ದಾವಣಗೆರೆ ವಿಶ್ವವಿದ್ಯಾನಿಲಯ

ಪ್ರೊ. ಎಮ್. ಎನ್. ಕಳಸದ
ಅಧ್ಯಕ್ಷರು
ಭೌತಶಾಸ್ತ್ರ ಅಧ್ಯಯನ ಮಂಡಳಿ(P.G., BOS)
ದಾವಣಗೆರೆ ವಿಶ್ವವಿದ್ಯಾನಿಲಯ.
ದಾವಣಗೆರೆ- 577 007

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ಸಂಖ್ಯೆ/ದಾವಿವಿ/ಭೌತಶಾಸ್ತ್ರವಿ/2024-25/40

ದಿನಾಂಕ:24-09-2024

ಗೆ,

ಮಾನ್ಯ ಕುಲಸಚಿವರು
ದಾವಣಗೆರೆ ವಿಶ್ವವಿದ್ಯಾನಿಲಯ
ಶಿವಗಂಗೋತ್ರಿ, ದಾವಣಗೆರೆ-02

ಮಾನ್ಯರೆ,

ವಿಷಯ : ಭೌತಶಾಸ್ತ್ರ ಅಧ್ಯಯನ ಸ್ನಾತಕೋತ್ತರ ಪದವಿ (PG) ಪರಿಷ್ಕೃತ ಪಠ್ಯಕ್ರಮವನ್ನು ಕಳುಹಿಸುತ್ತಿರುವ ಕುರಿತು.

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ಮೇಲ್ಕಂಡ ವಿಷಯಕ್ಕೆ ಸಂಬಂಧಿಸಿದಂತೆ, ಸ್ನಾತಕೋತ್ತರ ಪದವಿ (PG) ಪರಿಷ್ಕೃತ ಪಠ್ಯಕ್ರಮವನ್ನು ಹಾಗೂ Curriculum Structure ನ್ನು ಭೌತಶಾಸ್ತ್ರ ಅಧ್ಯಯನ ಮಂಡಳಿಯಲ್ಲಿ (PG) ಅನುಮೋದಿಸಿ ದ್ವಿ ಪ್ರತಿಯಲ್ಲಿ ಪಠ್ಯಕ್ರಮವನ್ನು ತಮ್ಮ ಕಛೇರಿಗೆ ಸಲ್ಲಿಸುತ್ತಿದ್ದೇನೆ.

ವಂದನೆಗಳೊಂದಿಗೆ,

ತಮ್ಮ ವಿಶ್ವಾಸಿ,

Chairman
Department of Physics
Davangere University
Shivagangothri, DAVANGERE-07
Karnataka, India

ಅಡಕಗಳು: 1. ಪಠ್ಯಕ್ರಮ
2. ನಡಾವಳಿಗಳು

DAVANGERE UNIVERSITY

Department of Studies in Physics

PROCEEDINGS OF THE BOS MEETING

The Board of Studies (BOS) in Physics (P.G.) met on 23rd September, 2024 at 11.00 AM in the Department of Studies in Physics, Davangere University, Shivagangothri, Davangere. The following are the members of the board.

1. Prof. M. N. KALASAD	Chairman
2. Prof. M. K. RABINAL	External Member
3. Prof. N. NAGAIAH	External Member
4. Dr. K. M. ESHWARAPPA	Member
5. Dr. PRASANNA G. D.	Member
6. Dr. ASHWAJEET J. S.	Member

Sl. No.	Agenda of the BOS meeting
1	Revision of P.G. Physics Syllabus (CBCS) to be effective from the academic year 2024-25.
2	Question paper pattern - P. G. Physics to be effective from the academic year 2024-25.
3	Approval of value added courses.
3	Panel of examiners.

Resolution:

- The board members have discussed the revision of P. G. Physics program structure and syllabus to be effective from the academic year 2024-25 as per the CBCS scheme. The board has considered and approved the revised P. G. Physics syllabus from the academic year 2024- 25.
- The P. G. Physics question paper pattern was discussed and approved to be effective from the academic year 2024-25.
- The panel of examiners is approved by the board.

The meeting ended with thanks to the members by the Chairman.

Signature of the Committee Members:

1. Prof. M. N. KALASAD 23/9/24
2. Prof. M. K. RABINAL 23.9.24
3. Prof. N. NAGAIAH
4. Dr. K. M. ESHWARAPPA
5. Dr. PRASANNA G D 23/09
6. Dr. ASHWAJEET J S 23/9

M. N. Kalasad 23/9/2024.
Chairman – BoS

Chairman
Board of Studies
Department of Physics
Davangere University
Shivagangotri, Davangere-07

Davangere University

Shivagangotri, Davangere- 577007

Department of Studies in Physics

Syllabus for M. Sc., PHYSICS

Choice Based Credit System (CBCS)

Effective from 2024-25

Chairman
Board of Studies
Department of Physics
Davangere University
Shivagangotri, Davangere-07

Registrar
Davangere University
Shivagangotri, Davangere.

Dr. U.S. MAHABALESHWAR
M.Sc., M.Phil., Ph.D.
Professor & Dean, Science & Technology
Davangere University, Shivagangotri,
Davangere-577 007, Karnataka, India.

DAVANGERE UNIVERSITY

Shivagangothri, Davangere-577 007

Post- Graduate Programme - Choice Based Credit Scheme (CBCS)

Master of Science (M.Sc.) in Physics **Syllabus: 2024-2025 onwards**

Structure, Course Titles, Workload & Credits

Course Number	Theory /Practicals	Workload per Week	Semester-I	Semester-II	Semester-III		Semester-IV			
I	Theory-1	T-4	Mathematical Methods of Physics	Mathematical and Computational Physics	Quantum Mechanics-II		Instrumentation Techniques			
II	Theory-2	T-4	Classical Mechanics	Quantum Mechanics-I	General Nuclear Physics		Statistical Mechanics			
III	Theory-3	T-4	Electrodynamics and Plasma Physics	Atomic and Molecular Physics	Advanced Condensed Matter Physics (CMP) -I / Advanced Nuclear Physics (NP) -I		Advanced Condensed Matter Physics (CMP)-II/ Nuclear Physics (NP)-II			
IV	Theory-4	T-4	Electronics	General Condensed Matter 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	Materials Characterization	4.4f	Accelerator Physics
					3.4b	Astrophysics	4.4b	Solar and Hydrogen Energy	4.4g	Radiation Physics and Dosimetry
					3.4c	Nanophysics	4.4c	Polymer Composites	4.4h	Nuclear Spectroscopy Methods
							4.4d	Biophysics	4.4d	Biophysics
							4.4e	Quantum Computing	4.4e	Quantum Computing
Course Related Practicals 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 Lab	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, 80 Marks for Dissertation and 20 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)						
Mandatory Courses	+4 Hours	Functional & Communicative English	Computer Basics & Applications	1. Introduction to Energy Science						
				2. Concepts of Nanoscience						

T-Theory P-Practical

Semester	Subject/ Paper Code	Title of the Paper	Instruction Hrs./week	Marks: Examination	Marks: Internal Assessment	Marks: Total Marks	Credits	Examination duration (Hrs.)
SEMESTER-I		THEORY PAPERS						
	24PHYC 1.1	Mathematical Methods of Physics	4	70	30	100	4	3
	24PHYC 1.2	Classical Mechanics	4	70	30	100	4	3
	24PHYC 1.3	Electrodynamics and Plasma Physics	4	70	30	100	4	3
	24PHYC 1.4	Electronics	4	70	30	100	4	3
		PRACTICAL PAPERS						
	24PHYL 1.5	Electronics Lab	8	80	20	100	4	4
	24PHYL 1.6	General Physics Lab	8	80	20	100	4	4
	Mandatory Credits: English Language Communication Skill		2	---	---	---	2	---
SEMESTER-II		THEORY PAPERS						
	24PHYC 2.1	Mathematical and Computational Physics	4	70	30	100	4	3
	24PHYC 2.2	Quantum Mechanics-I	4	70	30	100	4	3
	24PHYC 2.3	Atomic and Molecular Physics	4	70	30	100	4	3
	24PHYC 2.4	General Condensed Matter Physics	4	70	30	100	4	3
		PRACTICAL PAPERS						
	24PHYL 2.5	Computational Physics lab	8	80	20	100	4	4
	24PHYL 2.6	Optics lab	8	80	20	100	4	4
	Mandatory Credits: Computer Skill		2	---	---	---	2	---
SEMESTER-III		THEORY PAPERS						
	24PHYC 3.1	Quantum Mechanics -II	4	70	30	100	4	3
	24PHYC 3.2	General Nuclear Physics	4	70	30	100	4	3
	24PHYC 3.3a 24PHYC 3.3b	Advanced Condensed Matter Physics (CMP)- I/ Advanced Nuclear Physics (NP)-I	4	70	30	100	4	3
	24PHYE 3.4a 24PHYE 3.4b 24PHYE 3.4c	Lasers and Optoelectronic Devices. Astrophysics Nanophysics	4	70	30	100	4	3
	24PHYOE 3.5a 24PHYOE 3.5b	Introduction to Energy Science Concepts of Nanoscience	2	40	10	50	2	2
		PRACTICAL PAPERS						
	24PHYL 3.6	General Nuclear Physics Lab	8	80	20	100	4	4
	24PHYL 3.7	General Condensed Matter Physics lab	8	80	20	100	4	4
SEMESTER-IV		THEORY PAPERS & PROJECT WORK/DISSERTATION						
	24PHYC 4.1	Instrumentation Techniques	4	70	30	100	4	3
	24PHYC 4.2	Statistical Mechanics	4	70	30	100	4	3
	24PHYC 4.3a 24PHYC 4.3b	Advanced Condensed Matter Physics (CMP)- II Nuclear Physics (NP)-II	4	70	30	100	4	3
	CMP 24PHYE 4.4a Materials Characterization 24PHYE 4.4b Solar& Hydrogen Energy 24PHYE 4.4c Polymer Composites 24PHYE 4.4d Biophysics 24PHYE 4.4e Quantum Computing	NP 24PHYE 4.4f Accelerating Physics 24PHYE 4.4g Radiation Physics and Dosimetry 24PHYE 4.4h Nuclear Spectroscopy Methods 24PHYE 4.4d Biophysics 24PHYE 4.4e Quantum Computing	4	70	30	100	4	3
		PRACTICAL PAPERS & STUDY TOUR/FIELD VISIT						
	24PHYL 4.5a 24PHYL 4.5b	Condensed Matter Physics lab Nuclear Physics lab	8	80	20	100	4	4
	24PHYP 4.6	Project Work	8	80	20	100	4	4
	Mandatory Credits: Personality Development		2	---	---	---	2	---
	Total Credits for the Course		136	---	---	2400	104	---

