Program

M.Sc –Physics

Faculty of Sciences

Revised in June 2018

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Vision of the Institute

To be a global leader in the delivery of engineering education, transforming individuals to become creative, innovative, and socially responsible contributors in their professions.

Mission of the Institute:

1. To provide best-in-class infrastructure and resources to achieve excellence in technical education,
2. To promote knowledge development in thematic research areas that have a positive impact on society, both nationally and globally,
3. To design and maintain the highest quality education through active engagement with all stakeholders –students, faculty, industry, alumni and reputed academic institutions,
4. To contribute to the quality enhancement of the local and global education ecosystem,
5. To promote a culture of collaboration that allows creativity, innovation, and entrepreneurship to flourish, and
6. To practice and promote high standards of professional ethics, transparency, and accountability

PROGRAM ME SPECIFIC OUTCOMES (PSO)

PSO1: Students will demonstrate knowledge of mathematical physics, quantum mechanics, electrodynamics, statistical physics, and be able to apply this knowledge to analyze a variety of physical phenomena and related subjects.

PSO2: Students will acquire experimental skills which enable them to take precise measurements in physics labs and analyze the measurements to draw valid conclusions. In addition, students will exhibit skills in solving problems numerically using computer programming, plotting tools, and related software.

PSO3: Students will show enhanced oral and written scientific communication skills and be able to think critically and work independently as well as in a team and play beneficial role in the society as a person with better scientific outlook.

PROGRAMME OUTCOMES (PO)

Students of all Integrated/PG degree Programmes at the time of graduation will be able to

PO1 Science knowledge: Knowledge of basic science fundamentals

PO2 Problem analysis: Develop analytical skills to identify, formulate, analyze complex mechanisms using first principles basic sciences.

PO3 Development of solutions: Design solutions for complex chemical process problems and evolve procedures that meet the specified needs with appropriate consideration for the public health and safety and environmental considerations.

PO4 Critical review of solutions: Use of research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5 Modern analytical tool usage: Select, and apply appropriate techniques, resources, and modern analytical tools

PO6 The scientist and society: Apply reasoning through the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional chemical practice.

PO7 Environment and sustainability: Understand the impact of the chemical processes in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8 Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the chemistry practice.

PO9 Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10 Communication: Communicate effectively on complex scientific activities with the science community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11 Project management and finance: Demonstrate knowledge and understanding of the scientific and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

PO12 Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

SEMESTER I

Course Code	Course Title	L T P	Cr
18PHY501	Classical Mechanics	3 1 0	4
18PHY502	Quantum Mechanics I	3 1 0	4
18PHY503	Mathematical Physics I	3 1 0	4
18PHY504	Computational Physics	3 1 0	4
18PHY581	Advanced Physics Lab	0 0 6	2
18CUL501	Cultural Education	2 0 0	P/F
18PHY582	Simulation Lab	0 0 3	1
18PHY591	Mini Project	0 0 3	1
TOTAL			**20**

SEMESTER II

Course Code	Course Title	L T P	Cr
18PHY511	Quantum Mechanics II	3 1 0	4
18PHY512	Mathematical Physics II	3 1 0	4
18PHY513	Statistical Mechanics	3 1 0	4
18PHY514	Advanced Electrodynamics	3 1 0	4
18PHY515	Experimental Techniques	3 1 0	4
18PHY583	Advanced Electronics Lab	0 0 6	2
18AVP501	Amrita Value Programme	1 0 0	1
TOTAL			**23**

SEMESTER III

Course Code	Course Title	L T P	Cr
18PHY601	Atomic, Molecular and Optical Physics	3 1 0	4
18PHY602	Condensed Matter Physics	3 1 0	4
18PHY603	Nuclear and Particle Physics	3 1 0	4
18PHY604	Optics	3 1 0	4
	Elective	3 0 0	3
18PHY681	Spectroscopy Lab	0 0 6	2
18PHY690	Free/Open Elective / Live-in-Lab	2 0 0	2
TOTAL			**23**

SEMESTER IV

Course Code	Course Title	L T P	Cr
18PHY696	Dissertation		18
18PHY697	Viva voce		2
TOTAL			**20**
	TOTAL for 2 YR MSc		**86**

Electives

Course Code	Course Title	L T P	Cr
18PHY632	Astrophysics	3 0 0	3
18PHY633	Biophotonics	3 0 0	3
18PHY634	Earth's Atmosphere	3 0 0	3
18PHY635	Earth's Structure and E	3 0 0	3
18PHY636	Fibre-optic Sensors and Applications	3 0 0	3
18PHY637	Fibre Optics and Technology	3 0 0	3
18PHY638	Nanophotonics	3 0 0	3
18PHY639	Nonlinear Dynamics	3 0 0	3
18PHY640	Nuclear Physics	3 0 0	3
18PHY641	Optoelectronic Devices	3 0 0	3
18PHY642	Physics of Cold Atoms and Ions	3 0 0	3
18PHY643	Quantum Electrodynamics	3 0 0	3
18PHY644	Quantum Optics	3 0 0	3
18PHY645	Thin Film Technology	3 0 0	3
18PHY646	Fundamentals of Plasma Physics	3 0 0	3
18PHY336	Space Physics	3 0 0	3
18PHY648	Ultrafast lasers and Applications	3 0 0	3
18PHY649	Energy and Environment in the 21st century	3 0 0	3
18PHY650	Introduction to solar physics	3 0 0	3
18PHY651	Micro and Nano Magnetism Materials and its Applications	3 0 0	3
18PHY652	X-ray Diffraction and its Applications	3 0 0	3
18PHY653	Solar energy conversion	3 0 0	3
18PHY654	Fabrication of Advanced Solar cell	3 0 0	3
18PHY655	Astrophysics and Cosmology	3 0 0	3
18PHY656	Special Theory of Relativity	3 0 0	3

Open Electives

Course Code	Course Title	L T P	Cr
18OEL631	Advanced Statistical Analysis for Research	2 0 0	2
18OEL632	Basics of PC Software	2 0 0	2
18OEL633	Computer Hardware and Networking	2 0 0	2
18OEL634	Consumer Protection Act	2 0 0	2
18OEL635	Corporate Communication	2 0 0	2
18OEL636	Design Studies	2 0 0	2
18OEL637	Disaster Management	2 0 0	2
18OEL638	Essentials of Cultural Studies	2 0 0	2
18OEL639	Foundations of Mathematics	2 0 0	2
18OEL640	Foundations of Quantum Mechanics	2 0 0	2
18OEL641	Glimpses of Life through Literature	2 0 0	2
18OEL642	Information Technology in Banking	2 0 0	2
18OEL644	Knowledge Management	2 0 0	2
18OEL645	Marketing Research	2 0 0	2
18OEL646	Media for Social Change	2 0 0	2
18OEL647	Media Management	2 0 0	2
18OEL648	Object-Oriented Programming	2 0 0	2
18OEL649	Painting and Sculpture	2 0 0	2
18OEL650	Personal Finance	2 0 0	2
18OEL651	Principles of Advertising	2 0 0	2
18OEL652	Principles of Packaging	2 0 0	2
18OEL653	Scripting for Rural Broadcasting	2 0 0	2
18OEL654	Social Media Website Awareness	2 0 0	2
18OEL655	Theatre Studies	2 0 0	2
18OEL656	Writing for Technical Purposes	2 0 0	2
18OEL657	Yoga and Personal Development	2 0 0	2
18OEL658	Fundamentals of Legal Awareness	2 0 0	2
18OEL659	Solid Waste Management and Utilization	2 0 0	2
18OEL660	Relativistic Quantum Mechanics	2 0 0	2
18OEL661	Robotics and Biology	2 0 0	2
18OEL662	Science of Well Being	2 0 0	2
18OEL663	Operating Systems and Networks	2 0 0	2
18EN600	Technical Writing	2 0 0	2
18OEL664	BhagavatGeeta and Personality Development	2 0 0	2
18OEL665	Chemical Aspects of Forensic Science	2 0 0	2

* One Open Elective course has to be taken by each student, at 3rd semester, from the list of Open electives offered by the School.

@ Students undertaking and registering for a Live-in-Lab project can be exempted from registering for an Open Elective course in the fifth semester.

Evaluation Pattern

50:50 (Internal: External) (All Theory Courses)

Assessment	Internal	External
Periodical 1 (P1)	15	
Periodical 2 (P2)	15	
*Continuous Assessment (CA)	20	
End Semester		50

80:20 (Internal: External) (Lab courses and Lab based Courses having 1 Theory hour)

Assessment	Internal	External
*Continuous Assessment (CA)	80	
End Semester		20

70:30(Internal: External) (Lab based courses having 2 Theory hours/ Theory and Tutorial)

Theory- 60 Marks; Lab- 40 Marks

Assessment	Internal	External
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	10	
Continuous Assessment (Lab) (CAL)	40	
End Semester		30

65:35 (Internal: External) (Lab based courses having 3 Theory hours/ Theory and Tutorial)

Theory- 70 Marks; Lab- 30 Marks

Assessment	Internal	External
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	15	
Continuous Assessment (Lab) (CAL)	30	
End Semester		35

*CA – Can be Quizzes, Assignment, Projects, and Reports.

Letter Grade	**Grade Point**	**Grade Description**
O	10.00	Outstanding
A+	9.50	Excellent
A	9.00	Very Good
B+	8.00	Good
B	7.00	Above Average
C	6.00	Average
P	5.00	Pass
F	0.00	Fail

Grades O to P indicate successful completion of the course

$$CGPA = \frac{\sum (C_i x Gr_i)}{\sum C_i}$$

Where

C_i = Credit for the ith course in any semester

Gr_i= Grade point for the ith course

Cr. = Credits for the Course

Gr. = Grade Obtained

18PHY501 **Classical Mechanics** **3 1 0 4**

UNIT 1

Constrained Motion: Constraints, Classification of Constraints, Principal of Virtual Work, D'Alembert's principal and its applications.

