum wires and quantum films. Quantum confinement effect. Excitons and estimation of energy gap and particles size. Bandgap engineering. Applications of quantum dots and wires.

Unit-II   **(16Hrs.)**
Growth of Nanomaterials: Top-down and Bottom-Up Techniques: chemical vapour deposition (CVD), ion sputtering, laser ablation, molecular beam epitaxy, chemical precipitation. Concept of organic capping, core-shell structures. Self-assembled molecular materials- principles of self-assembly, micelles & green nanoscience.
Carbon Nanoclusters: Introduction: Graphite and Diamond, Fullerene, graphene and carbon nanotubes (CNT) – electrical, thermal, Mechanical and chemical properties and applications.

References
1. Charles. P. Poole and F. J. Owens, **"Introduction to Nanotechnology"**, John Wiley & Sons, Inc. 2003.
2. James Murday, **"Textbook of Nanoscience and Nanotechnology"** Universities Press-IIM, 2012.
3. T. Pradeep, **"Nano: The Essentials"** Tata McGraw Hill Education Pvt Ltd., 2013.
4. Sulabha K Kulkarni, **"Nanotechnology-Principles and Practices"**, Capital Publishing Company, 2007.

Semester-III
20PHYL 3.6: General Nuclear Physics Lab

List of Experiments

(At least Eight of the following to be performed)

1. Dead time of Geiger Muller Counter by double source method.
2. Detection efficiency of GM detector for Gamma rays/Beta rays.
3. Determination of absorption coefficient of Al, Cu, Zn and Fe for Beta rays.
4. Determination of end point energy of Beta particle by half value thickness measurement.
5. To construct and study the C-W voltage multiplier.
6. Energy resolution of a NaI (Tl) detector.
7. Determination of rest mass energy of an electron by Compton Scattering method using Gamma Ray Spectrometer (GRS).
8. Gamma ray absorption coefficient measurement using GRS/GM detector.
9. Construct and study coincidence circuit using transistor.
10. Common source amplifier.

(Additional Experiments may be added with BOS approval)

Semester-III
20PHYL 3.7: General Condensed Matter Physics Lab

List of Experiments

(At least Eight of the following to be performed)

1. Analysis of Powder X-ray photograph and cell parameters (Cu, Au, Ag).
2. Analysis of X-ray diffractogram -
3. Determination of Fermi energy of Copper.
4. Determination of reverse saturation current of a P-N junction.
5. Determination of energy gap of P-N junction.
6. Determination of Curie Temperature and Energy loss of ferromagnetic core material using magnetic Hysteris loop.
7. Study of dielectric constant and Curie temperature of ferroelectric material – $BaTiO_3$/PZT.
8. Determination of Hall co-efficient & carrier concentration using Hall effect.
9. Determination of co-efficient of Thermal expansion of materials (Al, Cu, Brass, NaCl, KCl).
10. Determination of optical constant, K, Energy gap using transmission data of thin films ($ZnO-B_2O_3-V_2O_5$/ $ZnO-B_2O_3-P_2O_5$).
11. Verification of Langmuir-Child's law.

(Additional Experiments may be added with BOS approval)

Semester-IV
20PHYC 4.1: Experimental Techniques

Course Objectives:

- To understand the various techniques involved in the production and measurement of Vacuum technology.
- To demonstrate the production and measurement of cryogenic technology and measurement of electrical resistivity and frequencies.
- To illustrate the working principle of various radiation detectors, magnetic sensors and their applications.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Describe the working principle of the various vacuum techniques – Production & Measurement, limitations and applications in various fields of research.

CO 2. Outline the basics of cryogenic technology, production and measurement of low temperature and its application.

CO 3. Demonstrate various radiation detectors and understand the different methods in the measurement of high and low electrical resistivity, their limitation and also electrical measurements at high frequencies.

CO 4. Understand various magnetic sensors, devices and their applications and evaluate the performance characteristics of various sensors.

Semester-IV
20PHYC 4.1: Experimental Techniques

Unit-I (16Hrs.)

Vacuum Technology: Production of vacuum: Introduction to vacuum, Characteristics of Vacuum, Production of vacuum using – rotary pump, root pump, diffusion pump, Turbo molecular pump, Sorption pump and cryopumps.

Measurement of Vacuum: Vacuum gauges: Mechanical gauges, Liquid column gauges, Thermal conductivity gauges, Ionization gauges.

Applications of vacuum systems in thin film technology, low temperature physics experiments, accelerators like Linac, Cyclotron, etc.

Unit-II (16Hrs.)

Cryogenic Techniques: Review of history, General techniques of Liquefaction of gases – Internal and external work methods, Adiabatic Expansion, Joule-Kelvin effect, Isenthalpic curve, Inversion curve, Regenerative cooling. Adiabatic demagnetization.

Design of Cryostats: Bath type and flow type cryostats.

Measurement of Low Temperature: International temperature scale, secondary standards, Resistance thermometers, Thermistors, Platinum resistance thermometers, Alloy thermometers, Thermocouples, Diodes, Semiconducting temperature sensors.

Unit-III (16Hrs.)

Radiation Detectors: Pyroelectric, ferroelectric, thermoelectric, photo conducting, photoelectric and photomultiplier, scintillation types of detectors.

Measurement of high and low electrical resistivity: DC and AC four probe technique, two probe techniques, errors in the measurement, impedance considerations and accuracy.

Electrical Measurements at High Frequencies: Resonance methods, Measurement of inductance, Capacitance, effective resistance, measurement of R, L, C, and ω through T-network at high frequencies, Q meter, methods of measurements of Q.

Unit-IV (16Hrs.)

Magnetic Sensors: Magnetic Field Sensors - Classification, Specification of the Performances of Magnetic Sensors,

Hall-Effect Sensors: Physical Principles of the Hall Effect, Performance of the Hall Sensors, Integrated Circuit Hall Sensors, Hall-Effect-Based Semiconductor Magneto resistors.