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Shivagangotri, Davangere.

Chairman
Board of Studies
Department of Physics
Davangere University
Shivagangotri, Davangere-07

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
24PHYC 1.1	Mathematical Methods of Physics	Algebra of tensors formulation of special functions, applications of matrices and integral transforms.
24PHYC 1.2	Classical Mechanics	Lagrangian, Hamiltonian and Jacobi formulations analysis of rigid body motion.
24PHYC 1.3	Electrodynamics and Plasma Physics	Felids of Moving charges, radiating systems propagation and interactions of electromagnetic waves, behaviors plasma.
24PHYC 1.4	Electronics	Usage of Op-Amp and analysis of digital electronic circuits.
24PHYL 1.5	Electronics Lab	Designing circuits and implementations.
24PHYL 1.6	General Physics Lab	Working with various devices.
Mandatory Credits: English Language Communication Skill		
24PHYC 2.1	Mathematical and Computational Physics	Working out the solution of partial differential equations. Group representation, identifying boundary conditions, errors analysis and Monte Carlo Calculations.
24PHYC 2.2	Quantum Mechanics-I	Interpretation and application of Statistical laws
24PHYC 2.3	Atomic and Molecular Physics	Wave function, working out the solution of Schrodinger, wave equation and Operator algebra.
24PHYC 2.4	General Condensed Matter Physics	Calculation of nuclear spin, IR, Raman Spectra, application of laser and Optics fiber
24PHYL 2.5	Computational Physics lab	Designing algorithm, implementation of physics problems and working with Linux operating system.
24PHYL 2.6	Optics lab	Space dynamics, remotes sensing, concepts stellar interferometer, H-R diagram and Solar system.
Mandatory Credits: Computer Skill		
24PHYC 3.1	Quantum Mechanics -II	Employing approximation methods to various systems and Dirac's Concepts.
24PHYC 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.
24PHYC 3.3a	Advanced Condensed Matter Physics	Crystal structure determination, thermal behavior of solids, structure of semiconductors and superconductors, electronic dielectric ferroelectric and magnetic properties of solids.
24PHYE 3.4a	Lasers and Optoelectronics Devices.	Pumping techniques, LASER Systems Optoelectronic devices manufacturing Process and applications.
24PHYE 3.4b	Astrophysics	Space dynamics, remote Sensing, concepts stellar interferometer H-R diagram and Solar system.
24PHYE 3.4c	Atmospheric Physics	Atmospheric Physics concepts, Monsoon dynamics, atmospheric models for pollutions studies & meteorology principle and working of Various instruments- Radar Systems.

24PHYOE 3.5a	Nanomaterials	Conventional and Non-conventional energy Sources.
24PHYOE 3.5b	Introduction to Energy Science	Physics of nanomaterials and Various techniques for the growth of nanomaterials.
24PHYL 3.6	General Nuclear Physics Lab	Handling devices -GM Counter, Gamma ray spectrometer & radioactive Sources.
24PHYL 3.7	General Condensed Matter Physics lab	X-ray diffraction analysis, measurement of energy gap, Hall co-efficient thermal expansions and Fermi energy of materials.
24PHYC 4.1	Experimental Techniques	Vacuum and cryogenic techniques radiation detectors, electrical measurements and sensors.
24PHYC 4.2a	Condensed Matter Physics (CMP)- I	Electronic, thermal and optical properties of Solids.
24PHYC 4.2b	Nuclear Physics (NP)-I	Nuclear Detectors, nuclear Pulse techniques, nuclear models timing and gamma rag Spectroscopy.
24PHYC 4.3a	Condensed Matter Physics (CMP)-II	Dielectric, ferroelectric properties of Solids, growth of nanomaterials, and studies on imperfections & dislocations.
24PHYC 4.3b	Nuclear Physics (NP)-II	Nuclear fission, neutron transport studies, analysis of nuclear rection mechanisms, & nuclear decay.
24PHYE 4.4a	Nanophysics	Growth & Characterization techniques and studies of applications.
24PHYE 4.4b	Solar& Hydrogen Energy	Photovoltaic energy conversion, solar cells, hydrogen production and storage studies and utilization of hydrogen.
24PHYE 4.4c	Polymer Composites	Concepts of Polymer Composites, functionalization of nanocomposites.
24PHYE 4.4d	Biophysics	Physics of biological Processes and Various experimental techniques.
24PHYE 4.4e	Accelerating Physics	Production of ion Sources, handling of ion sources and ion optics, Construction working and applications of particles accelerators.
24PHYE 4.4f	Radiation Physics and Dosimetry	Interaction of radiation with matter, Principles of dosimetry radiation of dosimeters.
24PHYE 4.4g	Nuclear Spectroscopy Methods	Ion implantation concepts& experimental methods of positron annellation spectroscopy.
24PHYL 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.
24PHYL 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.
24PHYP 4.6	Project Work	Problem Selection, Project Plan, instrumentation data collections, interpretation & Reporting.
Mandatory Credits: Personality Development		

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-I
24PHYC 1.1: Mathematical Methods of Physics

Course Objectives:

- 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.

Course Outcomes:

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
24PHYC 1.1: Mathematical Methods of Physics

Unit-I **(14 Hrs.)**

Vector Analysis: Vectors and scalars, dot and cross product, gradient – divergence & curl, vector integration, gauss and stokes theorem, orthogonal coordinate systems – differential vector operators, curvilinear coordinates - differential vector operators.

Tensors analysis: Space in N dimensions, Coordinate transformation, contravariant and covariant tensors, symmetric and skew-symmetric tensors, fundamental operations, matrices, metric tensor, associate tensors, Christoffel's Symbols, covariant derivative, tensor form of gradient, divergence and curl, applications.

Unit-II **(14 Hrs.)**

Special Functions: Review of second order differential equation, singular points, power series solution– Frobenius method, series solution of differential equations: Legendre, Bessel, Laguerre and Hermite polynomials, generating functions, Rodrigues formula, orthogonal properties and recurrence relations, beta and gamma functions.

Unit-III **(14 Hrs.)**

Matrices: 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.

Complex analysis: Analytic functions, Cauchy – Riemann equations, Cauchy – Riemann equations (polar form), Cauchy' s integral theorem, Cauchy integral formula, Taylor Series, Laurent's series, singularities, Cauchy's residue theorem.

Unit-IV **(14 Hrs.)**

Fourier's Integral Transforms: Introduction, Integral transforms, Fourier integrals theorem, Fourier integrals, Fourier transforms, properties of Fourier transforms, convolution theorem, Fourier transform of derivatives, relation b/w Fourier and Laplace transforms, applications of Fourier transform.

Laplace's Integral Transforms: Introduction, Laplace transform and their properties, Laplace transforms of derivatives, integral off(t), t f(t), initial and final value theorems, exponential integral function, Laplace transform of f(t)/t, error function, unit step function, periodic function, convolution theorem, inverse Laplace transforms.

References:

1. H.K. Dass and Dr. Rama Verma, **"Mathematical Physics"** 6th Edition S. Chand & Company, 2010.
2. Sathya Prakash, **"Mathematical Physics"** 6th Revised Edition Sultan Chand and Sons, 2011.
3. G. B. Arfken and H. J. Weber, **"Mathematical Methods of Physics"**, 4th Edition, Books Pvt Ltd., India, 1995.
4. B. D. Gupta, **"Fundamentals of Mathematical Physics"** 6th Edition Books and Allied (p) Ltd., 2012.
5. P. K. Chattopadhyay **"Mathematical Physics"** Wiley Eastern. 2009.
6. Sharma, **"Matrix methods and vector Spaces in Physics"** PHI. 2009.
7. G Ramachandran, M.S Vidya and Venkataraya, Vijayalakshmi, **"Introduction to vectors, axial vectors, tensors and spinors"**, Prakashana Mysuru, 2017.

Semester-I
24PHYC 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 and Lagrangian Mechanics.
CO 2. Understand and apply the Hamilton's equations to simple practical situations.
CO 3. Apply Hamilton-Jacobi Theory to simple practical situation and understand the concept of central force.
CO 4. Describe Euler's theorem, Euler's angles, Coriolis force and Four vectors.