UNIT 2

Lagrangian formulation: Generalized coordinates, Langrange's equations of motion, properties of kinetic energy function, theorem on total energy, generalized momenta, cyclic-coordinates, integrals of motion, Jacobi integrals and energy conservation, Concept of symmetry, invariance under Galilean transformation, velocity dependent potential.

UNIT 3

Hamilton's formulation: Hamilton's function and Hamilton's equation of motion, configuration space, phase space and state space, Lagrangian and Hamiltonian of relativistic particles and light rays.

UNIT 4

Canonical Transformations: Generating function, Conditions for canonical transformation and problem. **Poisson Brackets:** Definition, Identities, Poisson theorem, Jacobi-Poisson theorem, Jacobi identity,(Statement only), invariance of PB under canonical transformation.

UNIT 5

Central Force Problem:
Kepler's laws, Orbital Dynamics, Stability

Rotational Motion:
Rotating frames of reference, inertial forces in rotating frames, Larmour precision, electromagnetic analogy of inertial forces, effects of Coriolis force, Focoult's pendulum.

Course Outcomes

At the end of the course students will be able to

CO1 Understand the basic conservation laws in physics and the concept of phase portrait
CO2 Understand and apply the Lagrangian formalism to simple dynamical systems
CO3 Apply Hamilton's equations and solve dynamical systems
CO4 Apply the properties of Poisson's bracket and canonical transformations for solving simple systems
CO5 Apply the theory of Rigid body dynamics and analyze the motion of rigid bodies
CO6 Apply small oscillation theory developed in getting the frequencies of different of modes of oscillations in a coupled systems

Text Books:

H. Goldstein, Classical Mechanics, Addison – Wesly, 2E, 1980.

Reference Books:

1. Landau and Lifshitz, Mechanics, Butterworth-Heinemann, 3, 1976
2. S T Thomton and J B Marion, Classical Dynamics of Particles and Systems, Brooks Cole, 1E, 2009
3. Walter Greiner, Classical Mechanics: Systems of Particle and Hamiltonian Dynamics, Springer – Verlag, 1E, 2004

18PHY502 **Quantum Mechanics I** **3 1 0 4**

Objective

The course emphasize the students to familiarise the mathematical background (Hilbert space) required to understand the basic and applied quantum mechanics. The course further emphasize the students to understand the basic postulate and standard one dimensional problems of quantum mechanics. As outcome of the course, the students is expected to solve physical problems in few selected topics like quantum angular momentum, one and two body problems etc,.

UNIT 1:

Mathematical Introduction
Linear Vector Spaces : Basics, Inner Product Spaces , Dual Spaces and the Dirac Notation, Subspaces, Linear Operators, Matrix Elements of Linear Operators, Active and Passive Transformations, The Eigenvalue Problem, Functions of Operators and Related Concepts, Generalization to Infinite Dimensions.

UNIT 2:

Review of Classical Mechanics
The Principle of Least Action and Lagrangian Mechanics, The Electromagnetic Lagrangian, The Two-Body Problem, The Hamiltonian Formalism, The Electromagnetic Force in the Hamiltonian Scheme, Cyclic Coordinates, Poisson Brackets, and Canonical Transformations, Symmetries and Their Consequences

The Postulates of Quantum Mechanics
The Postulates, Discussion of Postulates I-III, The Schrödinger Equation, The Free Particle, The Particle in a Box, The Continuity Equation for Probability, The Single-Step Potential, The Double-Slit Experiment, Absence of degeneracy in one dimensional bound states, Ehrenfest's theorem.

UNIT 3:

The Harmonic Oscillator

Review of the Classical Oscillator, Quantization of the Oscillator (Coordinate Basis), The Oscillator in the Energy Basis, Passage from the Energy Basis to the X Basis.
Derivation of the Uncertainty Relations. (2 hours)

UNIT 4:

Systems with N Degrees of Freedom
N- Particles in One Dimension, More Particles in More Dimensions, Identical Particle
Symmetries and Their Consequences
Overview, Translational Invariance in Quantum Theory, Time Translational Invariance, Parity Invariance, Time-Reversal Symmetry

UNIT 5:

Rotational Invariance and Angular Momentum
Translations in Two Dimensions, Rotations in Two Dimensions, The Eigenvalue Problem of Angular Momentum in Three Dimensions, The Eigenvalue Problem of L^2 and L_z. Solution of Rotationally Invariant Problems
The Hydrogen Atom
The Eigenvalue Problem, The Degeneracy of the Hydrogen Spectrum, Numerical Estimates and Comparison with Experiment, Multi electron Atoms and the Periodic Table.

Course Outcomes

At the end of the course students will be able to

CO1 Understand and familiarize the mathematical background (Hilbert space) in which the basic and applied quantum mechanics are framed.
CO2 Apply the various postulates of quantum mechanics to one and three dimensional problems.
CO3 Understand the basic concepts of angular momentum and improve problem solving Skills

Text Books:

1. R Shankar, Principles of Quantum Mechanics, Pearson India (LPE), 2nd Ed., 2005.
2. JJ Sakurai, Modern Quantum Mechanics, Pearson, 1st Ed., 1994.

Referene Books:

- S Gasiorowicsz, Quantum Physics, Wiley India, 2E
- L I Schiff, Quantum Mechanics, TMH, 3E, 2010.
- David Griffiths, Introduction to Quantum Mechanics, Pearson India (LPE), 2E, 2005.

18PHY503	**Mathematical Physics 1**	**3 1 0 4**

UNIT 1:

VECTOR ANALYSIS:

Laws of vector algebra, Unit vectors, Rectangular unit vectors, Components of a vector, Scalar fields, Vector fields, Reciprocal sets of vectors, Ordinary derivatives of vectors, Space curves, Continuity and differentiability, Differen-tiation formulas, Partial derivatives of vectors Differentials of vectors, Differential geometry, Mechanics.

The vector differential operator del, Gradient, Divergence, Curl, Formulas involving del, Ordinary integrals of vectors, Line integrals, Surface integrals, Volume integrals, Divergence theorem of Gauss, Stokes' theorem, Green's theorem in the plane, integral theorems, Integral operator form for del.

Unit- II

Transformation of coordinates, Orthogonal curvilinear coordinates, Unit vectors in curvilinear systems, Arc length and volume elements, Gradient, divergence and curl, Special orthogonal coordinate systems, Cylindrical coordinates,

Spherical coordinates, Parabolic cylindrical coordinates, Paraboloidal coordinates, Elliptic cylindrical coordinates, Prolate spheroidal coordinates, Oblate spheroidal coordinates, Ellipsoidal coordinates, Bipolar coordinates.

Unit- III

TENSOR ANALYSIS:

Physical laws, Spaces of N dimensions, Coordinate transformations, The summation convention, Contravariant and covariant vectors, Contravariant, covariant and mixed tensors. The Kronecker delta. Tensors of rank greater than two. Scalars or invariants.

Tensor fields. Symmetric and skew-symmetric tensors. Fundamental operations with tensors. The line element and metric tensor.

Conjugate or reciprocal tensors. Associated tensors. Physical components. Christoffel's symbols. Transformation laws of Christoffel's symbols. Geo-desics. Covariant derivatives. Permutation symbols and tensors. Tensor form of gradient, divergence and curl. The intrinsic or absolute derivative. Relative and absolute tensors.

Unit- IV

GROUP THEORY Part – 1:

Elements of Group Theory :

Correspondences and transformations, Groups. Definitions and examples, Subgroups. Cayley's theorem, Cosets, Lagrange's theorem, Conjugate classes, Invariant subgroups, Factor groups, Homomorphism, Direct products.

Symmetry Groups :

Symmetry elements. Pole figures, Equivalent axes and planes, Two-sided axes, Groups whose elements are pure rotations, uniaxial groups, dihedral groups, The law of rational indices, Groups whose elements are pure rotations, Regular polyhedra, Symmetry groups containing rotation reflections, Adjunction of reflections to Cn, Adjunction of reflections to the groups Dn, The complete symmetry groups of the regular polyhedra, Summary of point groups. Other systems of notation, Magnetic symmetry groups (color groups).

Unit- V

Group Representations:
Linear vector spaces, Linear dependence; dimensionality, Basis vectors (coordinate axes), coordinates Mappings, linear operators, matrix representations, equivalence, Group representations, Equivalent representations, characters, Construction of representations, Addition of representations, Invariance of functions and operators, lassification of eigenfunctions, Unitary spaces; scalar product, unitary matrices, Hermitian matrices.

Unitary representations, Hilbert space, Analysis of representations, reducibility, irreducible representations. Schur's lemmas, Theorthogonality relations, Criteria for irreducibility. Analysis of representations. The general theorems. Group algebra, Expansion of functions in basis functions of irreducible representations. Representations of direct products.

Course Outcomes

At the end of the course, students should be able

CO1 To understand the basics of tensor calculus and familiarize with a range of Mathematical methods that are essential for studying different branches of physics.
CO2 To develop independent problem solving ability and enhance conceptual understanding using several mathematical techniques.
CO3 To develop required mathematical skills to study and solve problems in quantum mechanics, electrodynamics, statistical mechanics and other fields of theoretical physics.

Text Books:

1. Murray R Spiegel, Seymour Lipschutz, Schaum's Outline of Vector Analysis, 2nd Ed., Schaums' Outline Series, 2009.
2. Murray Spiegel, Vector Analysis And An Introduction To Tensor Analysis, Tata Mcgraw Hill. 1989
3. Morton Hamermesh, Group Theory and its Application to Physical Problems, Reprint Ed., Addison-Wesley Publishing Company Inc. 1989.
4. Arfken& Weber, Mathematical Methods for Physicists, Elsevier Indian Reprint, 7th Ed., 2012.

Reference Books:

1. Riley K F, Hobson M P, Bence S J, Mathematical Methods for Physics and Engineering, CUP, 3E, 2010
2. M Boas, Mathematical Methods in Physical Sciences, Wiley Indian Reprint 3E, 2006.
3. Mathews J and Walker R L, Mathematical Methods of Physics, Pearson India, 2E, 2004.