SQUID Sensors: Operating Principle of SQUID Sensors, Properties of SQUID Sensors, SQUID Magnetometers.

References:
1. C.S.Rangan, G.R.Sharma and V.S.V. Mani, **"Instrumentation Devices and Systems"**, Tata McGraw Hill,
2. R.A.Dunlop, **"Experimental Physics: Modern methods"**, Oxford University Press.
3. G.K. White, **"Experimental Techniques at low temperature"**, Monographs on the Physics and Chemistry of Materials-59, OXFORD Univ. press.
4. Michael Sayer, Abhai Mansingh, **"Measurement Instrumentation and Experiment Design in Physics and Engineering"**, PHI Learning Private Limited Delhi-110092,
5. S Dushman, **"Scientific Foundations of Vacuum Technique"**, 2nd Ed., John Wiley, New York.
6. H.H.Willard, L.L.Merrit and John A. Dean, **"Instrumental methods of analysis"**, VI edition, CBS Publishers and distributors.
7. D.Malacara (Editor), **"Methods of experimental Physics, Series of volumes"**, Academic Press Inc.(1988).
8. J.F. Rebek, **"Experimental methods in Photochemistry and Photo physics"**, Part 1 and 2, John Wiley.
9. S Tumanski, **"Hand book of magnetic measurements"**, Warsaw University of Technology, Poland, CRC Press , **"A Taylor and Francis Book International Standard Book Number-13"**: 978-1-4398-2952-3
10. Umesh Sinha, Electrical, **"Electronics measurements and instruments"**, Satya Prakashan, New Delhi, Reprint Edition.

Semester-IV
20PHYC 4.2a: Condensed Matter Physics -I

Course Objectives:

- To understand the basic theories of solid-state and electronic structure of materials.
- To demonstrate how band theory is applied to describe physical, electrical, thermal and optical behavior of solids.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Understand how crystal binding energy affects crystalline structure and lattice vibration on thermal behavior.

CO 2. Illustrate the electronic properties of solids with different approach and understand thermal properties of solids with different classical models.

CO 3. Apply the free electron theory to solids to describe electronic behavior with the help of energy bands.

CO 4. Understand the concept of semiconducting properties and optical properties of solids.

Semester-IV
20PHYC 4.2a: Condensed Matter Physics -I

Unit-I (16Hrs.)

Crystal Binding and Atomic Cohesion:

Types of Bonding: Primary & Secondary bond – Quantitative approach, Bond dissociation energy of NaCl molecule, Evolution of Madelung constant for alkali halide elements, cohesive energy of ionic crystals, calculation of repulsive exponent using compressibility data, Born-Haber cycle.

Lattice Vibration: vibration of crystals with monoatomic basis, Group velocity, two atoms per primitive basis, Quantization of elastic waves, phonon momentum, inelastic scattering by phonon.

Unit-II (16Hrs.)

Electrical Properties of Solids: Boltzmann equation, Relaxation time, collision time & mean free path, Quantum theory of free electrons, Fermi-Dirac statistics and electronic distribution in solids, Electrical conductivity for quantum mechanical consideration, Electron scattering & source of resistance in metals, Electron scattering mechanism and variation of resistivity with temperature, resistivity of alloys, variation of resistivity with pressure, Matthiessen's rule (Qualitative).

Thermal Properties of Solids: Specific heat of solids, Classical model (Dulong & Petit law), Einstein model, density of states, Debye model, Phone interaction, Normal and Umklapp process, thermal expansion, phonon collision process, thermal conductivity in solids, thermal conductivity due to electron and phonon, thermal resistance of solids.

Unit-III (16Hrs.)

Band Theory of Solids

Energy bands: Nearly free electron model, origin of energy gap, Bloch theorem and proof, Kronig Penny model, wave equation of electron in periodic potential, K-P model in reciprocal space, Approximation solution near a zone boundary, number of orbitals in a band – metal and insulators (C. Kittle) Construction of Brilouin zone, extended, reduced and periodic zone schemes, effective mass of an electron, Tight binding approximation.

Fermi Surfaces: Fermi surface and Brillouin zones, Harrison's method of constructing a fermi surfaces, Fermi surface in metals, Characteristics of Fermi surface, Effect of electric field on Fermi surface, Effect of magnetic field on Fermi surface, Experimental study of Fermi surface: Anomalous skin effect, Cyclotron resonance, de-Hass-van-Alphen effect.

Unit-IV (16Hrs.)

Semiconducting Properties of Solids: Concept of hole and effective mass in semiconductors, Free carrier concentration in semiconductor, physical derivation of $\hbar k = F$, Fermi level and carrier concentration in semiconductors, mobility of charge carriers, electric conductivity, impurity conductivity, Hall effect, Magnetoresistance with two carriers' types.

Optical Properties of Solids: Absorption process, photoconductivity, photoelectric effect, photovoltaic effect, photoluminescence, color centers, Kramer-Kronig relations, optical refractive index & relative dielectric constant, physics of optical fibers.

References:
1. C. Kittel "**Introduction to Solid State Physics**": (Wiley Eastern).
2. A.J. Dekkar "**Solid State Physics**": (Prentice Hall Inc).
3. M.A. Omar . "**Elementary Solid State Physics: Principles and applications**," (Addison-Wesley).
4. M. A. Wahab "**Essential of Crystallography**": (Narosa Publications).
5. S. O. Pillai "**Solid State Physics**": (New Age int. Publishers).

Semester-IV
20PHYC 4.3a: Condensed Matter Physics -II

Course Objectives:

- To understand dielectric behavior and magnetic properties of solids.
- To demonstrate the advanced concepts in superconductivity and specify the holistic view of nanomaterials. Illustrate the imperfections and dislocations in solids.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Understand the role of solids as dielectric, ferroelectric and piezoelectric materials.

CO 2. Explain the magnetic behavior of solids with different theories.