Semester-I
24PHYC 1.2: Classical Mechanics

Unit-I **(14 Hrs.)**

Newtonian Mechanics: Mechanics of single and many particle systems - conservation laws of linear momentum, angular momentum and energy.

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; Lagrangian formulation of conservation theorems; application of Lagrangian formulation to Atwood's machine, bead sliding on a rotating wire and simple pendulum.

Variational Principle and Lagrange's equations: Hamilton variational principle; Lagrangian equations of motion from variational principle; application of variational principle to a straight line, catenoid and brachistochrone problem.

Unit-II **(14 Hrs.)**

Hamiltonian Formulation: Hamilton's equations of motion from Legendre transformations; Physical significance of Hamiltonian; Cyclic coordinates and conservation theorems; Routh's procedure; Derivation of Hamilton equation from Variational principle; Principle of least action; application of Hamiltonian formulation to a simple pendulum, charged particle in an electromagnetic field, motion of a particle in central force field.

Canonical transformations: Condition for transformation to be canonical, illustrations; Poisson brackets – Properties, Canonical equations of motion in Poisson bracket notation; Lagrange brackets, relation between Lagrange and Poisson brackets.

Unit-III **(14 Hrs.)**

Hamilton - Jacobi theory: Hamilton-Jacobi equation for Hamilton's principal function; Harmonic oscillator problem as an example of the Hamilton-Jacobi method; Hamilton-Jacobi equation for Hamilton's characteristic function.

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 and impact parameter; the Rutherford scattering problem.

Unit-IV **(14 Hrs.)**

Motion of a Rigid Body: 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.

Relativistic Mechanics: Four-dimensional formulation: four-vectors, four-velocity, four-momentum and four-acceleration; Minkowski equation of motion; Lorentz co-variant form of equation of motion.

References

1. H. Goldstein, **Classical Mechanics:** (Addison-Wesley, 1950).
2. R.G. Takawale and P. S. Puranik, **Introduction to Classical Mechanics:** (Tata McGraw, 1979).
3. N. C. Rana and P. S. Joag, **Classical Mechanics:** (Tata McGraw, 1991).
4. Landau L. D. and Lifshitz E. M., **Mechanics:** (Addition-Wesley, 1960).
5. Dr. J.C. Upadhyaya, **Classical Mechanics:** (Himalaya Publishing House, 2009).
6. Satya Prakash, **Mathematical Physics with Classical Mechanics:** (Sultan Chand and sons, 1985).

Semester-I
24PHYC 1.3: Electrodynamics and Plasma Physics

Course Objectives:

- 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.

Course Outcomes:

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 and analyze the interaction between plasma and magnetic fields, with particular emphasis on how plasmas are influenced and controlled by magnetic fields.

Semester-I

24PHYC 1.3: Electrodynamics and Plasma Physics

Unit-I **(14 Hrs.)**

Electric Multipole Moments: The electric dipole and dipole in uniform and non-uniform electric field, mutual potential energy of two dipoles-electric quadrupole 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 **(14 Hrs.)**

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 **(14 Hrs.)**

Electromagnetic waves: Monochromatic plane waves- velocity, phase and polarization. Poynting theorem. Propagation of plane electromagnetic waves in (a) conducting media (b) nonconducting medium and (c) ionized gases. Reflection and refraction of electromagnetic waves at a plane interface—Fresnel formulae for parallel and perpendicular components. Brewster law. Normal and anomalous dispersion in gases—Dispersion in liquids and solids: Clausius-Mossotti relation.

Wave guides-TE waves in a rectangular wave guide-coaxial transmission line.

Unit-IV **(14 Hrs.)**

Plasma physics: Quasi neutrality of a plasma-plasma behavior in magnetic fields, Plasma as a conducting fluid, magneto hydrodynamics, magnetic confinement, Pinch effect, instabilities in pinched plasma column, Plasma waves, plasma oscillations.

References:

1. Laud B.B., **"Electromagnetics"**, Wiley Eastern Limited, India, 2000.
2. Griffiths D.J., **"Introduction to electrodynamics"**, 5th Edn., Prentice-Hall of India, New Delhi,2006.
3. Born M. and Wolf E., **"Principles of optics"**, 6th Edn., Pergamon Press, Oxford, 1980.
4. Gupta S L, Kumar V, Singh Sp, **"Electro Dynamics"**, 22nd edition, Pragati Prakashan, 1992.
5. Jackson J.D., **"Classical electrodynamics"**, 2nd Edn., Wiley-Eastern Ltd, India, 1998.
6. Matveev A.N., **"Optics"**, Mir Publishers, Moscow, 1988.
7. Grant I.S. and Phillips W.R., **"Electromagnetism"**, John Wiley and Sons Ltd. 1975.
8. Lorrain P. and D. Corson, **"Electromagnetic Fields and Waves"**, CBS. 1986.
9. Paul Bellan, **"Fundamentals of Plasma Physics"**, CUP 2006.
10. Pramanik, **"Electromagnetism"**, PHI.
11. Bittencourt J. A., **"Fundamentals of Plasma Physics"**, Springer. 2004.
12. Choudhuri A. R., **"The Physics of Fluids and Plasmas"**, Cambridge, UP 1998.

Semester-I
24PHYC 1.4: Electronics

Course Objectives:

- 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.

Course Outcomes:

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, non-linear, filters and interface circuit and other applications of an operational amplifiers,
CO 3. Understand the different building blocks in digital electronics using logic gates and solving Boolean expressions.
CO 4. Design of applications of digital electronics as combinational and sequential logic control circuits like flip flops, shift registers, counters.

Semester-I
24PHYC 1.4: Electronics

Unit-I **(14 Hrs.)**

Operational Amplifier: Basic information of Op-Amp, Characteristics of an ideal operational amplifier - comparison with 741, IC Op-Amp 741, equivalent circuit, open loop Op-Amp configurations – differential, inverting and non-inverting amplifiers (qualitative). Op-Amp as a feedback amplifier – feedback configurations, voltage-series feedback amplifiers – negative feedback, closed loop voltage gain, input & output impedance, bandwidth and voltage follower, differential amplifiers.

Unit-II **(14 Hrs.)**

Applications of an Operational Amplifier:

Linear Applications: Summing, scaling, averaging amplifiers, ideal and practical integrator, differentiator.

Non- Linear Applications: Comparators, schmitt trigger, 555 timer - astable & monostable multivibrator,

Active Filters: First order & second order low-pass filters, first order & second order high-pass filters, band-pass filters, all pass filters (qualitative).

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

Unit-III **(14 Hrs.)**

Boolean algebra and Logic Gates: Number systems, binary, decimal, octal, hexa decimal; Boolean operations and expressions, Boolean analysis of logic gates, universal gates, simplification of Boolean expression, SOP & POS simplification, NAND and NOR implementation, Karnaugh map: two, three and four variable map, simplification of Boolean expressions using K-map, don't care conditions; Tabulation method, determination and selection of prime implicates.

Unit-IV **(14 Hrs.)**

Combinational and Sequential logic circuits: Introduction, design procedure, Digital adders and subtractors; Multiplexer and demultiplexers.

Flip Flops, types - SR, JK, D & T, MS-JK flipflops, triggering of Flip Flops, timing diagrams, Flip flop excitation tables; Registers and types; Counters, Synchronous and Asynchronous Counters.

References:

1. Ramakanth A Goyakwad, **"Op-Amp and Linear Integrated Circuits"**: 2015.
2. M. Morris Mono, **"Digital Logic and Computer Design"**, PHI,2001.
3. Albert Malvino, David J Bates, **"Electronics Principals"**2002.
4. T. L. Floyd , **"Digital Fundamentals"**, 7th edn. (Pearson Education Asia)2002.
5. S L Kakani, K C Bhandari, **"Electronic Devices and Circuits"**2012.
6. A P Malvino and D P Leach, **"Digital Principles and Applications"**, TATA McGraw Hill, 2006.
7. Robert F. Coughlin and Fredericks, Driscoll, **"Operational Amplifiers and Linear Integrated Circuits"**: PHI 2001.
8. D Chattopadhya, **"Electronics-Fundamentals and Applications"**, 2008.

Semester-I
24PHYL 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. Study of Op-Amp as an inverting and non-inverting amplifier.
3. Design and construct the practical differentiator and study its performance.
4. Design and construct the practical integrator and study its performance.
5. Construct first/second order High Pass filter and to determine cut-off frequency.
6. Construct first/second order Low Pass filter and to determine cut-off frequency.
7. Construct Astable Multivibrator and hence find its duty cycle using (IC-741/555).
8. Design and construct summing, scaling and averaging amplifier using Op-Amp.
9. Design and construct comparator and subtractor using Op-Amp.
10. Realization of all gates using NAND gates (IC-7400).
11. Realization of all gates using NOR gates (IC-7402).
12. Verification of Half and Full adder.
13. Design and construct ADC and DAC.
14. Design and verification of flip-flops.

(Department of Studies in Physics, Davangere University may add new experiments).

References:

1. Albert Malvino, "**Electronic Principles", Experimental Manual**.2015.
2. Grob, Pugh, Ponic, "**Experiments in Basic Electronics"**, McGraw Hill.1997.
3. Horowitz and Hill, "**The Art of Electronics"**, CUP. 1987.