18PHY504 Computational Physics 3 1 0 4

Course Objective:

The objective of the Computational Physics course is to introduce the students to computational methods, to solve problems in physics which are hard to solve analytically. Therefore, the course is designed to make students think of programming as a way to learn physics, learn how to approach a problem computationally. It covers examples from various important core branches of Physics such as Mathematical Physics, Mechanics, Heat and Thermodynamics, Electrodynamics, Quantum Mechanics and Statistical Mechanics. The objective is to introduce computational techniques by considering one or two pedagogical examples in each of these fields and is by no means exhaustive. Students are therefore encouraged to work out further examples to consolidate their understanding of the subject through computational means.

Prerequisite:

1) Problem solving and computer programming: Introduction to Python 2) Introduction to Computational Physics.

Unit I
Methods of Mathematical Physics and introduction to programming languages: Python, Fortran/Matlab.

Unit II
Mechanics, Heat and Thermodynamics: Optimisation techniques, finite element and finite volume methods. Introduction to heat transfer.

Unit III
Electrodynamics: Boundary value problems, Solutions to Laplace Equations, finite difference method, relaxation methods. Calculations of magnetic field in a solenoid and Helmholtz coil.

Unit IV
Solutions for Quantum Mechanical problems: Functions as vectors, Differential operators as matrices, 1D potential well. Step Potentials.

Unit V
Advanced topics: Monte Carlo method for atomic collisions: Introduction to Monte Carlo method, Random Numbers, Distribution Functions, Monte-Carlo Integration, application to Coulomb collisions.

Course Outcomes

After completion of the course students will be able to

CO1 Analyze a Physics problem from the point of view of computation and compare that with a traditional analytical solution.
CO2 Able to formulate a computational method to solve a Physics problem.
CO3: Demonstrate the advantages of a computational approach over a traditional method.
CO3: Improve skills in writing a computer code in a suitable language to solve a Physics problems

Text / Reference books

1. P. Hamill, Intermediate Dynamics, Jones & Bartlett, 2010.
2. David Morin, Introduction to Classical Mechanics, Cambridge University Press, 2008.
3. Lecture notes -Numerical Methods in Quantum Mechanics - Paolo Giannozzi, 2017. (http://www.fisica.uniud.it/~giannozz/Corsi/MQ/LectureNotes/mq.pdf)
4. Computational Electrodynamics: The Finite-Difference Time-Domain Method - Allen Taflove, Susan C. Hagness, Artech. House, 2005

18PHY581 Advanced Physics Lab 0 0 6 2

1. Current-Voltage characteristics of dc glow discharge
2. Calibration of a vacuum gauge (Pirani) with the aid of McLeod gauge.
3. Mass susceptibility of paramagnetic Liquid substance by Quinkes's method
4. Studying the Hall Effect parameters
5. Elastics Constants – Elliptical and Hyperbolic Fringes
6. Skin depth in Al using electromagnetic radiation.
7. Thermionic Emission
8. Verification of Bohr's theory Franck – Hertz Experiment.
9. Stefan's constant – Black body radiation.
10. Study of plasma density, plasma conductivity and plasma temperature by glowing discharge method.
11. Van der Pauw method or Four Probe Method – Measurement of resistivity and Hall Coefficient of Thin Film .
12. e' by Millikan oil drop method.
13. Counting statistics, G.M. tube.

Course Outcomes

At the end of this course, students should be able

CO1 To expertise the usage of instruments and improve their skills pertaining to it.

CO2 To expertise the methods of error analysis and familiarize them to report their result With more precession.

CO3 To comprehend the theoretical concepts by doing the corresponding experiments.

CO4 To develop various skills such as observation, analysis, pictorial representation of the Data etc.

CO5 To verify or reproduce the concepts and results learnt in theory by performing

Experiments and compare their proximities.

18CUL501 CULTURAL EDUCATION 2 0 0 2

Objective:

Love is the substratum of life and spirituality. If love is absent life becomes meaningless. In the present world if love is used as the string to connect the beads of values, life becomes precious, rare and beautiful like a fragrant blossom. Values are not to be learned alone. They have to be imbibed into the inner sprit and put into practice. This should happen at the right time when you have vitality and strength, when your hearts are open.

The present course in value education is a humble experience based effort to lead and metamorphosis the students through the process of transformation of their inner self towards achieving the best. Amma's nectarous words of wisdom and acts of love are our guiding principles. Amma's philosophy provides an insight into the vision of our optimistic future.

1. Invocation, Satsang and Question - Answers
2. Values - What are they? Definition, Guiding Principles with examples Sharing own experiences
3. Values - Key to meaningful life. Values in different contexts
4. Personality - Mind, Soul and Consciousness - Q and A. Body-Mind-Intellect and the Inner psyche Experience sharing
5. Psychological Significance of samskara (with eg. From Epics)
6. Indian Heritage and Contribution and Q and A; Indian Ethos and Culture
7. Self Discipline (Evolution and Practice) – Q and A
8. Human Development and Spiritual Growth - Q and A
9. Purpose of Life plus Q and A
10. Cultivatingself Development
11. Self effort and Divine Grace - their roles – Q and A; - Vedanta and Creation - Understanding a spiritual Master
12. Dimensions of Spiritual Education; Need for change Lecture – 1; Need for Perfection Lecture - 2
13. How to help others who have achieved less - Man and Nature Q and A, Sharing of experiences

REFERENCES:

1. Swami AmritaswaroopanandaPuri - Awaken Children (Volume VII and VIII)
2. Swami AmritaswaroopanandaPuri - Amma's Heart
3. Swami RamakrishnandaPuri - Rising Along the Razor's Edge
4. Deepak Chopra - Book 1: Quantum Healing; Book 2: Alpha and Omega of God; Book 3: Seven Spiritual Rules for Success
5. Dr. A. P. J. Abdul Kalam - 1. Ignited Minds 2. Talks (CD)
6. Swami RamakrishnandaPuri - Ultimate Success
7. Swami JnanamritanandaPuri - Upadesamritham (Trans: Malayalam)

8. Vedanta Kesari Publication - Values - Key to a meaningful life
9. Swami Ranganathananda - Eternal values for a changing society 10 David Megginson and Vivien Whitaker - Cultivating Self Development
11. Elizabeth B. Hurlock - Personality Development, Tata McGraw Hill
12. Swami Jagatatmananda - Learn to Live (Vol.1 and 2), RK Ashram, Mylapore

Course Outcomes:

CO1: Understanding Indian culture
CO2: Understanding Indian value system, Human Development and Spiritual Growth
CO3: Learn about Dimensions of Spiritual Education

18PHY582	**Simulation Lab**	**0 0 6 2**

Mechanics:

(1) Motion of a Body Falling in Viscous Medium

(2) Motion of One-Dimensional Simple Harmonic Oscillator

(3) Motion of a Projectile Thrown Horizontally

(4) Motion of a Satellite

Waves and Optics:

(5) Construction of Standing Wave

(6) Formation of Square Wave

(7) Dispersion of Light Wave

(8) Polarization of Light Waves

Course Outcomes

At the end of the course students will be able to

CO1 Apply numerical methods to solve problems related to mechanics, wave and optics

CO2 Analyze numerical data and their physical meaning

CO3 Plotting data using various graphic tools

18PHY591 **Mini Project** **2 cr**

The aim of mini project work is to give first exposure to students on research methodology. This can include literature survey, review, data collection, theoretical / experimental work on small part of research area chosen by the faculty guiding the mini project work.

Course Outcomes:

On completion of the course the students will be able to:

CO1 Apply basic knowledge in physics and mathematics; learn to use modern experimental tools to address the real world problems and challenges that need solutions

CO2 Understand the vast array of literature in the field of interest and exposed to various research challenges

CO3 Gain knowledge of designing and execution of a research problem

CO4 Enhance the presentation and communication skills

18PHY511 **Quantum Mechanics II** **3 1 0 4**

Objective

The course emphases the students to familiarise the application of quantum mechanical postulates on single, multi body problems and method of approximations etc,.

UNIT 1:

Spin
Introduction, Nature of Spin, Kinematics of Spin, Spin Dynamics, Return of Orbital Degrees of Freedom.

UNIT 2:

Addition of Angular Momenta
Example, The General Problem, Irreducible Tensor Operators, Explanation of Some "Accidental" Degeneracies.
Variational and WKB Methods
The Variational Method, TheWentzel-Kramers-Brillouin Method.

UNIT 3:

Time-Independent Perturbation Theory
The Formalism, Some Examples, Degenerate Perturbation Theory

Time-Dependent Perturbation Theory

The Problem, First-Order Perturbation Theory, Higher Orders in Perturbation Theory, A General Discussion of Electromagnetic Interactions, Interaction of Atoms with Electromagnetic Radiation.

UNIT 4:

Scattering Theory

Introduction, Recapitulation of One-Dimensional Scattering and Overview, The Born Approximation (Time-Dependent Description), Born Again (The Time-Independent Approximation). The Partial Wave Expansion, Two-Particle Scattering.

UNIT 5:

The Dirac Equation

The Free-Particle Dirac Equation, Electromagnetic Interaction of the Dirac Particle, More on Relativistic Quantum Mechanics.

Course Outcomes

After completion of the course student should be able to:

CO1 Understand different aspects of the angular momentum, spin algebra and solve Problems related to angular momentum.
CO2 Apply the main approximation methods for stationary and time-dependent quantum mechanical problems.
CO3 Understand scattering theory and solve problems related to scattering.

TEXT BOOKS:

1. *R Shankar, Principles of Quantum Mechanics, Pearson India (LPE), 2E 2005*
2. *JJ Sakurai, Modern Quantum Mechanics, Pearson, 1E, 1994*

REFERENCE BOOKS:

1. S Gasiorowicsz, Quantum Physics, Wiley India, 2E
2. L I Schiff, Quantum Mechanics, TMH, 3E, 2010
3. David Griffiths, Introduction to Quantum Mechanics, Pearson India (LPE), 2E, 2005

18PHY512 Mathematical Physics II 3 1 0 4

UNIT 1:

GROUP THEORY Part – 2:

Irreducible Representations of the Point Symmetry Groups, Abelian groups, Nonabelian groups, Characterables for the crystal point groups, Operations with Group, Representations, Product representations (Kronecker products), Symmetrized and antisymmetrized products, The adjoint representation. The complex conjugate representation, conditions for existence of invariants, Real representations, The reduction of Kronecker products. The Clebsch-Gordan series, Clebsch-Gordan coefficients, Simply reducible groups, Three-j symbols.