CO 3. Acquire the knowledge about superconductors and different synthesis techniques of nanomaterials.

CO 4. Classify and analyze the types of imperfections, dislocations and defects present in the solids.

Semester-IV
20PHYC 4.3a: Condensed Matter Physics -II

Unit-I (16Hrs.)

Dielectric Properties of Solids: Concept of dipole moment and polarization, Electronic, Ionic and Orientational polarization, polar and non-polar materials, Clausius-Mosatti relation, local electric field of an atom, dielectric field and its measurement, polarizability, Ferroelectricity, Piezoelectricity, dielectric in alternating fields, dielectric loss, ionic polarizability as a function of frequency.

Ferroelectrics: Crystal types of ferroelectric, properties of Rochella salt and BaTiO3 (perovskite structure), dipole theory – dielectric constant near curie temperature, microscopic source of ferroelectricity, first and second order ferroelectric domains.

Piezoelectricity: properties, structure and application of Piezoelectric materials.

Unit-II (16Hrs.)

Magnetic Properties of Solids: Quantum theory of diamagnetism, quantum theory of paramagnetism, paramagnetism of free electrons, determination of susceptibilities of para & diamagnetic materials, soft & hard magnetic materials: soft iron-silicon alloys, iron-nickel alloys, ferrites. Ferromagnetism: Weiss theory of ferromagnetism, spontaneous magnetization, Curie-Weiss law, Ising model, Bloch 3/2 law, quantization of magnoses, Heisenberg exchange interaction. Ferromagnetic domains. Antiferromagnetism: Susceptibility above and below Neil temperature, two sub-lattice model, Neel temperature. Ferrites: Structure of ferrites, classification of ferrites, susceptibility of ferrites and saturation magnetization of ferrites.

Unit-III (16Hrs.)

Superconductivity and Nanomaterials: Normal Tunneling and AC and DC Josephson effect, High Tc superconductor, Type I and Type II superconductors, SQUIDs and its applications. Nanomaterials: Introduction, density of states in 0D, 1D, 2D, 3D. Preparation: Bottom-up approach: Sol-gel synthesis, hydrothermal growth, Thin film growth, Physical Vapor Deposition, Chemical Vapor Deposition, Top-Down approach: Ball milling, Microfabrication, Lithography, Ion-beam lithography. Ceramics: Classification of ceramics, structure of ceramics, Cesium Chloride, Rock Salt, Zinc blend, Wurtzite structure, Polymorphism, mechanical and thermal properties of ceramic – phases, application of ceramics.

Unit-IV (16Hrs.)

Imperfections and Dislocations: Types of imperfections, Point imperfections: concentration of point imperfections, vacancies, interstitials, Schottky defects and Frenkel defects, Compositional defects, Electronic defects, production of point defects, Line imperfections: Edge dislocation, Screw dislocation, Burgers vector & Burger Circuit, Dislocation motion, Slip planes and Slip directions, Dislocation reaction, Surface imperfections: External surface imperfections, internal surface imperfections, Stacking fault.

References:
1. C. Kittel **"Introduction to Solid State Physics"**: (Wiley Eastern).
2. A.J. Dekkar **"Solid State Physics"**: (Prentice Hall Inc).
3. M.A. Omar **"Elementary Solid-State Physics"**: Principles and applications,
4. (Addison-Wesley).
5. M. A. Wahab **"Essential of Crystallography"**: (Narosa Publications).
6. S. O. Pillai **"Solid State Physics"**: (New Age int. Publishers).
7. S. K. Hazra Choudary. **"Materials Science and processing"**

Semester-IV
20PHYE 4.4a: Nanophysics

Course Objectives:

- To understand and demonstrate the basic scientific principles related to the behavior of matter at the nanoscale.
- To illustrate the various techniques for the preparation and characterization of nanostructures.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Specify the holistic view of nanoscience, nanotechnology and the effect of quantum confinement.
CO 2. Understand the various properties of materials at the nanoscale.
CO 3. Illustrate the top-down and bottom-up approaches for preparation of nanomaterials and different lithographic techniques.
CO 4. Explain the underlying working principle of advanced instruments employed for characterization of nanomaterials and evaluate their merits and limitations.

Semester-IV

20PHYE 4.4a: Nanophysics

Unit-I **(16Hrs.)**

Nanomaterials: Introduction, history of nanomaterials, concepts of nanoscience & nanotechnology, importance of nanotechnology. Physics of nanomaterials – size and surface effects, variation of density of states, classification of nanomaterials – Shape & intrinsic - zero dimensional, one-dimensional & two-dimensional nanostructures. Size and shape dependent properties of nanomaterials and societal implications. Metal nanocrystals.

Unit-II **(16Hrs.)**

Metal and Semiconductors Nanomaterials: Plasmons, Surface Plasmon Resonance (SPR) - Gold, silver & iron nanoparticles. Quantum Dots, Quantum wires and Quantum wells - importance. Variation of energy gap with particle size. Organic capping, core shell structures and self-assembly-Intermolecular forces.

Properties Nanomaterials: Melting Point and Heat Capacity, Electronic and Optical properties- (Quantum Confinement of Superlattices and Quantum Wells – Dielectric Constant of Nanoscale Silicon – Doping of a Nanoparticle – Excitonic Binding and Recombination Energies – Capacitance in a Nanoparticle) and Magnetic properties.

Unit-III **(16Hrs.)**

Methods for Preparation of Nanomaterials:
Top-down and Bottom-up approaches: Solution growth and gas phase techniques chemical vapor deposition (CVD), ion sputtering, laser ablation, and chemical precipitation.

Carbon Nanoclusters: Introduction, Fullerene, Graphene and carbon nanotubes (CNT) – properties and applications - Solar cells, composite materials, sensors.

Unit-IV **(16Hrs.)**

Characterization Nanomaterials:

Spectroscopy Techniques: UV-Visible spectroscopy, Photoluminescence spectroscopy, IR spectroscopy and Raman spectroscopy; X-ray Absorption (XAS) and X-ray Photoelectron (XPS) Spectroscopy with Depth profiling.