Semester-I
24PHYL 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. Analysis of rotation vibration spectrum of a diatomic molecule (HCl/HBr).
8. Determination of Plank constant using photocell.
9. Determination of energy gap of thermistor.
10. Determination of Hartmann's constants and hence to verify the Hartmann's formula.
11. Determination of absorption coefficient of KMnO4 solution by transmission method.
12. Verification of law of intermediate metals for thermo emf.

(Department of Studies in Physics, Davangere University may add new experiments).

References:

1. Gupta and Kumar **"Practical Physics"**, Pragati Prakashan. 1976.
2. Misra and Misra **"Physics Lab",** Manual, South Asian Publishers. 2000.
3. Misra and Mohanty **"Advanced Physics Lab Manual",** South As An Publication. 2007.
4. Rajkumar and Madan Lal, **"Advanced Practical Physics"**, Kedarnath Ramnath.1963.
5. R.A. Sawyer **"Experimental Spectroscopy"**, Dover. 1963.
6. Singh and Chauhan **"Advanced Practical Physics",** 2 Vol., Pragati Prakashan. 1976.
7. Worsnop and Flint **"Advanced Practical Physics for Students",** AsiaPublishers.1971.

Semester-II
24PHYC 2.1: Mathematical and Computational Physics

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
24PHYC 2.1: Mathematical and Computational Physics

Unit-I **(14 Hrs.)**

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 **(14 Hrs.)**

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 **(14 Hrs.)**

Green's Functions and Integral Equations: Boundary value problems, Sturm-Lioville theory, Self-adjoint operators, Dirac delta functions and its properties, 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 **(14 Hrs.)**

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, 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, 2010.
2. Sathya Prakash, **"Mathematical Physics"** 6th Revised Edition Sultan Chand and Sons 2014.
3. G.B. Arfken and H. J. Weber **"Mathematical Methods of Physics"**, 4th Edition, Books Pvt Ltd., India. 1995.

4. B. D. Gupta, **"Fundamentals of Mathematical Physics"** 6th Edition Books and Allied (p) Ltd.1997.
5. P.K. Chattopadhyay **"Mathematical Physics"** Wiley Eastern 1990.
6. Sharma, **"Matrix methods and vector Spaces in Physics"** PHI 2009.
7. G Ramachandran, M S 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.2001.
9. Malvin H. Kalos and Paula A. Whitelock, **"Monte Carlo Methods"**, Second edition, Wiley-VCH, Verlag GmbH & Co. KGaA.2008.

Semester-II
24PHYC 2.2: 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
24PHYC 2.2: Quantum Mechanics - I

Unit I **(14 Hrs.)**

Fundamentals of Quantum Mechanics: Failures of classical mechanics and origin of quantum mechanics. de Broglie's hypothesis, wave particle duality, phase velocity and group velocity. Uncertainty: Principle, mathematical proof of uncertainty relation, application and illustrative examples. Complementarity and superposition principle, Expectation values Equation of motion of matter waves: time dependent and time independent Schrodinger equation, physical interpretation of wave function, Schrodinger equation in momentum space. The Ehrenfest's Theorem.

Unit II **(14 Hrs.)**

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), harmonic oscillator: energy eigenvalues, energy eigen states., raising and lowering operators.

Unit III **(14 Hrs.)**

General Formalism and Spin: Postulates of quantum mechanics, The Hilbert space, Dirac's notation, Operators: momentum operator, Hamiltonian operator, Hermitian operator & its properties, commutator algebra, unitary transformation.

Identical particles: Paulis exclusion principle, Stern Gerlach experiment, Paulis spin matrices for electron, its properties and commutation relation.

Unit IV **(14 Hrs.)**

Angular Momentum: Orbital Angular Momentum, spin angular momentum, Total Angular Momentum: Eigen values and Eigen functions of $\hat{J}^2$and $\hat{J}_z$, Eigen value of $\hat{J}_+ \ and \ \hat{J}_-$, commutator relation of total angular momentum with components, Clebsch-Gordan (CG) Coefficients and its properties and CG coefficients for $j_1 = \frac{1}{2}$and $j_2 = \frac{1}{2}$.

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. D.J. Griffiths, **"Introduction to Quantum Mechanics"** Pearson Education,2nd ed.2005.
4. Ghathak and Lokanathan, **"Principles of Quantum Mechanics"**, Macmillan,2004.
5. E. Merzbacher, "**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.
7. G., Aruldhas, "**Quantum Mechanics"**, Prentice-Hall of India. 2009,
8. V. K. Thankappan, **"Quantum Mechanics"** Quantum Mechanics", 5th edition, New Age International.

Semester-II
24PHYC 2.3: 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 diatomic and polyatomic rotors with their rotational spectra.
CO 3. Explain different oscillators with their vibrational spectra and demonstrate the IR, Raman spectroscopy techniques.
CO 4. Analyze the electronic structure of molecules and outline the properties and applications of lasers.

Semester-II

24PHYC 2.3: Atomic and Molecular Physics

Unit-I **(14 Hrs.)**

Atomic Physics: Brief review of atomic models of Bohr and Sommerfeld; Determination of spectral terms; Spin-orbit interaction: Spin-orbit interaction energy, fine structure separation; LS and jj coupling schemes: derivation of interaction energies for two valence electrons, Lande interval rule, Selection rules, Intensity relations; The breadth of spectral lines: Doppler effect, natural breadth (from classical and quantum mechanical theory), Collision damping, asymmetry and pressure shift, Stark broadening; Interaction with the external fields: Zeeman effect (Normal and anomalous); Paschen-Back effect; Stark effect.

Unit-II **(14 Hrs.)**

Rotational Spectra of diatomic molecules: Classification of molecules, Rotational spectra of diatomic molecule as a rigid diatomic molecule: Energy levels, selection rules, IR and Raman spectra, intensities of spectral lines, effect of isotopic substitution; Diatomic molecule as a non-rigid rotator: Energy levels, selection rules, IR and Raman spectra.

Rotational Spectra of polyatomic molecules: Linear molecules, Symmetric top molecules, Asymmetric top molecules.

Instrumentation for rotational spectroscopy, Chemical analysis by rotational spectroscopy.

Unit-III **(14 Hrs.)**

Vibrational Spectra of diatomic molecules: Classical and quantum theory of Raman scattering; Types of molecular vibrations; Energy levels, selection rules, IR and Raman spectra of a diatomic molecule as a (a) harmonic oscillator, (b) anharmonic oscillator, (c) vibrating rotator.

Instrumentation for vibrational spectroscopy: Fourier Transform IR instruments; Dispersive IR instruments; advantages of FT spectrometers; Intensity of Raman bands; depolarization ratio Dispersive and FT-Raman spectrometers; applications.

Unit-IV **(14 Hrs.)**

Electronic Spectra of diatomic molecules: The Born-Oppenheimer approximation; Vibrational Coarse Structure of electronic spectra: Intensity of Vibrational-Electronic Spectra, The Frank-Condon Principle; Dissociation energy; Rotational fine Structure of electronic spectra; The Fortrait Diagram; Predissociation; Instrumentation for electronic spectroscopy (Qualitative).

Lasers: Characteristics of a laser beam: Coherence of light, Spatial and temporal coherence; absorption, spontaneous and stimulated emission; Idea of light amplification; Einstein's co-efficients; Threshold condition for laser oscillation; He-Ne lasers, Ruby laser: construction and working, energy level diagram; Applications of lasers.

References:

1. H. E White, "Introduction to Atomic Spectra", McGraw Hill, 1934.
2. Rajkumar, "Atomic and molecular spectra, lasers", 5th Edition 2014.
3. G. Aruldhas, "Molecular Structure and Spectroscopy", 2nd Edition, PHI Learning Pvt. Ltd.,2007.
4. J. M. Hollas, "Modern Spectroscopy", John Wiley, 2004.
5. Banwell and McCash, "Fundamentals of Molecular Spectroscopy", Tata McGraw Hill, 1998.
6. G. Herzberg, "Spectra of Diatomic Molecules", Vol. I, Van Nostrand Company, 1950.
7. G. Herzberg, "Infrared and Raman Spectra of Polyatomic molecules", Vol.2, Van Nostrand Reinhold,1945.
8. D. A. Skoog, F. J. Holler and T. A. Nieman, "Instrumental Analysis" 5th edition, Harcourt Asia Pte. Ltd., 1998.
9. Ghatak and Tyagarjan, "Optical Electronics", Cambridge, Press, 2004.
10. B.B. Laud "Lasers and Nonlinear Optics", Wiley- Eastern Ltd, 1991.
11. Nambiar, "Lasers", New Age International, 2004.
12. W. T. Silfvast "Lasers", Cambridge Press, 1998.

Semester-II

24PHYC 2.4: 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. Synthesize knowledge from atomic structure and bonding to analyze real-world materials and deeper understanding of materials properties and behaviors.

CO 2. Identify and describe various unit cells and lattice parameters and applying the concept of reciprocal lattice and utilize it to analyze crystal structure.

CO 3. Integrate knowledge of electrical and thermal properties of solids to analyze real-world applications.

CO 4. Connect the semiconductor principles to their practical applications, identify and describe the properties of various magnetic materials and evaluate the implications of superconductivity in advanced technologies.