Physical Applications :
Classification of spectral terms, Perturbation theory, Selection rules, coupled systems. The Symmetric Group, The deduction of the characters of a group from those of a subgroup, Frobenius' formula for the characters of the symmetric group. Graphical methods, Lattice permutations, Young patterns, Young tableaux, Graphical method for determining characters, Recursion formulas for characters, Branching laws, Calculation of characters by means of the Frobenius formula, The matrices of the irreducible representations of Sn.

Yamanouchi symbols, Hund's method, Group algebra, Young operators, The construction of product wave functions of a given symmetry, Fock's cyclic symmetry conditions, Outer products of representations of the symmetric group, Inner products. Clebsch-Gordan series for the symmetric group, Clebsch-Gordan (CG) coefficients for the symmetric group.
Symmetry properties, Recursion formulas.

Unit – II

Continuous Groups:

Summary of results for finite groups, Infinite discrete groups, Continuous groups, Lie groups, Examples of Lie groups, Isomorphism. Subgroups. Mixed continuous groups, One-parameter groups, Infinitesimal transformations, Structure constants, Lie algebras, Structure of Lie algebras, Structure of compact semisimple Lie groups and their algebras, Linear representations of Lie groups, Invariant integration, Irreducible representations of Lie groups and Lie algebras,
The Casimir operator, Multiple-valued representations. Universal covering group.

Axial and Spherical Symmetry, The rotation group in two dimensions, The rotation group in three dimensions, Continuous single-valued representations of the three-dimensional rotation group, Splitting of atomic levels in crystalline fields (single-valued representations), Construction of crystal eigenfunctions, Two-valued representations of the rotation group, The unitary unimodular group in two dimensions, Splitting of atomic levels in crystalline fields, Double-valued, representations of the crystal point groups, Coupled systems, Addition of angular momenta. Clebsch-Gordan coefficients.

Unit – II

Linear Groups in n-dimensional Space:

Irreducible Tensors, Tensors with respect to GL(n), The construction of irreducible tensors with respect to GL(n), The dimensionality of the irreducible representations of GL(n), Irreducible representations of subgroups of U(n), SU(n), The orthogonal group in n dimensions, Contraction, Traceless tensors, The irreducible representations of 0{n), Decomposition of irreducible representations of JJ{n) with respect to 0+{n), The symplectic group Sp(ri), Contraction, Traceless Tensors, The irreducible representations of Sp(n), Decomposition of irreducible representations of U(n) with respect to its simplistic subgroup.

Applications to Atomic and Nuclear Problems (Optional) 1#
The classification of states of systems of identical particles according to SU(n), Angular momentum

analysis, Decomposition of representations of SU(n) into representations of 0+(3), The Pauli principle, Atomic spectra in Russell-Saunders coupling, Seniority in atomic spectra, Atomic spectra in jj-coupling, Nuclear structure, Isotopic spin, Nuclear spectra in L-S coupling, Supermultiplets, The L-S coupling shell model, The jj-coupling shell model, Seniority in jj-coupling.

COMPLEX VAIRABLES:

COMPLEX NUMBERS :

The Real Number System, Graphical Representation of Real Numbers, The Complex Number System, Fundamental Operations with Complex Numbers, Absolute Value, Axiomatic Foundation of the Complex Number System, Graphical Representation of Complex Numbers, Polar Form of Complex Numbers, De Moivre's Theorem, Roots of Complex Numbers, Euler's Formula, Polynomial Equations, The n th Roots of Unity, Vector Interpretation of Complex Numbers, Stereographic Projection, Dot and Cross Product, Complex Conjugate Coordinates, Point Sets.

Unit –IV

FUNCTIONS, LIMITS, AND CONTINUITY:

Variables and Functions, Single and Multiple-Valued Functions, Inverse Functions, Transformations, Curvilinear Coordinates, The Elementary Functions, Branch Points and Branch Lines, Riemann Surfaces, Limits, Theorems on Limits, Infinity, Continuity, Theorems on Continuity, Uniform Continuity, Sequences, Limit of a Sequence, Theorems on Limits of, Sequences, Infinite Series.

C**OMPLEX DIFFERENTIATION AND THE CAUCHY–RIEMANN EQUATIONS:**

Derivatives, Analytic Functions, Cauchy–Riemann Equations, Harmonic Functions, Geometric Interpretation of the Derivative, Differentials, Rules for Differentiation, Derivatives of Elementary Functions, Higher Order Derivatives, L'Hospital's Rule, Singular Points, Orthogonal Families, Curves Applications to Geometry and Mechanics, Complex Differential Operators,
Gradient, Divergence, Curl, and Laplacian.

Unit – V

COMPLEX INTEGRATION AND CAUCHY'S THEOREM:

Complex Line Integrals, Real Line Integrals, Connection Between, Real and Complex Line Integrals, Properties of Integrals, Change of Variables, Simply and Multiply Connected Regions, Jordan Curve Theorem, Convention Regarding Traversal of a Closed Path, Green's Theorem in the Plane, Complex Form of Green's Theorem, Cauchy's Theorem, The Cauchy–Goursat Theorem, Morera's Theorem, Indefinite Integrals, Integrals of Special Functions, Some Consequences of Cauchy's Theorem. Cauchy's Integral Formulas, Some Important Theorems

INFINITE SERIES TAYLOR'S AND LAURENT'S SERIES:

Sequences of Functions, Series of Functions, Absolute Conver-gence, Uniform Convergence of Sequences and Series, Power Series, Some Important Theorems, Taylor's Theorem, Some Special Series, Laurent's Theorem, Classification of Singularities, Entire Functions, Meromorphic Functions, Lagrange's, Expansion, Analytic Continuation.

THE RESIDUE THEOREM EVALUATION OF INTEGRALS AND SERIES:

Residues, Calculation of Residues, The Residue Theorem, Evaluation of Definite Integrals, Special Theorems Used in Evalua-ting Integrals, The Cauchy Principal Value of Integrals, Differentiation Under the Integral Sign. Leibnitz's Rule, Summation of Series, Mittag–Leffler's Expansion Theorem, Some Special Expansions.

CONFORMAL MAPPING (Optional) 2#

Transformations or Mappings, Jacobian of a Transformation, Complex Mapping Functions, Conformal Mapping, Riemann's Mapping Theorem, Fixed or Invariant Points of a Transformation, Some General Transformations, Successive Transformations, The LinearTransformation, The Bilinear or Fractional Transformation, Mapping of a Half Plane onto a Circle, The Schwarz–Christoffel Transformation. Transformations of Boundaries in Parametric Form, Some Special Mappings,

PHYSICAL APPLICATIONS OF CONFORMAL MAPPING (Optional) 3 #

Boundary Value Problems, Harmonic and Conjugate Functions, Dirichlet and Neumann Problems, The Dirichlet Problem for the, Unit Circle, Poisson's Formula, The Dirichlet Problem for the Half Plane, Solutions to Dirichlet and Neumann Problems by Conformal Mapping, Applications to Fluid Flow, Basic Assumptions, The Complex Potential, Equipotential Lines and Streamlines, Sources and Sinks, Some Special Flows, Flow Around Obstacles, Bernoulli's Theorem, Theorems of Blasius, Applications to Electrostatics, Coulomb's Law, Electric Field Electro-static Potential, Gauss' Theorem, The Complex Electrostatic, Potential, Line Charges, Conductors, Capacitance, Applications to Heat Flow, Heat Flux, The Complex Temperature.

SPECIAL TOPICS (Optional) 4#

Analytic Continuation, Schwarz's Reflection Principle, Infinite Products, Absolute, Conditional and Uniform Convergence of Infinite Products, Some Important Theorems on Infinite Products, Weierstrass' Theorem for Infinite Products, Some Special Infinite Products, The Gamma Function, Properties of the Gamma Function, The Beta Function, Differential Equations, Solution of Differential Equations by Contour Integrals, Bessel Functions, Legendre Functions, The Hypergeometric Function, The Zeta Function, Asymptotic Series, The Method of Steepest Descents, Special Asymptotic Expansions, Elliptic Functions.

Note:The topics #1, #2, #3, and #4 may be taught if time permits.

Course Outcomes

After completion of the course, students will be able to
CO1 Solve second order differential equations with series solutions
CO2 Understand the basics and applications of Legendre polynomials
CO3 Understand the concepts of complex analysis
CO4 Apply the methods of complex analysis to evaluate definite integrals and infinite series
CO5 Familiarize various mathematical methods used in advanced physics topics to solve

associated problems.

Text Books:

1. *Murray R Spiegel, Seymour Lipschutz*, **"**Schaum's Outline of Vector Analysis, 2ed (Schaums' Outline Series)" second Edition.
2. *Murray Spiegel,* Vector Analysis And An Introduction To Tensor Analysis, Tata Mcgraw Hill.
3. *Morton Hamermesh,* Group Theory and its Application to Physical Problems, Addison-Wesley Publishing Company Inc. 1962.
4. *Arfken& Weber,* Mathematical Methods for Physicists, Elsevier Indian Reprint, 6E, 200.

Reference Books:

1. Riley K F, Hobson M P, Bence S J, Mathematical Methods for Physics and Engineering, CUP, 3E, 2010

2. M Boas, Mathematical Methods in Physical Sciences, Wiley Indian Reprint 3E, 2006

3. Mathews J and Walker R L, Mathematical Methods of Physics, Pearson India, 2E, 2004

18PHY513 Statistical Mechanics 3 1 0 4

UNIT 1

Review of thermodynamic variables and thermodynamic potentials. Review of probability functions-random walk problem.