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

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

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

References:
1. Sulabha K Kulkarni, **"Nanotechnology-Principles and Practices",** Capital Publishing Company, 2007.
2. CNR Rao, GU Kulkarni and John Thomas and **"Springer Series in materials science",** Springer-Verlag Berlin Heidelberg 2007
3. James Murday, **"Textbook of Nanoscience and Nanotechnology"** Universities Press-IIM, 2012.
4. T. Pradeep, **"Nano: The Essentials"** Tata McGraw Hill Education Pvt Ltd., 2013.
5. Charles. P. Poole and F. J. Owens, **"Introduction to Nanotechnology"**, John Wiley & Sons, Inc. 2003.
6. Jain K. P., (1997) **"Physics of Semiconductor Nanostructures"**, Narosa.

Semester-IV

20PHYE 4.4b: Solar and Hydrogen Energy

Course Objectives:

- To impart fundamental knowledge of solar energy, Solar cell and their types.
- To understand the basics of Hydrogen Energy-Production storage, safety features and utilization of Hydrogen energy.
- To understand the basics of various renewable energy sources.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Describe the fundamentals of Photovoltaic energy conversion and the various properties of semiconductor solar cell.
CO 2. Explain the working principle, properties and types of solar cell.
CO 3. Describe the production of hydrogen energy, its importance and storage through various methods.
CO 4. Evaluate the safety and utilization of hydrogen energy and understand the fundamentals of renewable energy sources.

Semester-IV

20PHYE 4.4b: Solar and Hydrogen Energy

Unit-I (16Hrs.)

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

Unit-II (16Hrs.)

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

Unit-III (16Hrs.)

Hydrogen Energy: Relevance in relation to depletion of Fossil fuels and Environmental considerations. Hydrogen Production: Solar hydrogen through Photo lectrolysis and Photocatalytic process. Physics of material characteristics for production of solar hydrogen. **Storage of Hydrogen:** Brief discussion of various storage processes, Special features of Solid-state hydrogen storage materials, Structural and electronic characteristics of storage materials. New storage modes.

Unit-IV (16Hrs.)

Safety and Utilization of Hydrogen: Various factors relevant to Safety, Use of hydrogen as fuel, Use in vehicular transport, Hydrogen for electricity generation - Fuel cells, Elementary concepts of Other hydrogen based devices such as Air conditioners and Hydride batteries. Other Renewable Clean Energies: Elements of Solar thermal energy, Wind energy and Ocean Thermal Energy Conversion. Tidal energy

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

Semester-IV
20PHYE 4.4c: Polymer Composites

Course Objectives:

- To understand the methods of processing of Polymer Composites and their properties.
- To illustrate the concepts of Polymer Composites, Conducting Polymer Composites, Functional Polymer Nanocomposites and Bio and Natural Polymers Composites.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Explain the concepts of Polymer Composites and their uses.
CO 2. Demonstrate the conduction mechanism of conducting polymers.
CO 3. Classify the various polymer composites based on their properties and understand the production of various polymer composites.
CO 4. Identify and explain the need of bio and natural polymer composites.

Semester-IV
20PHYE 4.4c: Polymer Composites

Unit-I   **(16Hrs.)**

Polymer Composites: Introduction, Fibrous and particulate composites, concepts of matrix and pillars. Types of reinforcement such as natural, glass, carbon/graphite, aramid fibers, high strength and high modulus fibers. Surface treatment and various forms of fibers. Types of composites, Reinforcements: Glass, boron, carbon, organic and ceramic fibers, their structure, properties and processing. Wood, Concrete, Fibre-reinforced plastic (FRP) and some advanced composites. Wettability and interface bonding.

Unit-II   **(16Hrs.)**

Conducting Polymer Composites: Conducting polymers: Types of conducting polymers. Chemical and electrochemical routes of synthesis. Percolation theory - Conduction mechanism and continuum percolation, quantum tunneling, concept of sensing, carbon nanotubes, graphene, epoxy resin and polyurethane based conducting polymer composites, doping and dedoping of conjugated polymers.

Unit-III   **(16Hrs.)**

Functional Polymer Nanocomposites: Introduction, polyurethane – graphene composites, epoxy – graphene composites, Biopolymer graphene composites
Polymer Matrix Composites: Lamina, laminate composites. Primary and Secondary manufacturing: Lay-up, Filament winding, Pultrusion, Compression moulding. Machining, drilling and routing. Applications.

Unit-IV   **(16Hrs.)**

Bio and Natural Polymers Composites: Proteins, nucleic acids, lipids, cellulose and polysaccharides. Medicinal and biomedical applications of polymers. Introduction of Inorganic Polymers and application. Biodegradable polymers. Polymer waste management. Designing with composites. Engineering applications of composites.

References:
1. Sabu Thomas, Prof. Dr. Joseph Kuruvilla, Dr. S K Malhotra, Koichi Goda, Meyyarappallil Sadasivan Sreekala, **"Polymer Composites",** Wiley-VCH Verlag GmbH & Co. KGaA, 2021
2. **"The Physics of Materials: How Science Improves Our Lives"**, Solid State Sciences Committee, (National Research Council, 1997)
3. **"The Science of the World Around US"**, Solid State Sciences Committee, National Research Council, 2007.
4. V Raghavan, **"Materials Science and Engineering"**, Prentice Hall India, 1993.
5. B. J. Zang, **"Advanced Polymer Composites: Principles and Applications"**, (Handbook Series), 1994.