Semester-II
24PHYC 2.4: General Condensed Matter Physics

Unit-I **(14 Hrs.)**

Atomic structure: Drawbacks of the Rutherford Model of Atom, Bohr's theory of Hydrogen Atom, Sommerfeld's relativistic atom model, drawbacks of Bohr-Sommerfeld atom model, vector atom model, quantum number, The Pauli's Exclusion principle, electron configuration, wave mechanical concept of the atom.

Bonding in solids: Forces between atoms, cohesive energy, bonding in solids: ionic bond – bond energy of NaCl molecule, lattice energy of ionic crystal, Madelung constant of ionic crystal, calculation of repulsive exponent from compressibility data, The Born-Haber cycle, properties of ionic bonding, covalent bond – directional nature, hybridization and properties, metallic bond, hydrogen bond.

Unit-II **(14 Hrs.)**

Crystal structure: Lattice points and space lattice, the basis and crystal structure, unit cells and lattice parameters, crystal systems, crystal symmetry, Five-fold rotation axis is not compatible with lattice, translation symmetry elements, metallic crystal structure, directions, planes and Miller indices.

Reciprocal Lattice and Crystal Diffraction: Definition of Reciprocal lattice and its , properties, application FCC and BCC unit cells, Heisenberg's Uncertainty principle, Bragg's law in reciprocal lattice and its significance. Bragg's X-ray diffraction and Bragg's law. Methods of X-ray diffraction - powder crystal method, rotating crystal method, and Lauw method. Electron and neutron diffraction.

Unit-III **(14 Hrs.)**

Electrical properties of Solids: Classical free electron theory and its drawbacks, relaxation time, collision time and mean free path, quantum theory of free electrons, classical wave equation, Schrodinger's wave equation and its importance, physical significance of the Wave function ψ, Fermi-Dirac statistics and electronic distribution in solids, density of energy state and fermi energy.

Thermal properties of Solids: Specific Heat, classical theory (Dulong and Petit Law), Einstein's theory and Debye's theory of specific heat, Thermal expansion, Phonon collision process, Thermal conductivity in solids.

Unit-IV **(14 Hrs.)**

Semiconductors: Band structure of semiconductors, intrinsic semiconductors – electrons and holes, electrical conductivity extrinsic semiconductors, mechanism of current conduction, generation and recombination, mobility, Hall effect.

Magnetism and Superconductivity: Magnetic permeability, magnetization, diamagnetism, paramagnetism and ferromagnetism, the domain model, hysteresis, antiferromagnetism. *Superconductivity* - Survey of superconductivity, effects of magnetic field, critical current, Flux exclusion: The Meissner effect, Isotope effect, a Survey of BCS theory.

References:

1. S O Pillai., **"Solid State Physics"**, NAI Publishers, Tenth edition, 2023.
2. M A Wahab, **"Solid State Physics"**, Narosa Publications, Second Edition, 2011.
3. A.J. Dekkar **"Solid State Physics"**, MacMillan India Ltd., 2000.
4. C. Kittle **"Solid state Physics"**, Wiely Eastern, 1996.
5. J.P. Srivastava **"Elementary Solid-State Physics"**, PHI, 2008.
6. S L Gupta and V Kumar, "Solid State Physics", K Nath & Co Publications, 2009.

Semester-II
24PHYL 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 $m \times n$ 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.

Semester-II
24PHYL 2.6: Optics Lab

List of Experiments

(Atleast 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 Birefringence of mica 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.

(Department of Studies in Physics, Davangere University may add new experiments).

Semester-III
24PHYC 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
24PHYC 3.1: Quantum Mechanics - II

Unit I **(14 Hrs.)**

Applications of Schrodinger Wave Equation: Introduction, 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. energy eigen value and eigen functions. isotropic harmonic oscillator: energy eigen value and eigen functions. hydrogen atom and its normal state.

Unit II: **(14 Hrs.)**

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: **(14 Hrs.)**

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: **(14 Hrs.)**

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. Dirac hole theory - Negative energy states.

References:

1. Satya Prakash, **"Advanced Quantum Mechanics"** KNRN, 5th ed. 2019.
2. D.J. Griffiths, **"Introduction to Quantum Mechanics"** Pearson Education, 2nd ed.2005.
3. N. Zettili, **"Quantum Mechanics, Concepts and Applications"** John Wiley and Sons, Ltd. 2nd ed. 2009.
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
24PHYC 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
24PHYC 3.2: General Nuclear Physics

Unit-I **(14 Hrs.)**

Properties of the Nucleus: Nuclear radius-determination by mirror nuclei, mesic X-rays and electron scattering methods.

Nuclear Spin and Moments: Nuclear spin (j), magnetic dipole moment (μ). Electric quadrupole moment. Relation between j and μ on the basis of single particle model. Determination of nuclear magnetic moment by molecular beam experiment.

Nuclear Reactions: Q-value expression, threshold energy. Cross section of nuclear reaction, reactions induced by proton, neutron, deuteron and Photodisintegration. (Ref 1: 344-362).

Unit-II **(14 Hrs.)**

Nuclear models: Shell model: Magic numbers, shell model potential, spin-orbit potential. predictions of shell model: spin, parity, magnetic dipole moments, and electric quadrupole moments Liquid drop model-Weissacker's mass formula and its application to (i) stability of isobars and (ii) fission process. Fermi gas model-well depth

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 **(14 Hrs.)**

Interaction of Nuclear Radiation with Matter: 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.

Nuclear Detectors: NaI (Tl) Scintillation detector, NaI (Tl) based gamma ray spectrometer (GRS). 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 **(14 Hrs.)**

Nuclear Forces: Properties 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. S.N. Ghoshal **"Nuclear physics"**, S. Chand and Company, Delhi, 1994.
2. K.S Krane **"Introductory nuclear physics"**, Wiley, New York, 1987.
3. S.S.M. Wong **"Introductory nuclear physics"**, Prentice Hall of India, Delhi, 1998.
4. M.P. Khanna**"Introduction to particle physics"**, Prentice Hall of India, Delhi, 2008.
5. S.S. Kapoor and Ramamoorthy V., **"Nuclear radiation detectors"**, Wiley Eastern, Bangalore,2007.

6. P. Mermier and E. Sheldon **"Physics of the nuclei and particles"**, Vol. 1, Academic Press, Inc, New York and London.1967.
7. D.C. Tayal **"Nuclear Physics"**, Himalaya Publishing House, New Delhi, (Unit 1. Chapter 1, Page 6-14. Page 30- 35, 40-49. Chapter 9. Page 355-369. Chapter 10. Page 401-411.) 2012.
8. S. N. Ghoshal **"Nuclear physics"**, S. Chand and Company, Delhi, (Unit 2: Chapter 5 page 137-155, Chapter 6 page 187-204, 222, 262, Chapter 13, page 647-651, chapter 15, page 717-721.) 1994.
9. S.S.M. Wong **"Introductory nuclear physics",** Prentice Hall of India, Delhi, 1998.
10. M.P. Khanna **"Introduction to particle physics",** Prentice Hall of India, Delhi, 2008.
11. S.S. Kapoor and V. Ramamoorthy s**"Nuclear radiation detectors",** Wiley Eastern, Bangalore,2007.

Semester-III

24PHYC 3.3a: Advanced Condensed Matter Physics - I

Course Objectives:

- To understand the evolution of atomic theory and investigate the properties and behavior of different types of bonds.
- To identify and describe the unit cells, crystal structure and their symmetry properties. Familiarize students with various methods of X-ray diffractions.
- To examine the electrical and thermal properties of solids to their practical applications in materials science, electronics and engineering.
- To explore basic principles of semiconductors, examine the different types of magnetic materials and investigate the phenomenon of superconductivity.

Course Outcomes:

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

CO 1. Describe the various types of crystal defects, understand and explain the different mechanisms of atomic diffusion and describe how lattice vibrations affect various properties of materials.

CO 2. Classify materials based on their band structure (conductor, semiconductor & insulators) and describe the characteristics of Fermi surface and its importance in understanding the electronic behaviors of metals and semiconductors.

CO 3. Use fundamental theories to analyze the behaviors of dielectric and ferroelectric materials under different conditions.

CO 4. Describe the different types of magnetic behavior in solids and articulate the importance of superconducting materials in technological applications.

Semester-III

24PHYC 3.3a: Advanced Condensed Matter Physics - I

Unit-I **(14 Hrs.)**

Imperfections & Dislocations: Point imperfections, line imperfections, burgers vector and burgers circuit, presence of dislocation, motion and energy of dislocations, slip planes and slip direction, surface imperfections.

Atomic diffusion & Lattice Vibrations: Fick's first and second law, applications, diffusion mechanisms, Random Walk treatment of diffusion, The Kirkendall effect, diffusion in alkali halides, *Lattice vibrations* - dynamics of the chain of identical atoms, diatomic linear chain, identical atoms in three dimensions, experimental measurements of dispersion relation.

Unit-II **(14 Hrs.)**

Band Theory: Bloch theorem (qualitative), the Kronig-Penny model, construction of Brillouin zones, extended, reduced and periodic zone schemes, effective mass of an electron, nearly free electron model.

Fermi Surface: Fermi Surface and Brillouin zones, Harrison's method of constructing fermi surfaces, characteristics of fermi surface, effect of electric field and magnetic field on fermi surfaces, experimental study of fermi surfaces.

Unit-III **(14 Hrs.)**

Dielectrics: Dipole moment, Polarization, Macroscopic electric field, Depolarization filed, Local electric field at an atom, Lorentz field, Field of dipole inside the cavity, Dielectric Constant, Polarizability.