UNIT 2

Foundations of statistical mechanics-specification of states of a system-contact between statistics and thermodynamics-classical ideal gas-entropy of mixing and Gibb's paradox

UNIT 3

Micro canonical ensemble - phase space - trajectories and density of states - Lowville's theorem - canonical and grand canonical ensembles-partition function - calculation of statistical quantities - Energy and density fluctuations.

UNIT 4

Statistics of indistinguishable particles - Maxwell- Boltzman, Fermi Dirac and Bose Einstein statistics-properties of ideal Bose and Fermi gases-Bose-Einstein condensation

UNIT 5

Phase transitions- phase diagram for a real gas- Analogy of fluid and magnetic systems- Cluster expansion of classical gas - Landau theory of phase transition - critical indices - scale transformation and dimensional analysis.

Course Outcomes

At the end of the course, students will be able to

CO1 Apply basic knowledge of Thermodynamics co-ordinates and potentials to systems
CO2 Understand the statistical nature with specific examples of binomial and poison's distributions
CO3 Understand the concept of micro canonical ensembles and relations between partition function and thermo dynamical potentials
CO4 Apply statistical relations in phase transition problems of Liquid – Vapor phase
CO5 Application of statistical relations to study para, Ferromagnetism and Superconducting phase transitions

Text Books:

F Reif, Foundations of Statistical and Thermal Physics, TMH, IE, 2011

Reference Books

1. Silivio Salinas, Introduction to Statistical Physics, Springer Indian Reprint, IE, 2006
2. Statistical Mechanics - R K Pathria
3. Statistical and Thermal Physics – Landau and Lifshitz
4. Statistical Physics- An Introductory course, Daniel J Amit and Yosef Verbin- World Scientific Co Pvt Ltd, 1995

18PHY514 Advanced Electrodynamics 3 1 0 4

Course Objective:

Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: The connection between Electromagnetic phenomena and light, Wave equations for electromagnetic waves, Reflection and Transmission in dielectric media, Reflection and Transmission in conducting media, Waveguides, Radiation, Power radiated by a point charge, The physical basis of radiation reaction. Special theory of relativity and its connection to Electrodynamics, Applications of electrodynamics in modern experimental techniques, Basic charged particle optics, Theory of linear accelerators.

Unit 1

The wave equation, Sinusoidal waves, Boundary conditions: Reflection and Transmission Polarization, The wave equation for E and B, Monochromatic plane waves, Energy and Momentum in Electromagnetic Waves, Propagation in linear media, Reflection and Transmission at Normal Incidence, Reflection and Transmission at Oblique Incidence.

[14 hrs]

Unit 2

Electromagnetic Waves in Conductors, Reflection at a Conducting Surface, The frequency dependence of Permittivity, Wave Guides, The waves in a Rectangular Wave Guide, The Coaxial Transmission Line.

[12 hrs]

Unit 3

Definition of radiation, Electric dipole radiation, Magnetic dipole radiation, Radiation from an arbitrary source, Power radiated by a point charge, Radiation reaction, The physical basis of radiation reaction.

[10 hrs]

Unit 4

Einstein's postulates, Geometry of relativity, The Lorentz transformations, The Structure of space time, Proper time and proper velocity, Relativistic energy and momentum, Relativistic kinematics, Relativistic dynamics, Magnetism as a relativistic phenomenon, How the fields transform, The field tensor, Electrodynamics in tensor notation.

[14 hrs]

Unit 5

Applications of electrodynamics in modern experimental techniques, Basic charged particle optics, Theory of linear accelerators, Wancroft accelerators, pulsed drift tubes, rflinacs, circular accelerators and synchrotron radiation. Basic beam line equipment and design.

[10 hrs]

Course Outcomes

After completion of the course, students will be able to

CO1 : Understand energy and momentum associated with electromagnetic waves and the propagation of electromagnetic waves in linear medium

CO2: Apply the concept of propagation of em waves in wave guides to understand the Designing aspects of a simple microwave wave guide.

CO3 Understand the physical basis of simple dipole radiation and radiation reaction

CO4 Apply the concepts of relativistic principles to understand electrodynamics

CO5 Apply the concepts of electrodynamics in modern experimental techniques

Textbooks

1. Introduction to electrodynamics – David J Griffiths, 4th edition, Pearson publication

Reference books

1. J.D. Jackson, Classical Electrodynamics, 3E, Wiley, 2007
2. W, Greiner, Classical Electrodynamics, 1E, Springer, 2006
3. The Physics of Particle Accelerators: An Introduction - Klaus Wille, Oxford University Press,

2000

18PHY515 EXPERIMENTAL TECHNIQUES 3 1 0 4

Expected Outcomes:

(a) Build up on existing idea of probability to analyse continuous distribution functions
(b) Review error propagation and linear/non linear regression analysis
(c) Introduction and definite level of understanding in principles of diffraction, and spectroscopy

Unit I:

Error and data analysis:
Review of error analysis – estimate confidence intervals – statistical inferences – linear and non linear regression analysis including analysis of fits (LI^2 test), correlation analysis (R^2)

Unit II:

Review of Fourier Transforms:
Time domain and frequency domain spectra, Implementing Fast Fourier Transforms.

Unit III:

X-ray diffraction and detectors
Production of X-rays, Scattering from an electron, atom and unit cell (calculation of structure factors), Powder X-ray diffraction and determination of crystal structures from diffraction data, particle and photon detectors: GM counter, Scintillation detector, Proportional counter

Unit IV:

Microscopy
Scanning electron microscopy and transmission electron microscopy – Discussion of electron sources, Secondary and Back scattered electrons, analytical electron microscopy, electron diffraction, amplitude and phase contrast microscopy.

Unit V:

Spectroscopy
Review of IR, EPR and NMR spectral lines including selection rules, calculation of *g*-factor, instrumentation for IR, EPR and NMR

Course Outcomes:

At the end of the course students will be able to

CO1 Understand the existing idea of probability to analyze continuous distribution functions
CO2 Apply error analysis and quantification of error propagation in linear/non-linear

systems

CO3 Understand and apply Fourier transforms and their relevance in extracting signals from time domain and displaying in frequency domain

CO4 Understand the principles of diffraction, and various types of spectroscopy.

CO5 Interpret 1D X-ray diffraction data, understand imaging modes in microscopes and interpretation of signals from various spectroscopic instruments

Text Books:

For Error analysis (Unit I):

1. Bevington and Robinson, Data Reduction and Error Analysis for the physical sciences, 3rd Ed., McGraw-Hill Education, 2002.
2. John. R Taylor, An introduction to error analysis: The study of uncertainties in physical measurements, 2nd Ed., University Science Books, 1997.

For Fourier Transforms (Unit II):

1. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Ed., Wiley, 2015.
2. J. F James, A students guide to Fourier Transforms, 3rd Ed., Cambridge University Press, 2012.

For X-ray diffraction and detection (Unit III):

1. S S Kapoor and V S Ramamoorthy, Nuclear Radiation detectors, New Age International, 1993.
2. RamakanthHebbar, Basics of X-ray diffraction and its applications, 1st Ed., I. K. International Publishing House, 2011.
3. B E Warren, X-ray diffraction, New edition Ed., Dover Publications Inc. 1990.

For Microscopy (Unit IV):

1. Ray F Egerton, Physical Principles of Electron Microscopy: An introduction to SEM, TEM and AEM, Springer, 2005.

For Spectroscopy (Unit V):

1. Colin Banwell, Elaine Mccash, Fundamentals of Molecular spectroscopy, McGraw Hill Education, 4th Ed., 1994.
2. “Instrumental methods of analysis” by Williams, Merrit, Dean and Settle (***Chemistry section of our library***)

Reference books:

1. Schaums Series on Probability and Statistics
2. “Elements of X-ray diffraction”, B. D. Cullity
3. “Transmission electron microscopy” by Williams and Carter
4. “X-ray diffraction : In crystals, Imperfect crystals and amorphous bodies” by A Guiner
5. “X-ray diffraction” by West

18PHY583 ADVANCED ELECTRONICS LAB 0 0 6 2

Design and study of CE amplifier with and without feedback, two stage amplifier, Power amplifier, Differential amplifier, Voltage regulated power supplies with Zener diodes and transistors, Design of basic DL. TI and TTL logic gates, RS and JK flip flops using NOR-NAND gates, Schmitt trigger using op-amp, Uses of IC 741, Phase shift oscillator, 555 timer, three terminal IC voltage regulator, Familiarization of 8085 kit and programming, A/D and D/A converters, control of stepper motor.

Course Outcomes

At the end of the course students will be able to:

CO1 Apply the technical knowledge gained from electronics courses that they have studied in design and analysis of circuits

CO2 Analyze and design simple circuits using diodes and transistors as well as higher level Circuits employing integrated-circuit operational amplifiers according to the required specifications and also to evaluate combinational and sequential logical digital circuits

CO3 Program and construct applications using a microcontroller (Arduino),

TEXTBOOK/ REFERENCES:

Paul B. Zbar& Alert P Malvino, Basic Electronics - A text-Lab Manual.

18AVP501 AMRITA VALUES PROGRAMME 1 0 0 1

Amrita University's Amrita Values Programme (AVP) is a new initiative to give exposure to students about richness and beauty of Indian way of life. India is a country where history, culture, art, aesthetics, cuisine and nature exhibit more diversity than nearly anywhere else in the world.

Amrita Values Programmes emphasize on making students familiar with the rich tapestry of Indian life, culture, arts, science and heritage which has historically drawn people from all over the world. Post-graduate students shall have to register for any one of the following courses, in the second semester, which may be offered by the respective school.

***Courses offered under the framework of Amrita Values Programme:* Art of Living through Amma**

Amma's messages can be put to action in our life through pragmatism and attuning of our thought process in a positive and creative manner. Every single word Amma speaks and the guidance received in on matters which we consider as trivial are rich in content and touches the very inner being of our personality. Life gets enriched by Amma's guidance and She teaches us the art of exemplary life skills where we become witness to all the happenings around us still keeping the balance of the mind.