20PHYL 4.5a: Condensed Matter Physics Lab

List of Experiments

(At least Eight of the following to be performed)

1. Study of energy gap of a semiconductor using Four probe method.
2. Calibration of electromagnet and determination of Magnetic susceptibility of magnetic salts by Quincke's method.
3. Calibration of electromagnet and determination of Magnetic susceptibility of ferromagnetic materials by Guy's balance method.
4. Measurement of magnetoresistance of a semiconductor.
5. 5. Study of Solar cell characteristics – illumination characteristics, V-I characteristics (ISCand VOC), power characteristics.
6. Determination of depletion capacitance of P-N junction diode.
7. Determination of Coercivity, Retentivity, energy loss of ferromagnetic materials using B-H curve.
8. Analysis of X-ray diffraction and estimation of R-factor.
9. Determination of temperature dependence of electrical resistivity of thin films by four probe method.
10. Ionic conductivity of alkali halide (NaCl) and study of temperature variation and estimation of activation energy.

(Additional experiments may be added with BOS approval)

Semester-IV
20PHYC 4.2b: Nuclear Physics - I

Course Objectives:

- To demonstrate and understand the nuclear radiation detection principles and methods, Describe the nuclear detector pulse processing techniques.
- To understand and evaluate the formulation and the relevance of various nuclear models.
- To analyze the methods and procedures of gamma ray spectroscopy methods and experiments.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Describe nuclear radiation detection principles and methods.

CO 2. Design and construct the simple pulse shaping circuits and Illustrate pulse processing.

CO 3. Identify the relevance of nuclear models and relate the nuclear models results to the experimental results and acquire computational skills to fit theory and experimental results.

CO 4. Outline the gamma ray spectroscopy methods and explain the experimental procedures, evaluate the errors with statistical significance thereof for experimental data.

Semester-IV
20PHYC 4.2b: Nuclear Physics - I

Unit-I   **(16Hrs.)**

Nuclear Detectors: Scintillation processes in inorganic crystals (NaI(Tl)). Semiconductor detectors—Diffused junction, Surface barrier and Lithium drifted detectors Relation between applied voltage and depletion layer thickness in junction detectors, Hyper pure germanium detectors, Cerenkov detectors. Slow neutron detection methods.

Unit-II   **(16Hrs.)**

Nuclear Pulse Techniques: Preamplifier circuits. Charge sensitive and voltage sensitive preamplifiers. Linear pulse amplifiers. Linearity, stability, pulse shaping, pulse stretching. Operational amplifiers. Analog to digital converters. Scalars, Schmidt trigger as a pulse discriminator, Single channel analyser-Integral and differential discriminators. Multichannel Analysers, memory devices and online data processing.

Unit-III   **(16Hrs.)**

Shell Model: Motion in a mean potential. Square well and simple harmonic oscillator potential well, spin-orbit interaction and Magic numbers. Extreme single particle model, Ground state properties of nuclei based on shell model. Nordheim's Rules.

Collective Model: Evidences for the collective motion. Nuclear rotational motion. Rotational energy spectrum and nuclear wave functions for even-even nuclei. Odd- A nuclei energy spectrum and wave function.

Nilsson model: Nilsson diagrams.

Many Body Self-Consistent Models: Hartree-Fock model.

Unit-IV   **(16Hrs.)**

Timing Spectroscopy: Coincidence and anti-coincidence circuits. Delay circuits. Time to amplitude conversion- Start-stop and overlap converters.

Gamma Ray Spectroscopy: Life time measurements. Gamma-gamma, beta-gamma angular correlation studies. Angular distribution of gamma rays from oriented nuclei. Polarization of gamma rays.

References:
1. Mermier P. and Sheldon E., **"Physics of the nuclei and particles"**, Vol. 1 and 2, Academic Press,New York 1970.
2. Segre E., **"Nuclei and particles"**, Benjamin Inc, New York, 1977.
3. Arya A.P., **"Fundamentals of nuclear physics"**, Allyn and Bacon, USA, 1968.
4. Blatt J.M. and Weisskopf V.F., **"Theoretical nuclear physics"**, Wiley and Sons, New York, 1991.
5. Siegbahn K., **"The alpha, beta and gamma ray spectroscopy"**: Vol. 1 and 2, North Holland, Amsterdam, 1965.
6. Price J.W., **"Nuclear radiation detectors"**, McGraw Hill, New York, 1965.
7. Kapoor S.S. and Ramamoorthy V., **"Nuclear radiation detectors"**, Wiley Eastern, Bangalore,1993.
8. Kowalski E., **"Nuclear electronics"**, Springer Verlag, Berlin,1970.
9. Leo W.R., **"Techniques for nuclear and particle physics experiments"**, Springer Verlag, 1992.
10. Roy R.R. and Nigam B.P., **"Nuclear physics"**, New Age International, New Delhi, 1986.
11. Hans H.S., **"Nuclear physics—Experimental and theoretical"**, New Age International Publishers,2001.

Semester-IV
20PHYC 4.3b: Nuclear Physics - II

Course Objectives:

- To demonstrate and understand nuclear fission. Formulate the statistical model of nuclear fission. Illustrate the theory and principles of nuclear reactor.
- To analyze the two-particle system to demonstrate and understand nuclear forces characteristics.
- To understand and evaluate the formulation and the relevance of nuclear reactions models. Understand and illustrate the nuclear decay phenomena.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Explain the nuclear fission phenomena, identify the relevance of statistical model of nuclear fission, demonstrate the principle of nuclear reactor and analyze the effectiveness of the two-particle system in understanding the nuclear properties

CO 2. Understand nucleon-nucleon scattering and analyze its cross section.

CO 3. Evaluate nuclear reaction models and compare their results with experimental measurements.

CO 4. Differentiate and illustrate the nuclear decay phenomena and interpret the results.

Semester-IV
20PHYC 4.3b: Nuclear Physics - II

Unit-I (16Hrs.)

Nuclear Fission: Nuclear fission, Mass-energy distribution of fission fragments. Statistical model of fission.

Reactor Theory: Neutron and its interaction with matter-collision kinematics, differential elastic scattering cross sections, isotropic scattering, The criticality condition for a reactor. Neutron transport equation using elementary diffusion theory. One group critical equation, The critical size-on the basis of Fermi Age theory.