Ferroelectricity: Properties of ferroelectric materials, dipole theory of ferroelectricity, ionic displacement and the behavior of $BaTiO_3$ above the Curie temperature, The theory of spontaneous polarization of $BaTiO_3$, Thermodynamics of ferroelectric transitions, ferroelectric domains.

Unit-IV **(14 Hrs.)**

Magnetic Properties of Solids: Classification of magnetic materials, atomic theory of magnetism, the origin of permanent magnetic moments, Langevin's classical theory of – diamagnetism and paramagnetism, Weiss molecular field theory, ferrimagnetism and ferrites.

Superconductivity: Sources of superconductivity, origin of energy gap, London equations, penetration depth, coherence length, BCS theory, flux quantization, type I & II superconductors, Josephson effect and high Tc superconductors.

References:

1. M A Wahab, **"Solid State Physics"**, Narosa Publications, second edition, 2011.
2. S O Pillai., **"Solid State Physics"**, NAI Publishers, tenth edition, 2023.
3. Ali Omar, **"Elementary Solid-State Physics"**, Adison wisely, 2000.
4. F.W. Ackroft and N. D. Mermin, **"Solid State Physics"**, Saunders Collage, 1976.
5. A.J Dekkar **"Solid State Physics"**, MacMillan India Ltd., 2000.
6. C. Kiettle **"Solid State Physics"**, Wiley Eastern, 1996.
7. J. P. Srivastava **"Elementary Solid-State Physics"**, PHI, 2008.
8. S L Gupta and V Kumar, **"Solid State Physics"**, K Nath & Co Publications, 2009.

Semester-III
24PHYC 3.3b: Advanced 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-III
24PHYC 3.3b: Advanced Nuclear Physics (NP- I)

Unit-I **(14 Hrs.)**

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 **(14 Hrs.)**

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., memory devices and online data processing, multichannel analysers.

Unit-III **(14 Hrs.)**

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 **(14 Hrs.)**

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

Semester-III
24PHYE 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

24PHYE 3.4a: Lasers and Optoelectronic Devices

Unit-I **(14 Hrs.)**

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 **(14 Hrs.)**

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 **(14 Hrs.)**

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: heterojunction 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 **(14 Hrs.)**

Photo Detectors: Photodiode, quantum efficiency, responsivity, long-wavelength cut-off, p-i-n photodiode, avalanche photodiode (APD), heterojunction photodiodes, separate absorption and multiplication (SAM) APD, superlattice APD, phototransistors.

Modulators: Introduction, Pockels effect, optical polarization, birefringence, retardation plates, electro-optic modulator (EOM), longitudinal and transverse EOMs, acousto-optic modulator (AOM), Raman - Nath modulator, Bragg modulator.

References:

1. W. T. Silfvast, **"Laser Fundamentals"** Cambridge University Press, Second Edition.2004.
2. B.B. laud, **"Lasers and non-linear optics",** New -Age international Publisher.2011.
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. K. Thyagarajan and A. K. Ghatak **"Lasers: Theory and Applications",** McMillan India. 1981.
6. O. Swelto **"Principles of Lasers"**, Springer. 1998.
7. A.E. Sigman **"Lasers"**, University Press 1986.
8. A. K. Ghatak and K. Thyagarajan, **"Optical Electronics"**, Cambridge University Press 1997.

Semester-III
24PHYE 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
24PHYE 3.4b: Astrophysics

Unit-I **(14 Hrs.)**

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 **(14 Hrs.)**

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 **(14 Hrs.)**

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 **(14 Hrs.)**

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

Semester-III
24PHYE 3.4c: 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-III
24PHYE 3.4c: Nanophysics

Unit-I **(14 Hrs.)**

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 **(14 Hrs.)**

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 of Nanomaterials: Melting Point depression and heat capacity, Electronic and Optical properties- quantum confinement in 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 **(14 Hrs.)**

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 **(14 Hrs.)**

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. S 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. C. P. Poole and F. J. Owens, **“Introduction to Nanotechnology”**, John Wiley & Sons, Inc. 2003.
6. K. P. Jain, **“Physics of Semiconductor Nanostructures”**, Narosa 1997.

Semester-III
24PHYOE 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
24PHYOE 3.5a: Introduction to Energy Science

Unit-I **(14 Hrs.)**

Conventional Sources of Energy: Introduction, work and energy, different forms of energy, conversion of energy, power, practical units of energy, energy audit, fossil fuels and their formation, processing of coal, coal gasification and liquefaction, extraction and refining of oil, biomass energy-origin, classification and use, significance of biogas, combustion of fossil fuels, effects of carbon dioxide and monoxide.

Unit-II **(14 Hrs.)**

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. A. K. Bakshi, **"Energy"**, NBT, 1995.
2. S.P. Sukhatme and J K Nayak, **"Solar Energy"**, TMH, 2008.
3. N. Jelley, **"Renewable Energy - A Very Short Introduction",** Oxford University Press, 2020.
4. R. K. Singal, **"Non-Conventional Energy Sources"**, S.K. Kataria & Sons.2013.

Semester-III
24PHYOE 3.5b: Concepts of Nanoscience

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

24PHYOE 3.5b: Concepts of Nanoscience

Unit-I **(14 Hrs.)**

Introduction to Nanomaterials: History of nanoscience, 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. Applications of quantum dots and wires.

Unit-II **(14 Hrs.)**

Nanoscience applications in general:

Mechanical; Electrical classification metals semiconductors, insulators, band structures; mobility, resistivity, Hall effect, magneto resistance; Optical absorption and transmission, photoluminescence, electro luminescence, thermoluminescence; Magnetic magnetism and types of magnetic materials dia, para, ferro, antiferro; nano magnetism.

References:

1. C. 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. S. K Kulkarni, **"Nanotechnology-Principles and Practices"**, Capital Publishing Company, 2007.

Semester-III
24PHYL 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.

(Department of Studies in Physics, Davangere University may add new experiments).

Semester-III
24PHYL 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 energy gap by reverse saturation current of a P-N junction.
5. Determination of Curie Temperature and Energy loss of ferromagnetic core material using magnetic Hysteresis loop.
6. Study of dielectric constant and Curie temperature of ferroelectric material – $BaTiO_3$/PZT.
7. Determination of Hall co-efficient & carrier concentration using Hall effect.
8. Determination of co-efficient of Thermal expansion of materials (Al, Cu, Brass, NaCl, KCl).
9. 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).

(Department of Studies in Physics, Davangere University may add new experiments).

Semester-IV
24PHYC 4.1: Instrumentation 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.

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

Semester-IV

24PHYC 4.1: Instrumentation Techniques

Unit-I **(14 Hrs.)**

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 and other gauges; applications of vacuum systems in thin film technology and industries.

Unit-II **(14 Hrs.)**

Low temperature Physics: Review of history, general techniques internal and external work methods, adiabatic expansion, Joule-Kelvin effect, isenthalpic cooling, inversion curve; liquefaction of gases: Hampson and Linde's Process, Claude Process, Kamerlingh Onne's process; Regenerative cooling, Adiabatic demagnetization.

Design of Cryostats: Bath type and flow type cryostats.

Measurement of Low Temperature: Temperature scales; resistance thermometers, platinum resistance thermometers, thermistors, semiconductor temperature sensors, thermocouples.

Unit-III **(14 Hrs.)**

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

Measurement of electrical resistivity: Fundamentals of electrical resistivity, surface and volume resistivity; general methods: 2 and 4 probe methods, experimental techniques to avoid errors; resistivity measurement in insulators, semiconductors, and conductors. common sources of errors.

Unit-IV **(14 Hrs.)**

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, design and properties of SQUID Sensors, SQUID Magnetometers.

References:

1. **Walter Umrath,** "Fundamentals of Vacuum Technology", Leybold Vacuum Products and Reference Book, 2016.
2. **D. M. Hoffman, B. Singh, J. H. Thomas**, "Handbook of Vacuum Science and Technology", Academic Press.1997.
3. **Walt Boyes**, "Instrumentation Reference Book", Fourth edition, Elsevier, 2010.
4. **R. J. Sandberg**. "Temperature" CRC Press, 2000.
5. **Guy K. White**, "Experimental Techniques at low temperature Physics", Clarendon Press, Oxford
6. **Mohammad Matboo Ghorbani and Reza Taherian**, "Electrical Conductivity in Polymer-Based Composites: Experiments, Modelling and Applications", Elsevier, 2019.
7. **S Tumanski**, "Hand book of Magnetic Measurements", CRC Press, 2011.

Semester-IV
24PHYC 4.2: Statistical Mechanics

Course Objectives:

- 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.

Course Outcomes:

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-IV
24PHYC 4.2: Statistical Mechanics

Unit-I **(14 Hrs.)**

Concepts of Thermodynamics: Introduction, equation of state of an ideal gas, thermodynamic processes, entropy, thermodynamic potentials, maxwell's relations.

Statistical Mechanics: statistics and probability, phase space, ensembles, Liouville's theorem, postulate of equal a priori, microstate and microstates, Stirling formula, behavior of density of states, quasi-static process, equilibrium condition and constraints, reversible and irreversible process, distribution of energy between the system in equilibrium.

Unit-II **(14 Hrs.)**

Classical Statistics: Thermal interaction, heat reservoir, isolated system, system in contact with heat reservoir, applications of canonical distribution, calculation of mean values, connection with thermodynamics, grand canonical ensemble. 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.