Insights from the Ramayana

Historical significance of Ramayana, the first Epic in the world – Influence of Ramayana on Indian values and culture – Storyline of Ramayana – Study of leading characters in Ramayana – Influence of Ramayana outside India – Misinterpretation of Ramayana by Colonial powers and its impact on Indian life - Relevance of Ramayana for modern times.

Insights from the Mahabharata

Historical significance of Mahabharata, the largest Epic in the world – Influence of Mahabharata on Indian values and culture – Storyline of Mahabharata – Study of leading characters in Mahabharata – Kurukshetra War and its significance – Importance of Dharma in society – Message of the Bhagavad Gita - Relevance of Mahabharata for modern times.

Insights from the Upanishads

Introduction: Sruti versus Smrti - Overview of the four Vedas and the ten Principal Upanishads - The central problems of the Upanishads – Ultimate reality – thenature of Atman - the different modes of consciousness - Sanatana Dharma and its uniqueness - The Upanishads and Indian Culture – Relevance of Upanishads for modern times – A few Upanishad Personalities: Nachiketas, SatyakamaJabala, Aruni, Shvetaketu.

Insights from Bhagavad Gita

Introduction to Bhagavad Gita – Brief storyline of Mahabharata - Context of Kurukshetra War – The anguish of Arjuna – Counsel by Sri. Krishna – Key teachings of the Bhagavad Gita – Karma Yoga, Jnana Yoga and Bhakti Yoga - Theory of Karma and Reincarnation – Concept of Dharma – Idea of the Self and Realisation of the Self – Qualities of a Realised person - Concept of Avatar - Relevance of Mahabharata for modern times.

Swami Vivekananda and his Message

Brief Sketch of Swami Vivekananda's Life – Meeting with Guru – Disciplining of Narendra - Travel across India - Inspiring Life incidents – Address at the Parliament of Religions – Travel in United States and Europe – Return and reception India – Message to Indians about our duties to the nation.

Great Spiritual Teachers of India

Sri Rama, Sri Krishna, Sri Buddha, AdiShankaracharya, Sri Ramanujacharya, Sri Madhvacharya, Sri Ramakrishna Paramahamsa, Swami Vivekananda, Sri RamanaMaharshi, Mata Amritanandamayi Devi

Indian Arts and Literature:

The aim of this course is to present the rich literature and culture of Ancient India and help students appreciate their deep influence on Indian Life - Vedic culture, primary source of Indian Culture – Brief introduction and appreciation of a few of the art forms of India - Arts, Music, Dance, Theatre, Paintings, Sculpture and architecture – the wonder language, Sanskrit and ancient Indian Literature

Importance of Yoga and Meditation in Life:

The objective of the course is to provide practical training in YOGA ASANAS with a sound theoretical base and theory classes on selected verses of Patanjali's Yoga Sutra and Ashtanga Yoga. The coverage also includes the effect of yoga on integrated personality development.

Appreciation of Kerala's Mural Art Forms:

A mural is any piece of artwork painted or applied directly on a wall, ceiling or other large permanent surface. In the contemporary scenario Mural painting is not restricted to the permanent structures and are being done even on canvas. A distinguishing characteristic of mural painting is that the architectural elements of the given space are harmoniously incorporated into the picture. Kerala mural paintings are the frescos depicting mythology and legends, which are drawn on the walls of temples and churches in South India, principally in Kerala. Ancient temples, churches and places in Kerala, South India, display an abounding tradition of mural paintings mostly dating back between the 9th to 12th centuries CE when this form of art enjoyed Royal patronage. Learning Mural painting through the theory and practice workshop is the objective of this course.

Practicing Organic Farming

Life and nature are closely linked through the healthy practices of society for maintaining sustainability. When modern technological knowhow on microorganisms is applied in farming using the traditional practices we can avoid damage to the environment. The course will train the youth on modern practices of organic farming. Amma says “we have to return this land to the coming generations without allowing even the slightest damage to happen to it”. Putting this philosophy to practice will bring about an awakening and enthusiasm in all to strive for good health and to restore the harmony in nature”

Ancient Indian Science and Technology

Science and technology in ancient and medieval India covered all the major branches of human knowledge and activities, including mathematics, astronomy, physics, chemistry, medical science and surgery, fine arts, mechanical, civil engineering, architecture, shipbuilding and navigation. Ancient India was a land of sages, saints and seers as well as a land of scholars and scientists. The course gives an awareness on India's contribution to science and technology.

Course Outcomes:

CO1: Understanding Indian Value system

CO2: Learning for Indian historical epics

CO3: Understandin the importance of Yoga ,Meditation in Life and organic farming.

18PHY601 Atomic Molecular and Optical Physics 3 1 0 4

Course Objective:

Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: Origin of line widths and shapes in atomic spectra, Quantum number and their physical significance, Quantum mechanical states of the hydrogen atom, Effect external electric and magnetic fields on atoms, Origins of fine structure in atomic spectra, Hyperfine structure and Lamb shifts, Origin of molecular spectra, Bonding and antibonding orbitals, Molecular symmetry, Vibration spectroscopy, Einstein A and B coefficients and the relationship between them and various line broadening mechanisms.

Note:
Existing title is an obsolete usage. The new title is suggested in the brackets. Also, the existing syllabus is bit too lengthy and it has been modified with relevance to the ongoing research areas of our campus.

Unit 1

One electron atoms -1:
Brief Review of Quantum mechanics. One electron atoms: Operators and observables, Angular momentum, Schrodinger equation for one electron atoms, energy levels, eigen function of the bound states, Expectation values and the Virial theorem.

Unit 2

One electron atoms -2: Fine structure of Hydrogen like atoms, Zeeman Effect, Stark effect, Lamb shift, Hyperfine structure and isotope shifts.

Unit 3

Molecular structure and Spectra:

Nature of Molecular structure, Electronic structure of Molecules, Building principle: determination of term manifold, LCAO approximation, Molecular Orbital theory treatment of H_2^+ and H_2 electronic energy levels, σ and π – bonds, Formation of bonding and anti-bonding orbitals from atomic orbitals in simple diatomic molecules.

Unit 4

Molecular symmetry and vibrations: Properties of Symmetry, Point groups, Characters and representation groups, Reducible and irreducible representations, Normal co-ordinates and normal modes of vibration, Infrared and Raman spectra, Selection rules, Application of group theory to molecular vibrations

Unit 5

Absorption and emission of radiation: Interaction of radiation with matter, Einstein's A and B coefficients, Beer's law for normal absorption, electric dipole approximation, width and shape of spectral lines, Homogenous and inhomogeneous broadening, natural broadening, Doppler broadening, Doppler broadening: estimation of half-widths, external effects – collision broadening and pressure broadening.

Text books

1. B. H. Bransden and C. J. Joachain, Physics of Atoms and Molecules, 2nd Ed., Prentice Hall, 2003.
2. C.J. Foot, Atomic Physics, 1st Ed., Oxford Master Series in Physics, 2004.

Reference books

1. Peter W. Atkins and Ronald S. Friedman, Molecular Quantum Mechanics, 5th Ed., Oxford University Press, 2012.
2. Demtröder, Wolfgang, Atoms, Molecules and Photons: An Introduction to Atomic-Molecular- and Quantum Physics, Springer-Verlag Berlin Heidelberg, 2010.

18PHY602	**Condensed Matter Physics**	**3 1 0 4**

Prerequisites:

This course requires the basics of solid state physics, electrodynamics, quantum mechanics and statistical physics.

Course outcome:

This course gives an extended knowledge about crystalline structure and defects, electronic band structure, electrical, thermal and magnetic properties of solid state systems and their technological applications.

UNIT 1

Review on crystal physics: Crystal Structure and symmetry, Point and Space groups, Crystal systems, planes and direction, Structure Property-Relations, Diffraction of waves by crystals, Scattered wave amplitude: Fourier analysis, Reciprocal Lattice vectors, Diffraction conditions, Laue equations, Brillouin zones: Reciprocal lattice to SC, BCC and FCC lattice, Fourier analysis of Basis: Structure and atomic Form factor.

Crystal defects: Classification of defects - Points defect - The Schottky defect - The Frenkel defect - colour centers - F center - other colour centers - Dislocations - Slip and plastic deformation - Shear strength of single crystals - Edge dislocation - Screw dislocation - Stress field around an edge dislocation. (5 hrs)

UNIT 2 Metals I : The Free-Electron model

Free electron gas in three-dimension, Heat capacity of the free electrons, Electrical conductivity; effects of Fermi surface, Motion in magnetic fields; cyclotron resonance and the Hall effect, Thermal conductivity in metals

Unit 3:

Energy Bands in Solids and Fermi surfaces: Nearly free electron model: Origin of Energy Gap, Brillouin zones, Bloch functions, Construction of Fermi surfaces, Tight binding method for energy bands, Wigner-Seitz method, Cohesive energy, Pseudopotential methods, Experimental methods in Fermi surface studies; Quantization of Orbits in a Magnetic field, De Haas-van Alphen Effect, Landau levels

Superconductivity: Meissner effect, London’s equations, introduction to BCS theory and its predictions, Ginzburg-Landau theory, flux quantization, Josephson effects; application: SQUID

UNIT 4 Semiconductors

Semiconductors: energy band structure, intrinsic and extrinsic semiconductors, Fermi levels of intrinsic and extrinsic semi-conductors, Direct and indirect gap semiconductors, Effective mass, Hydrogenic model of impurity levels and p-n junctions: theory of I–V characteristics, Schottky-barrier.

UNIT 5 Magnetism

Langevin theory of diamagnetism and paramagnetism, Quantum theory of Diamagnetism of Mononuclear systems, Quantum theory of paramagnetism: Rare Earth Ions, Hund Rules, Iron group ions, Crystal field splitting, Cooling by Isentropic Demagnetization, Paramagnetic susceptibility of conduction electrons, Ferromagnetism and antiferromagnetism: Ferromagnetic order, Curie point and exchange integral, Temperature dependence of saturation magnetization, Ferrimagnetic order: Curie temperature and susceptibility of ferrimagnets, antiferromagnetic order, susceptibility below Neel temperature, Ferromagnetic domains.