Two Particle Systems: Deuteron: Schrodinger equation for a two-nucleon system. Theory of the ground state of the deuteron under central and non-central forces. Excited states of the deuteron. Rarita-Schwinger relations. Deuteron magnetic and Quadrupole moments

Unit-II (16Hrs.)

Nucleon-Nucleon Scattering Processes: Theory of s-wave scattering of neutrons by free protons and experimental results. Wigner's formula for n-p scattering. Theory of scattering of slow neutrons by bound protons (Ortho and Para hydrogen) and experimental results. Effective range theory for np scattering. S-wave theory of proton-proton scattering.

Nuclear reactions-1: Plane wave theory of direct reactions. Born approximation-(Plane wave)-Butler's theory. Cross section for nuclear scattering and reactions. Shadow scattering, Berit-Wigner resonance formulae.

Unit-III (16Hrs.)

Nuclear Reactions-2: Bohr's independence hypothesis. The compound nucleus (CN) reactions, decay rates of CN, Statistical theory of nuclear reactions. Evaporation probability and cross sections for specific reactions.

Optical Model: Giant resonances, Kapur-Pearls' dispersion formula for potential scattering. Direct reactions: Kinematics of stripping and pickup reactions. Theory of stripping and pickup reactions. Inverse reactions. **Heavy Ion Physics:** Special features of heavy ion Physics. Remote heavy ion electromagnetic interactions. Coulomb excitations.

Unit-IV (16Hrs.)

Beta Decay: Classification of beta interactions. Matrix elements. Fermi and Gamow-Teller selection rules for allowed beta decay. The non-conservation of parity in beta decay. Wu et al. experiment. The universal Fermi interaction.

Gamma Decay: Electromagnetic interactions with nuclei. Multipole transitions. Transition probabilitiesin nuclear matter. Weisskopf's estimates. Structure effects. Selection rules. Internal conversion Photo disintegration of deuteron and radiative capture of neutron by proton.

References:
1. Glasstone S. and Edlund M.C., **"Elements of nuclear reactor theory"**, D. Van Nostrand Co.,USA, 9th Print, 1963. Unit 1 Chapter 5–6 page 90-135, Unit 2. Chapter 7 page 191-290.
2. Garg S., Ahmed F. and Kothari I.S., **"Physics of nuclear reactors"**, Tata McGraw-Hill, New Delhi,1986.Unit 1.
3. Roy R.R. and Nigam B.P., **"Nuclear physics"**, New Age International, New Delhi, 1986. Chapter 5, page 162-165.
4. Hans H.S., **"Nuclear physics—Experimental and theoretical"**, New Age International Publishers,2001.
5. Unit 2 Ghoshal S.N., **"Nuclear physics"**, Vol. 2., S.Chand and Company, Delhi, 1994. Chapter 15, page 714-730.
6. Roy R.R. and Nigam B.P., **"Nuclear physics—Theory and experiment"**, New Age International Ltd, New Delhi, 1986.
7. Sachtler G.R., **"Nuclear reactions"**, Addison Wesley, New York, 1983.
8. Mermier P. and Sheldon E., **"Physics of nuclei and particles"**, Vol. 2, Academic Press, USA,1971.

Semester-IV
20PHYE 4.4e: Accelerator Physics

Course Objectives:

- To demonstration and understanding of production and theory ion sources. Critical evaluation of ion sources and their properties for particle accelerators.
- To illustrate the working principle and understand the theory of various particle accelerators.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Explains the need of ion sources, classify the ion sources based on their properties and describe the various ion sources construction and production techniques

CO 2. Illustrate the various concepts involved in ion optics and ion focusing.

CO 3. Understand the theory, working principle of particle accelerators. Also, relate the basic physics laws to the principles of working of various resonance accelerators.

CO 4. Analyze and explain the theory of various advanced electron accelerators.

Semester-IV
20PHYE 4.4e: Accelerator Physics

Unit-I   (16Hrs.)

Ion Sources: Brief introduction to ion sources for positive and negative ions. Ion production. Semi classical treatment of ionization, Townsend theory-comparison of theory and experiment for ion production. Examples of ion sources-properties of ion sources. Insulation at high voltages-Spark voltage. Paschen's law for gas breakdown.

Unit-II   (16Hrs.)

Ion Optics and Focusing: transverse beam control, paraxial approximation for electric and magnetic fields, focusing properties of linear fields, Electrostatic and Magnetic lenses: lens properties, electrostatic aperture lens, electrostatic immersion lens, solenoidal magnetic lens, magnetic sector lens, edge focusing, magnetic quadrupole lens.

Unit-III   (16Hrs.)

Particle Accelerators: Introduction, development of accelerators. Direct-voltage accelerators: Cockroft-Walton generator, Van de Graff generator, Tandem accelerators, Pelletron**.**
Resonance Accelerators: Cyclotron—fixed and variable energy, principles and longitudinal dynamics of the Uniform field cyclotron. Linear accelerators.

Unit-IV   (16Hrs.)

Electron Accelerators: Betatron, Beam focusing and Betatron Oscillation, Microtron. Synchronous accelerators: Principle of phase stability, Mathematical theory for Principle of phase stability. Electron synchrotron. Proton synchrotron. Alternating gradient machines: Alternating gradient principle, AG proton synchrotron.

References:
1. Townsend P.D., Kelly J.C. and Hartley N.E.W., **"Ion implantation, sputtering and their applications"**, Academic Press, London, 1976.
2. Humphrey S. Jr., **"Principles of charged particle acceleration"**, John Wiley, 1986.
3. Arya A.P., **"Fundamentals of nuclear physics"**, Allyn and Bacon, USA, 1968.
4. Ghoshal S.N., **"Atomic and nuclear physics"**, Vol. 2, S.Chand and Company, Delhi, 1994.
5. Varier K.M., Joseph A. and Pradyumnan P.P., **"Advanced experimental techniques in modern physics"**, Pragathi Prakashan, Meerut, 2006.