Unit-III **(14 Hrs.)**

Quantum Statistics: Identical particles and symmetry requirements, formulation of the statistical problem, quantum distribution functions, Maxwell-Boltzmann statistics, photon statistics, Bose-Einstein statistics, Fermi-Dirac statistics, quantum statistical in the classical limit, Quantum states of a single particle, evaluation of partition function, black body radiation-Stefan-Boltzmann law, consequence of Fermi Dirac distribution, calculation of electronic specific heat.

Unit-IV **(14 Hrs.)**

Irreversible Processes and Fluctuations: Transition probabilities and master equation for an isolated system, system in contact with a heat reservoir, Brownian Motion - Langevin equation, 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., **"Statistical Mechanics"**, KNRN, 2020.
2. F. Reif **"Fundamentals of Statistical and Thermal Physics"**, McGraw Hill, 1985.
3. E.S.R. Gopal **"Statistical mechanics and properties of Matter"**, Macmillan, Indian, 1976.
4. R.K. Patria **"Statistical mechanics"**, 2nd Edition, Pergamon Press, 1972.
5. S.R.A. Salinas **"Introduction to statistical Physics"**, Springer International, 2009.
6. B.B. Laud **"Fundamental of Statistical Mechanics"**, NAI publisher, 2007.
7. Landau and Lifshitz, **"Statistical Physics"**, Pergamon Press, Oxford, 1974.
8. Srivastava and Ashok, **"Statistical Mechanics"**, PHI.2005.

Semester-IV
24PHYC 4.3a: Advanced Condensed Matter Physics - II

Course Objectives:

- To understand properties of amorphous semiconductors and liquid crystals.
- To specify the holistic view of nanomaterials and demonstrate the concepts of polymers and organic semiconductor devices.

Course Outcomes:

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

CO 1. Understand the basics of amorphous semiconductors, classification and electronic & optical properties.

CO 2. Explain the classification and properties of liquid crystals.

CO 3. Acquire the knowledge of physics of nanomaterials and different types of nanolithography techniques.

CO 4. Classify and analyze the polymers, conducting polymers and organic semiconductor devices.

Semester-IV
24PHYC 4.3a: Advanced Condensed Matter Physics - II

Unit-I **(14 Hrs.)**

Amorphous semiconductors: Introduction, amorphous semiconductors: preparation of amorphous semiconductors, classification, band structure, electronic structure -Band Tails and structural defects, electrical switching (Ovonic diode). Optical properties - fundamental optical Absorption, Urbach and weak absorption tails, photoluminescence and photoconduction.

Unit-II **(14 Hrs.)**

Liquid Crystals: Introduction, Classification, orientational order and inter-molecular forces, magnetic effects, optical properties, phase transition, doped liquid crystals and general applications. Light scattering in liquid crystals- electromagnetic, isotropic phase, Raman scattering, effect of temperature, wavelength and cell geometry.

Unit-III **(14 Hrs.)**

Nanomaterials: Introduction, classification, physics of nanomaterials – size and surface effects - density of states, widening of energy levels and surface are to volume ratio. growth of nanomaterials - organic capping, core shell structures and self-assembly-intermolecular forces]

Nanolithography: Introduction photo lithography (Optical, UV & EUV), electron beam, X- ray lithography, dip-pen lithography, immersion lithography, nanoimprint lithography and soft lithography.

Unit-IV **(14 Hrs.)**

Polymers: Basic concepts, classification of polymers, effect of temperature, mechanical properties of general polymers.

Conducting polymers: Introduction, classes, synthesis, charge transport mechanism, Fracture in polymers and applications.

Organic semiconductor devices: Introduction, electronic transitions, excitons, and Energy transfer; Charge generation and recombination mechanisms.

References:

1. C. Kittel "**Introduction to Solid State Physics**": Wiley Eastern,.2006.
2. A. J. Dekker **"Solid State Physics"**: (Prentice Hall Inc.).1956.
3. M. A. Omar **"Elementary Solid-State Physics"**: Principles and applications, (Addison-Wesley) 1993.
4. Dilip K Roy **"Physics of Semiconductor Devices"** Universities Press, 2004.
5. S. O. Pillai **"Solid State Physics"**: New Age int. Publishers, 2023.
6. IAM-Choon Khoo. **"Liquid Crystals"** Wiley-Interscience, 2nd Edition 2007.
7. J.P. Srivastava **"Elements of Solid State Physics"** 2nd Edition, PHI Learning Pvt. Ltd., Delhi, 2009.
8. D. Adler **"Amorphous Semiconductors"**: 1st Edition, Butterworth & Co Publishers, London, 1971.
9. Vasant R. Gowariker **"Polymer Science"**: 1st Edition, New Age International, 1986.
10. Arun Kumar Singh R. Gowariker **"Applied Polymer Science"**: 1st Edition, Anmol Publication, 2012.

Semester-IV
24PHYC 4.3b: Advanced 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
24PHYC 4.3b: Advanced Nuclear Physics (NP-II)

Unit-I **(14 Hrs.)**

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.

Unit-II **(14 Hrs.)**

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.

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.

Heavy Ion Physics: Special features of heavy ion Physics. Remote heavy ion electromagnetic interactions. Coulomb excitations.

Unit-III **(14 Hrs.)**

Nuclear reactions: 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. 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.

Unit-IV **(14 Hrs.)**

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

Semester-IV
24PHYE 4.4a: Materials Characterization

Course Objectives:

- To understand and apply various microscopy and diffraction techniques to analyze materials at different scales, gaining insights into their structure and composition.
- To gain proficiency in surface probe methods, such as atomic force microscopy (AFM) and scanning tunneling microscopy (STM), to characterize the surface properties and chemical states of materials with high precision.
- To achieve a thorough understanding of spectroscopic techniques to study the optical, electrical, and vibrational properties of materials, enhancing the ability to characterize their behavior.
- To develop competency in thermal analysis techniques transport measurements to assess material stability and transport properties under various conditions.

Course outcomes:

At the end of the course, students are able to:

- know the various microscopy and diffraction techniques to analyze materials at different scales and understand their structure and composition.
- Develop proficiency in surface probe analysis methods to characterize surface properties and chemical states of materials.
- Gain a thorough understanding of spectroscopic techniques to study materials' optical, electrical, and vibrational properties.
- Learn thermal analysis and transport measurement methods to evaluate material stability, conductivity, and transport properties under different conditions.

Semester-IV
24PHYE 4.4a: Materials Characterization

UNIT I **(14 Hrs.)**

Microscopy: Optical Microscopy, Scanning Electron Microscopy (SEM), Field Emission Scanning Electron Microscopy (FESEM), Energy-dispersive X-ray spectroscopy (EDS), Transmission Electron Microscopy (TEM), High resolution TEM, Selected area electron diffraction (SAED).

Diffraction Methods: Generation and detection of X-rays, Diffraction of X-rays, X-ray diffraction techniques, Electron diffraction.

UNIT II **(14 Hrs.)**

Surface Probe Analysis: Atomic Force Microscope (AFM), Scanning Tunneling Microscope (STM), X-ray photoemission spectroscopy (XPS), Angle Resolved XPS (ARPS), Rutherford Back Scattering, Carbon Dating, Ion Beam (Low energy and high energy) irradiation.

UNIT III **(14 Hrs.)**

Spectroscopy: IR Spectroscopy, FTIR, UV-Visible spectroscopy, Raman Spectroscopy, Auger Spectroscopy, Impedance Spectroscopy (Nyquist Plot, Bode Plot, Electrical {: electronic, ionic, cationic} conductivity estimation, ac conductivity and Jonscher Power law), Dielectric Spectroscopy (Cole-Cole Plot, Cole-Davidson plot, Debye Plot, loss tangent, sigma representation, relaxation time), Modulus spectroscopy.

UNIT IV **(14 Hrs.)**

Transport Number Analysis: Transference Number (Electron, ion, cation transport measurement) Analysis, IV characteristics, Activation Energy Estimation (VTF and Arrhenius), Transport Parameters analysis.

Thermal Analysis: Thermogravimetric analysis, Differential thermal analysis, Differential Scanning calorimetry, Modulated DSC, Dynamic Thermal Analysis, Universal tensile testing.

REFERENCES

1. Yang Leng, "**Materials Characterization: Introduction to Microscopic and Spectroscopic Methods**", 2nd Edition Wiley 2013.
2. Greg Haugstad, "**Atomic Force Microscopy: Understanding Basic Modes and Advanced Applications**", Wiley 2012.
3. C. Julian Chen, "**Introduction to Scanning Tunneling Microscopy**", Oxford University. 1993.
4. J. F. Watts and John Wolstenholme, "**An Introduction to Surface Analysis by XPS and AES**, Wiley 2003.

Semester-IV
24PHYE 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

24PHYE 4.4b: Solar and Hydrogen Energy

Unit-I **(14 Hrs.)**

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 **(14 Hrs.)**

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 **(14 Hrs.)**

Hydrogen Energy: relevance in relation to depletion of fossil fuels and environmental considerations. Hydrogen production: solar hydrogen through photo electrolysis 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 **(14 Hrs.)**

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"**.2020.
2. Fahrenbruch & Bube, **"Fundamentals of Solar Cells Photovoltaic Solar Energy"**.1983.
3. Fonash, **"Solar Cell Devices"**, Physics.2012.
4. Winter & Nitch (Eds), **"Hydrogen as an Energy Carrier Technologies Systems Economy"**1988.