Course Outcomes:

On completion of the course students will be able to

CO1 Acquire knowledge on Bravais lattices, symmetry, defects in crystals and the concepts of reciprocal lattice and diffraction

CO2 Comprehensive understanding on the basic approaches to the formation of electronic Band structure of materials and the Fermi surfaces

CO3 Understand the different theories of superconductivity and its applications

CO4 Describe the behaviour of the carriers in semiconductors, doping, formation of Junctions and their characteristics.

CO5 Acquire complete knowledge on the classical and quantum theories of the different types of magnetism and elucidate the exchange interaction and domain theories of ferromagnetism.

Text Books/ References:

1. N.W. Ashcroft and N.D. Mermin, Solid Satate Physics, Brooks Cole, 1 E12003.
2. Ibach and Luth, Soil State Physics, Springer India, 3E, 2002.
3. M.Marder, Condensesd Matter Physics, Wiley Intersciences, 1E, 2000.
4. *Charles Kittel, Introduction to Solid State Physics, Wiley, 8th Edition, Reprint: 2016*
5. M. Ali Omar, Elementary Solid State Physics: Principles and Applications, Pearson Education India.
6. Adrianus J. Dekker, Solid State Physics, Library of Congress Catalog Card No.: 57-8688, 1958.

18PHY603 Nuclear and Particle Physics 3 1 0 4

Unit I

Basic Concepts: History and Overview, Units and Dimensions, Nuclear Properties, Radius, Mass and Abundance of nuclides, Binding energy, Angular Momentum, Spin and Parity, Electromagnetic moments and Nuclear excited states

Unit II

Nuclear Stucture: The Deuteron, Nucleon-Nucleon Scattering, Proton-Protron and Neutron-Neutron Interactions, Properties of Nuclear Forces, The Exchange Force Model, Nuclear Models, Liquid-Drop Model, Shell Model, Collective Model of the Nucleus

Unit III

Radioactive Decay: Alpha Decay, The Q-value of alpha decay, Gamow's theory of alpha decay, Beta decay, Fermi theory of beta decay, Parity violation in beta decay, Gamma Decay, Internal conversion, Nuclear Isomers

Unit IV

Nuclear Reactions:The Optical Model, The Compound Nucleus and Direct Reactions, Resonance Reactions, Heavy-Ion Reactions, Nuclear Fission, Characteristics of Fission, Energy in Fission, Nuclear Fusion, Characteristics of Fusion, Solar Fusion

Unit V

Particle Physics: Particle Interactions and Families, Symmetry and Conservation laws, Standard Model, Quark Dynamics, Grand Unified Theories

Course Outcomes

After completion of the course student should be able to:

CO1: Understand the key ideas and terminologies of nuclear physics.

CO2: Understand various nuclear models and solve various problems related to nuclear structure.

CO3: Analyze and solve problems related to nuclear reactions.

CO4: Understand basic aspects of particle physics

Text Book:

S. Krane, Introductory Nuclear Physics, 2^{nd} Ed., Wiley India Pvt Ltd, 2013.

Reference Book:

V. Devanathan, Nuclear Physics, Narosa Publishing House, 2012.

8PHY604 Optics 3 1 0 4

Course Objectives:

This course is intended to impart knowledge to students in geometrical, wave, polarization optics and their usagesalong withfamiliarization of different optical techniques such as Fourier, Jones and Muller matrices for various analysis and applications

At the end of the course Students will be able to

CO1.Familiarize the fundamental principles and basic mathematical technique required to understand the optics and its related parameters

CO2 Understand the basic laws of geometrical optics and extend its knowledge in designing and utilization of various optical components

CO3 Understand basic laws of polarization and extending its knowledge in analyzing various polarization problems using Muller's and Jone's matrices

CO4. Acquire knowledge in interference and diffraction techniques and apply them to solve in various realistic problems.

CO5.Analyze the problems related to coherence, Fourier optics and its application**.**

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3			2							1	3	3		
CO2	3	3			2							1	3	3		
CO3	3	3			2							1	3	3		
CO4	3	3			2							1	3	3		
CO5	3	3			2							1	3	3		

Skills

Technique of using mirrors and lenses and its related optical components, Analysis of polarization problems using the techniques of Muller’s and Jone’s matrices, Usage of Fourier techniques in optical applications.

Unit 1

Review of basics: Wave motion in 1D: harmonic waves, phase and phase velocity, superposition principle, complex representation; Wave equation: plane, cylindrical and spherical waves and wave-fronts; Maxwell equations, EM waves, photons, and light, energy and momentum transport, radiation pressure; Propagation of light in matter, Rayleigh scattering, origin of refractive index.

Unit 2

Review of (a selection of topics in) geometric optics: reflection, refraction, total internal reflection, beam splitting; Lenses, Stops, Mirrors, Prisms, Lens &Optical systems; Introduction to wave front shaping, analytical ray tracing, aberrations; Wave optics: superposition of waves having same and different frequencies, group and phase velocities; anharmonic periodic and aperiodic waves; pulses and wave packets, natural linewidth, coherence time and length.

Unit 3

Polarization: linear, elliptical and circular polarizations; Dichorism, Birefringence, polarization by scattering and reflection; Retarders; Circular polarizers; Basics of optical activity, induced optical effects, modulators, and liquid crystals; Mathematical theory of polarization: polarization ellipse, Poincare sphere, Stokes parameters, Jones vectors & matrices.

Unit 4

Interference: introduction, conditions for interference, wavefront splitting and amplitude splitting interferometers, types and location of interference fringes, multiple beam interference, interferometry, applications; Diffraction: Introduction, Fraunhofferand Fresnel diffraction, Kirchoff's scalar diffraction theory; diffraction by circular aperture, single, double and multiple slits, diffraction grating, resolving power.

Unit 5

Fourier Optics: Fourier transforms, optical applications; Basics of Coherence Theory - introduction, visibility, mutual coherence function, degree of coherence, stellar interferometry; Basic ideas on nonlinear optics: harmonic generation, optical rectification, frequency mixing, self-focusing.

TEXTBOOKS/ REFERENCES:

1. E. Hecht and A.R. Ganesan, Optics, 4E, Pearson, 2008 (Prescribed)
2. AjoyGhatak, Optics, 5E, Tata-McGraw Hill, 2012
3. J. Peatross& M. Ware, Physics of Light and Optics (Available online at:http://optics.byu.edu/BYUOpticsBook_2013.pdf)
4. G.R. Fowles, Introduction to Modern Optics, 2E, Dover, 1989
5. M. Born M & E. Wolf, Principles of Optics, 7th Expanded Ed., CUP, 1999 (Reference)

18PHY681 SPECTROSCOPY LAB 0 0 6 2

1. Determination of Wavelength and distance between D1 & D2 of sodium vapor light using Michelson Interferometer
2. Thermal expansively using interferometric technique
3. Observation of hyperfine splitting of spectral lines - Fabry-Perot Interferometer
4. Determination of e/m of electron by Normal Zeeman effect using Fabry-Perot etalon
5. Mach-Zehnder Interferometer using a He-Ne laser.
6. Fourier Filtering
7. Measurement and analysis of fluorescence spectrum of I2 vapor
8. Measurement of optical spectrum of an alkali atoms or alkaline earth metals
9. Measurement of Band positions and determination of vibrational constants of N2 molecule
10. Electron Spin Resonance Spectroscopy.
11. Energy band gap of semiconductor by studying the luminescence spectra
12. Study of temperature variation of refractive index of a liquid using hollow prism and laser source.
13. Clausius – Mossotti equation using sugar solution.

Course Outcomes:

On completion of the course students should be able to:

CO1 Enhance instrumentation skills by constructing simple instruments related to spectroscopy
CO2 Understand the principles of spectroscopic instruments.
CO3 Obtain and analyze atomic spectra of different elements.

18PHY696 DISSERTATION 18 cr

The aim of the project work is to give more detailed exposure to the student for research methodology. This can include literature survey, review, data collection, and theoretical/ experimental work on small parts of research in area chosen by the faculty guiding the project work. If the project to be carried out at other institutions/ laboratories, the experts from these institutions are to be associated in choosing the research topic and its execution.

Course Outcomes

At the end of this course, students will be able to

CO1 Understand and practice scientific recording and reporting.
CO2 Apply and put to use the methods of analytical, logical and scientific reasoning that Have been taught in the various subjects to address a relevant real time problem with clear objectives, depth and a well articulated roadmap.
CO3 Gain better knowledge of the use of analytical, theoretical and experimental tools to solve/design/study a problem/system.
CO4 Enhance presentation and communication skills.

18PHY697 Viva-voce 1 cr

A comprehensive viva-voce will be conducted to assess the general understanding of the student in the basic courses that he/she has studied. It will not be topic-specific, but will cover both basic and PG level of physics. This is meant to evaluate the student's grasp on the subject, and also to help students face interviews.

ELECTIVES

18PHY632 Astrophysics 3 0 0 3

Unit 1

Astronomical units, Universal Law of Gravity - Derivation of Kepler's law of planetary motion,

The Sun – Structure and various layers, sunspots, flares, faculae, granules, solar wind and solar

Atmosphere, properties of solar system, solar neutrino problem, The Planets - Planetary orbits - Orbital inclination - Secondary atmospheres- The evolution of the earth's atmosphere.

Unit 2

The Hertzsprung–Russell Diagram, Saha and Boltzmann equations-derivation and interpretation, Stellar evolution, Novae, Supernova explosions, Interstellar Matter, Jean's criteria, White dwarfs -

The evolution of a sun-like star - Evolution in close binary systems –Neutron stars and black holes - The discovery of pulsars - Black holes.