Semester-IV
20PHYE 4.4f: Radiation Physics and Dosimetry

Course Objectives:

- To understand the reason for environmental radiation. Illustrate the sources of radiation and their interaction mechanism with matter.
- To demonstrate and understand the principles of radiation dosimetry, dosimeters and detectors.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Explains the reason for background radiation and radon in the atmosphere.
CO 2. Understand the photon and charged particle interaction mechanism with matter.
CO 3. See how interaction mechanisms applicable to choose dosimeter materials. Demonstrate the principle of dosimetry and identify the need of dosimeter
CO 4. Illustrate and explain the type dosimeter needed for different of type radiations and explain the procedure for preparation different dosimeters.

Semester-IV
20PHYE 4.4f: Radiation Physics and Dosimetry

Unit-I (16Hrs.)

Radioactivity: Radioactive decay law, Successive disintegration (No derivation), Secular equilibrium, Transient equilibrium, Natural Radioactive series, Units of radioactivity.

Background Radiation: Classification of Radiation, Background Radiation, Characteristic Radiation, Continuous Radiation. Radioactivity in Atmosphere. Radon, Properties of Radon, Origin of Radon, Radon in the atmosphere.

Unit-II (16Hrs.)

Interaction of Photons with Matter: General Aspects, Attenuation Coefficients, Classical, Coherent and Incoherent Scattering, Photoelectric Effect, Pair Production.

Interactions of Charged Particles with Matter: General Aspects, Stopping Power Range, Heavy Charged Particles, Light Charged Particles, Energy Deposition, Radiation Yield, Bremsstrahlung Targets.

Unit-III (16Hrs.)

Dosimetric Principles, Quantities and Units: Fluence and energy fluence, absorbed dose, Kerma, Inter relationships, Fluence and dose (electrons), Energy fluence and kerma (photons), Kerma and dose (electronic equilibrium), Kerma and exposure. Inhalation dose, ingestion dose, working level.

Radiation Dosimeters and Detectors: Desirable properties, Ionization chambers and electrometers, Environmental dosimeters, TLD, Solid state Nuclear Track Detectors.

Unit-IV (16Hrs.)

Neutron Standards & Dosimetry: Neutron classification, neutron sources, Neutron standards - primary standards, secondary standards, Neutron yield and fluence rate measurements, Manganese sulphate bath system, precision long counter, Activation method. Neutron spectrometry, threshold detectors, scintillation detectors & multi-spheres, Neutron dosimetry, Neutron survey meters, calibration, neutron field around medical accelerators – Proportional counter – CR-39 Dosimetry.

References:
1. Krane K.S., **"Introductory nuclear physics"**, Wiley, New York, 1955.
2. Krane K., **"Modern Physics"**, John Wiley and Sons, Inc. 1998.
3. Evans R.D., **"The atomic nucleus"** , Tata McGraw Hill, New Delhi, 1980.
4. Wilkening M., **"Radon in the environment"**, Elsevier Science Publishers, AE Amsterdam, The Netherlands, 1990.
5. Kapoor S.S. and Ramamoorthy V., **"Nuclear radiation detectors"**, Wiley Eastern, Bangalore,2007.
6. F.H. Attix. **"Introduction to Radiological Physics and Radiation dosimetry",** Viley-VCH, Verlog, 2004.
7. Knoll G.F., **"Radiation detection and measurement"**, John Wiley and sons, 1979.

Semester-IV
20PHYE 4.4g: Nuclear Spectroscopy Methods

Course Objectives:

- To demonstrate and understand the ion implantation techniques. Present the need of backscattering spectroscopy. In-depth analysis of Compton scattering and to illustrate Compton scattering for metal, ionic and covalent crystals.
- To outline and understand the principle, theory and experimental methods of positron annihilation spectroscopy.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Describes the ion implantation techniques.
CO 2. Explains the importance of backscattering spectroscopy and analyze Compton scattering to realize its importance.
CO 3. Demonstrate and understand the positron annihilation spectroscopy principle.
CO 4. Analyze the various experimental methods and identify the possible application of various nuclear spectroscopy methods.

Semester-IV
20PHYE 4.4g: Nuclear Spectroscopy Methods

Unit-I (16Hrs.)

Ion implantation and backscattering spectroscopy: Ion implantation, Implantation technique, Ion beam diffusion, Thermal annealing and sputtering, Analysis techniques. Backscattering, Energy loss and straggling. Kinematics factor, differential scattering cross sections, depth scale, backscattering yield, instrumentation. Application to elemental and compound targets. Axial and planar half angles. Estimates of minimum yield. Lattice location of impurities, alignment procedures. Ion induced X-rays. Application of ion implantation.

Unit-II (16Hrs.)

Compton Scattering: Compton scattering from free electrons. Effects of external potential. Klein-Nishina cross sections for polarized and unpolarized radiation. Compton profiles, momentum distributions and impulse Compton profiles. Calculation of Compton profiles for electron models. Relativistic profile corrections: experimentation. Discussion of methodology including sources, de-tectors and geometry. Data accumulation, analysis and multiple scattering corrections. Discussion of experimental results for some simple metals, ionic and covalent crystals.

Unit-III (16Hrs.)

Positron Annihilation Spectroscopy: The positron and its discovery, Positronium, its characteristics, formation. Spur model and Ore gap model of positronium formation. Quenching and enhancement. Theory of 2-gamma and 3-gamma annihilations. Positron and positronium states in solids: trapping of positrons. Two state trapping model.

Unit-IV (16Hrs.)

Experimental Methods of Positron Annihilation Spectroscopy: Positron lifetime techniques (PLT), Angular Correlation of Annihilation Radiation (ACAR), Doppler broadening (DB) and Coincidence DB. Methods of data analysis: PLT and ACAR. Experimental results of some metals and defected materials. Interpretation of the experimental results. PAS in the study of polymers. Multiparameter techniques. A brief mention of slow positron beams.