Semester-IV
24PHYE 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
24PHYE 4.4c: Polymer Composites

Unit-I **(14 Hrs.)**

Polymer Composites: Introduction, concepts of matrix and fillers, fibrous and particulate composites. 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 **(14 Hrs.)**

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 **(14 Hrs.)**

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 **(14 Hrs.)**

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 and 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.

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
24PHYE 4.4d: Biophysics

Unit-I **(14 Hrs.)**

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 **(14 Hrs.)**

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 **(14 Hrs.)**

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 **(14 Hrs.)**

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

Semester-IV
24PHYE 4.4e: Quantum Computing

Course Objectives:

- To acquire proficiency in Hilbert spaces, bra-ket notation, and the mathematical representations of quantum states and operators.
- To develop a solid understanding of quantum phenomena, including superposition, entanglement, and quantum decoherence.
- To investigate the physical implementation of qubits using photons, electrons, ions, and other quantum systems, while addressing decoherence.
- To study and apply key quantum algorithms and analyzing their computational advantages over classical algorithms.
- To gain insight into the physical implementation of qubits using various technologies.

Course Outcomes:

After successful completing this course, students will be able to:

CO 1. Describe quantum entanglement and have a deeper understanding of quantum states.

CO 2. Demonstrate a working knowledge of quantum key exchange protocols.

CO 3. Articulate different qubit storage technologies and understand quantum gates.

CO 4. Understand decoherence and explain methods to mitigate decoherence.

CO 5. Understand basic quantum algorithms and examine algorithm structure.

CO 6. Explain the purpose and structure of quantum algorithms.

Semester-IV
24PHYE 4.4e: Quantum Computing

UNIT I **(14 Hrs.)**

Basic physics for quantum computing: Quantum physics essentials; Hilbert spaces, uncertainty, quantum sates, entanglement, Bra-Ket notation, Hamiltonian, wave function collapse, Schrödinger's equation, quantum decoherence.

Quantum Entanglement and QKD: Quantum entanglement, interpretation; the copenhagen interpretation, the many-worlds interpretation, decoherent histories, objective collapse theory. Quantum key exchange (QKE); BB84 protocol, B92 protocol, SARG04, six-state protocol.

UNIT II **(14 Hrs.)**

Quantum Architecture: Quantum bits, examples of realisations of qubits, Bloch sphere representation of a qubit. Quantum gates, Hadamard gate, Phase shift gates, Pauli gates, swap gates, Fredkin gate, Toffoli gates, controlled gates, Ising gates, Gottesman–Knill theorem, quantum Circuits.

UNIT III **(14 Hrs.)**

Quantum Hardware: Specific approaches to physically implementing qubits; Photons, electron, ions, nuclear magnetic resonance quantum computing (NMRQC), Bose-Einstein condensate quantum computing, GaAs quantum dots, superconducting junctions. Addressing decoherence; physical mechanisms to mitigate decoherence, Supercooling.

UNIT IV **(14 Hrs.)**

Quantum Algorithms: Deutsch's Algorithm, Deutsch-Jozsa Algorithm, Bernstein-Vazirani Algorithm, Simon's Algorithm, Shor's Algorithm, The Quantum Period-Finding Function, Grover's Algorithm.

References:

1. Chuck Easttom, "**Quantum Computing Fundamentals"**, Addison-Wisley, 2021.
2. Giuliano Benenti, Giulio Casati and Giuliano Strini, "**Principles of Quantum Computation and Information"**, Volume I: Basic Concepts, "World Scientific", 2004.
3. Michael A. Nielsen & Isaac L. Chuang, "**Quantum Computation and Quantum Information**, Cambridge University Press, 10th Anniversary Edition, 2010.

24PHYL 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. Study of Solar cell characteristics – illumination characteristics, V-I characteristics (I_{SC} and V_{OC}), 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.

(Department of Studies in Physics, Davangere University may add new experiments).

Semester-IV
24PHYE 4.4f: 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
24PHYE 4.4f: Accelerator Physics

Unit-I **(14 Hrs.)**

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 **(14 Hrs.)**

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 **(14 Hrs.)**

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 **(14 Hrs.)**

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

Semester-IV
24PHYE 4.4g: 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
24PHYE 4.4g: Radiation Physics and Dosimetry

Unit-I **(14 Hrs.)**

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 **(14 Hrs.)**

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 **(14 Hrs.)**

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 **(14 Hrs.)**

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

Semester-IV
24PHYE 4.4h: 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
24PHYE 4.4h: Nuclear Spectroscopy Methods

Unit-I **(14 Hrs.)**

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 **(14 Hrs.)**

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, detectors and geometry. Data accumulation, analysis and multiple scattering corrections. Discussion of experimental results for some simple metals, ionic and covalent crystals.

Unit-III **(14 Hrs.)**

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 **(14 Hrs.)**

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. P.D. Townsend, J.C. Kelly and N.E.W. Hartley **"Ion implantation, sputtering and their applications"**, Academic Press, London, 1976.
2. W.K. Chu, J.W. Mayer and M.A.O. Nicholate **"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. B. Williams (Ed.), **"Compton scattering"**, McGraw-Hill, New York, 1977.Hautojarvi P. (Ed.), Positrons in solids, Springer Verlag, New York, 1979.
5. R.A. Fava (Ed.), **"Methods of experimental physics"**, Academic Press, New York, 1980.
6. D.M. Schradev and Y.C. Jean **"Positron and positronium chemistry"**, Elsevier Science Publication, Amsterdam, 1988.
7. B. Jayaram **"Mass spectrometry–Theory and applications"**, Plenum Press, New York, 1966.

Semester-IV
24PHYE 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 7. Explain the various principles of Physics of Biological processes.
CO 8. Demonstrate the applications of thermodynamics and XRD for the understanding the biological system.
CO 9. Apply the knowledge of molecular spectroscopy to understand the biological system.
CO 10. Illustrate the applications of Nuclear magnetic resonance (NMR) for the study of biological system.

Semester-IV
24PHYE 4.4d: Biophysics

Unit-I **(14 Hrs.)**

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 **(14 Hrs.)**

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 **(14 Hrs.)**

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 **(14 Hrs.)**

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

Semester-IV
24PHYE 4.4e: Quantum Computing

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 Describe quantum entanglement and have a deeper understanding of quantum states.

CO-2 Demonstrate a working knowledge of quantum key exchange protocols.

CO-3 Articulate different qubit storage technologies and understand quantum gates.

CO-4 Understand decoherence and explain methods to mitigate decoherence.

CO-5 Understand basic quantum algorithms and examine algorithm structure.

CO-6 Explain the purpose and structure of quantum algorithms.

Semester-IV
24PHYE 4.4e: Quantum Computing

Unit-I **(14 Hrs.)**

Basics physics for quantum computing: Quantum physics essentials; Hilbert spaces, Uncertainty, Quantum Sates, Entanglement, Bra-Ket Notation, Hamiltonian, Wave Function Collapse, Schrödinger's Equation, Quantum Decoherence.

Quantum Entanglement and QKD: Quantum entanglement, interpretation; The copenhagen interpretation, The Many-Worlds interpretation, decoherent histories, objective collapse theory. Quantum key exchange (QKE); BB84 protocol, B92 protocol, SARG04, Six-State Protocol.

Unit-II **(14 Hrs.)**

Quantum Architecture: Quantum bits, examples of realisations of qubits, Bloch sphere representation of a qubit. Quantum gates, Hadamard gate, phase shift gates, Pauli gates, Swap gates, Fredkin gates, Toffoli Gates, controlled gates, ising gates, Gottesman–Knill theorem, quantum circuits.

Unit-III **(14 Hrs.)**

Quantum Hardware: Specific approaches to physically implementing qubits; photons, electron, ions, nuclear magnetic resonance quantum computing (NMRQC), Bose-Einstein Condensate Quantum Computing, GaAs Quantum Dots. Addressing Decoherence; physical mechanisms to mitigate decoherence, Supercooling.

Unit-IV **(14 Hrs.)**

Quantum Algorithms: Deutsch's Algorithm, Deutsch-Jozsa Algorithm, Bernstein-Vazirani Algorithm, Simon's Algorithm, Shor's Algorithm, The Quantum Period-Finding Function, Grover's Algorithm.

References:

1. Quantum Computing Fundamentals, Dr. Chuck Easttom, ADDISON-WISLEY, 2021.
2. Principles of Quantum Computation and Information, Volume I: Basic Concepts, Giuliano Benenti, Giulio Casati and Giuliano Strini, World Scientific, 2004.
3. Quantum Computation and Quantum Information, Michael A. Nielsen & Isaac L. Chuang, CAMBRIDGE UNIVERSITY PRESS, 10th Anniversary Edition, 2010.

Semester-IV
24PHYL 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 hysteresis 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.

(Department of Studies in Physics, Davangere University may add new experiments).

QP CODE:

I/II/III/IV Semester M. Sc. Degree Examination, Month, Year
(CBCS Scheme 2024-25 New Syllabus)
PHYSICS
Course Code: Course Title

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

PART-A

1. Answer any **five** of the following. **(2x5=10)**

a)

b)

c)

d)

e)

f)

g)

h)

PART-B

Answer any **four** of the following. **(5x4=10)**

2.

3.

4.

5.

6.

7.

PART-C

Answer any **four** of the following. **(10x4=10)**

8.

9.

10.

11.

12.

13.

*****

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