References:
1. Townsend P.D., Kelly J.C. and Hartley N.E.W., **"Ion implantation, sputtering and their applications"**,Academic Press, London, 1976.
2. ChuW.K., Mayer J.W. and Nicholate Mar A.O., **"Backscattering spectroscopy"**, Academic Press,New York, 1978.
3. Mayer J.W. and Rimini B. (Eds.), **"Ion beam handbook for material analysis"**, Academic Press, 1977.
4. Williams B. (Ed.), **"Compton scattering"**, McGraw-Hill, New York, 1977.Hautojarvi P. (Ed.), Positrons in solids, Springer Verlag, New York, 1979.
5. Fava R.A. (Ed.), **"Methods of experimental physics"**, Academic Press, New York, 1980.
6. Schradev D.M. and Jean Y.C., **"Positron and positronium chemistry"**, Elsevier Science Publication,Amsterdam, 1988.
7. Jayaram B., **"Mass spectrometry−Theory and applications"**, Plenum Press, New York, 1966.

Semester-IV
20PHYE 4.4d: Biophysics

Course Objectives:

- To understand the underlying principles of Physics of Biological processes.
- To illustrate the applicability of thermodynamic concepts to Biological processes. Demonstrate the applications of various Physics techniques for the study of biological system.

Course Outcomes:

After successful completion of this course, students will be able to:

CO 1. Explain the various principles of Physics of Biological processes.

CO 2. Demonstrate the applications of thermodynamics and XRD for the understanding the biological system.

CO 3. Apply the knowledge of molecular spectroscopy to understand the biological system.

CO 4. Illustrate the applications of Nuclear magnetic resonance (NMR) for the study of biological system.

Semester-IV
20PHYE 4.4d: Biophysics

Unit-I **(16Hrs.)**

The broad characteristics of a typical cell-cell organelles-The molecular composition of a cell. Biological molecules and their general character-Cell Behavior-Viruses-Genetics and Biophysics. Molecular Physics. The conservation of energy in biological process-Metabolism or chemical energy turnover-Statistical thermodynamics and biology-The theory of absolute reaction rates-Thermal inactivation.

Unit-II **(16Hrs.)**

The entropy transfer of living organisms-Information Theory-Relation between information and entropy-Information content of some biological systems-Information content of a bacterial cell. Determination of size and shape of molecules-Random motion-diffusion-sedimentation-Optical Methods-Rotational diffusion and birefringence. X-ray analysis and molecular structure-diffraction of x-rays-crystal structure and the unit cell.

Unit-III **(16Hrs.)**

Diffraction patterns of some protein fibers-the structure of globular proteins-the structure of polypeptide chains-the pleated sheets and beta keratin-the alpha-helix and alpha-keratin-the structure of nuclei acids polymers - the structure of nucleoproteins-the analysis of virus structures. Absorption spectroscopy-vibrations of polyatomic molecules-characteristic bond frequencies-Raman spectra and the dipolar nature of amino acids- the vibrational spectra of proteins-the energy levels of hydrogen bonded structures.

Unit-IV **(16Hrs.)**

Absorption coefficient and cross section- Experimental techniques for absorption measurements- Absorption by oriented dipoles-dichroic ratios of proteins and nucleic acids electronic spectra of polyatomic molecules-Ultraviolet absorption by proteins and nucleic acids- The fine structure in spectra-Polarized ultra violet light- electron spin resonance(briefly)-Nuclear magnetic resonance (brief).

References:
1. Setlow R.B. and Pollard E.C., **"Molecular biophysics",** Pergamon Press, London-Paris 1962.
2. Volkenshtein M.V., **"Biophysics"**, Mir Publishers, Moscow, 1983.
3. Sam K., **"Biophysics"**, Rajat Publication, 2005.
4. Rodney C., **"Biophysics"**, Johy-Wiley, 2004.
5. Glaser R., **"Biophysics-An introduction"**, Springer, 2004.
6. Nihaluddin, **"A Textbook of biophysics",** Sonali Publications, 2009.

Semester-IV
20PHYL 4.5b: Nuclear Physics Lab

List of Experiments

(At least Eight of the following to be performed)

1. Determination of end point energy of Beta rays using Feather analysis method.
2. Determination of end point energy of Beta rays using plastic scintillation detector (Fermi-Curie plot).
3. Construct and study the variable delay line circuit.
4. To construct and study the Schmitt trigger and hence find threshold upper voltage, lower threshold voltage and hysteris voltage.
5. Construct and study the performance of liner pulse amplifier.
6. Construct and study the transistorized binary circuit.
7. Randomicity of radioactive decay.
8. Determination of end point energy of Beta rays using Nomogram method.
9. Study the variation of energy resolution of NaI (Tl) spectrometer as a function of energy.
10. To determine the activity of unknown gamma source using GRS.
11. Study the linearity of NaI (Tl) gamma ray spectrometer and hence determine the energy of gamma rays of unknown radioactive source.

(Additional experiments may be added with BOS approval)

Question Paper Pattern
M.Sc. Physics (CBCS) (2020-21 onwards)
I/II/III/IV Semester M.Sc. Examination, Month, Year
(2020-21 CBCS; New Syllabus)
Physics
Course Code: Course Title

Time: 3 Hours   **Max. Marks: 70**

Part-A

1. **Answer any five of the following:**   **(2×5=10)**

a)

b)

c)

d)

e)

f)

Part-B

(10x4=40)

2. From Unit-I

or

3. From Unit-I

4.From Unit-II

or

5.From Unit-II

6. From Unit-III

or

7. From Unit-III

8. From Unit-IV

or

9. From Unit-IV

Part-C

10. **Answer any four of the following:**   **(5X4=20)**

    Note: *One problem from each Unit. Remaining two questions from any unit.*

    a.

    b.

    c.

    d.

    e.

    f.

***