Unit 3

The Milky Way - Open star clusters - Globular clusters - Size, shape and structure of the Milky Way – observations of the hydrogen line - Other galaxies - Elliptical galaxies, Spiral galaxies - The Hubble classification of galaxies - The universe – The Cepheid variable distance scale - Starburst galaxies - Active galaxies – Groups and clusters of galaxies –

Super clusters

Course Outcomes:

After completion of the course students will be able to

CO1: Learn theoretical methods and observational tools in astrophysics.

CO2: Apply theoretical models to solve astronomical problems.

CO3: Develop critical/logical thinking and scientific reasoning in the area of astrophysics.

TEXTBOOK:

B. W. Carroll and D. A. Ostlie, An Introduction to Modern Astrophysics, 2nd edition, Addison Wesley, 2006.

REFERENCE BOOK:

K. D. Abhyankar, Astrophysics: Stars and galaxies, Universities Press India Ltd, 2001.

18PHY633 BIOPHOTONICS 3 0 0 3

Unit 1

Photobiology: Interaction of light with cells and tissues, Photo–processes in Biopolymers, human eye and vision, photosynthesis. Photo-excitation: free space propagation, optical fiber delivery system, articulated arm delivery, hollow tube wave-guides. Optical coherence tomography, special and time-resolved imaging, fluorescence resonance energy transfer (FRET) imaging, nonlinear optical imaging, Bio-imaging:

Unit 2

Transmission microscopy, Kohler illumination, microscopy based on phase contrast, dark-field and differential interference contract microscopy, fluorescence, confocal and multi-photon microscopy. Applications of bio-imaging: Bio-imaging probes and fluorophores, imaging of microbes, cellular imaging and tissue imaging.

Unit 3

Optical biosensors: Fluorescence and energy transfer sensing, molecular beacons and optical geometries of bio-sensing, biosensors based on fibre optics planar waveguides, evanescent waves, interferometry and surface Plasmon resonance. Flow cytometry: Basics, fluorochromes for flow cytometry, DNA analysis.

Unit 4

Laser activated therapy: Photodynamic therapy, photo-sensitizers for photodynamic therapy, applications of photodynamic therapy, two photon photodynamic therapy. Tissue engineering using light: Contouring and restructuring of tissues using laser, laser tissue regeneration, femto-second laser surgery.

Unit 5

Laser tweezers and laser scissors, design of laser tweezers and laser scissors, optical trapping using non Gaussian optical beam, manipulation of single DNA molecules, molecular motors, lasers for genonmocs and proteomics, semiconductor quantum dots for bio imaging, metallic nano-particles and nano-rods for bio-sensing. Photonics and biomaterials: Baceria as bio-synthesizers for photonic polymers.

Course Outcome:

By the end of the course, students should be able to

CO1: Understand the interaction of light with cells and tissues, photo-excitation and optical imaging.

CO2: Acquire knowledge on the use of microscopic techniques for analyzing the biological materials and bio-imaging.

CO3: Gain knowledge on photonic biosensors, laser activated therapy, optical tweezers and the modern biophotonic techniques

Course Articulation Matrix:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	3	1			1				1			2	3		2
CO2	3	3	1			1				1			2	3		2
CO3	3	3	1			1				1			2	3		2

TEXTS:

1. *Introduction to Bio-photonics- V N Prasad (Wiley-Interscience April 2003)*
2. *Biomedical photonics: A Handbook - Tu Vo Dinh (CRC Press, Boca Raton, FL 2003)*

REFERENCES:

1. A Handbook of Optical Biomedical diagnostics, SPIE press monograph vol pm 107

2. *Biomedical Optics - Principles and Imaging - Lihong V and Hsin-IWU, Wiley Interscience 1 sted, 2007*
3. *Optical coherence Tomography - Principles and Applications – Mark E.Brezinski, (Academic press 1st ed, 2006)*
4. *Biophysics - An Introduction - Rodney cotterill, (John Wiley Student edition)*

18PHY634 EARTH’S ATMOSPHERE 3 0 0 3

Unit 1

Earth's atmosphere: overview and vertical structure. Warming the earth and the atmosphere: temperature and heat transfer; absorption, emission, and equilibrium; incoming solar energy. Air temperature: daily variations, controls, data, human comfort, measurement. Humidity, condensation, and clouds: circulation of water in the atmosphere; evaporation, condensation, and saturation; dew and frost; fog.

Unit 2

Cloud development and precipitation: atmospheric stability & determining stability, cloud development and stability, precipitation processes, collision and coalescence, precipitation types, measuring precipitation. Air pressure and winds: atmospheric pressure, pressure measurement, surface and upper-air charts, surface winds, winds and vertical air motions, measuring and determining winds. Atmospheric circulations: scales of atmospheric motion, eddies, local wind systems, global winds, global wind patterns and the oceans.

Unit 3

Air masses, fronts, and mid-latitude cyclones. Weather forecasting: acquisition of weather information, forecasting methods and tools, forecasting using surface charts. Thunderstorms: ordinary (air-mass) thunderstorms, mesoscale convective complexes, floods and flash floods, distribution of thunderstorms, lightning and thunder. Tornadoes: severe weather and Doppler radar, waterspouts.

Unit 4

Hurricanes (cyclones, typhoons): tropical weather; anatomy, formation, dissipation and naming of hurricanes. Air pollution: a brief history, types and sources, factors that affect air pollution, the urban environment, acid deposition. Global climate: climatic classification; global pattern of climate.

Unit 5

Climate change: possible causes; carbon dioxide, the greenhouse effect, and recent global warming. Light, color, and atmospheric optics: white and colors, white clouds and scattered light; blue skies and hazy days, red suns and blue moons; twinkling, twilight, and the green flash; the mirage; halos, sundogs, and sun pillars; rainbows; coronas and cloud iridescence.

Course Outcomes:

After completion of the course students should be able to

CO1: Learn basic physics principles to understand Earth's atmosphere.
CO2: Develop analytical skills to solve problems related to Earth's Atmosphere.
CO3: Develop critical/logical thinking and scientific reasoning in the field of Earth's atmosphere.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3												2			
CO2		3												2		
CO3		3														1

TEXTBOOK:

C. Donald Ahrens: Essentials of Meteorology: An Invitation to the Atmosphere (6th edition), Brooks-Cole, 2010.

REFERENCE:

Frederick K. Lutgens& Edward J. Tarbuck: The Atmosphere, An Introduction to Meteorology (11th Edition), Prentice Hall, 19 January, 2009

18PHY635 EARTH'S STRUCTURE AND EVOLUTION 3 0 0 3

Unit 1

Introduction: geologic time; earth as a system, the rock cycle, early evolution, internal structure & face of earth, dynamic earth. Matter and minerals: atoms, isotopes and radioactive decay; physical properties & groups of minerals; silicates, important nonsilicate minerals, resources. Igneous rocks: magma, igneous processes, compositions & textures; naming igneous rocks; origin and evolution of magma, intrusive igneous activity, mineral resources and igneous processes.

Unit 2

Volcanoes and volcanic hazards: materials extruded, structures and eruptive styles, composite cones and other volcanic landforms, plate tectonics and volcanic activity. W eathering and soils: earth's external processes; mechanical & chemical weathering, rates; soils, controls of formation, profile, classification, human impact, erosion, weathering and ore deposits. Sedimentary rocks: the importance and origins of sedimentary rocks; detrital & chemical sedimentary rocks, coal, converting sediment into sedimentary rock; classification & structures, nonmetallic mineral & energy resources. Metamorphism and metamorphic rocks: metamorphic textures, common metamorphic rocks, metamorphic environments & zones.

Unit 3

Mass wasting: gravity, mass wasting and landform development, controls and triggers, classification of mass-wasting processes, slump, rockslide, debris flow, earthflow, slow movements. Running water: hydrologic cycle, running water, streamflow, work of running water, stream channels, base level and graded streams, shaping stream valleys, depositional landforms, drainage patterns, floods and flood control. Groundwater: importance and distribution, water table, factors influencing storage and movement, springs, wells, artesian wells, environmental problems, hot springs and geysers, geothermal energy, geologic work. Glaciers and glaciation: formation and movement, erosion &landforms, deposits, other effects, causes. Deserts and wind: distribution and causes, geologic processes, basin and range, wind transport, erosion & deposits.

Unit 4

Shorelines: coastal zone, waves & erosion, sand movement, shoreline features & stabilization; erosion problems along U.S. coasts, hurricanes, coastal classification, tides. Earthquakes and earth's interior: faults, seismology, locating the source of an earthquake, measuring intensity, belts and plate boundaries, destruction, damage east of the Rocky Mountains, earthquake prediction, earth's interior. Plate tectonics: continental drift, divergent boundaries, convergent boundaries, transform fault boundaries, testing the plate tectonics model, the breakup of Pangaea, measuring plate motion, what drives plate motions, plate tectonics in the future.

Unit 5

Origin and evolution of the ocean floor: continental margins, features of deep-ocean basins, anatomy of oceanic ridge, oceanic ridges and seafloor spreading, nature of oceanic crust, continental rifting, destruction of oceanic lithosphere. Crustal deformation and mountain building: structures formed by ductile & brittle deformation, mountain building at subduction zones, collisional mountain belts, fault-block mountains, vertical movements of the crust. Geologic time: time scales, relative dating, correlation of rock layers; dating with radioactivity, the geologic time scale, difficulties in dating. Earth's evolution: birth of a planet, origin of the atmosphere and oceans, Precambrian (formation of continents); Phanerozoic (formation of modern continents & earth's first life); Paleozoic (life explodes); the Mesozoic (dinosaurs); Cenozoic era (mammals). Global climate change: climate & geology, climate system, detecting change; atmospheric basics & heating the atmosphere; natural & human causes; carbon dioxide, trace gases, and climate change; climate-feedback mechanisms, aerosols, some possible consequences.

Course Outcomes:

After completion of the course students should be able to

CO1: Learn basic and advanced physics principles to understand Earth structure and its evolution.
CO2: Develop analytical skills to solve problems related to Earth structure.
CO3: Develop critical/logical thinking and scientific reasoning in the field of planetary science.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4

CO1	3															
CO2													2			
CO3		3												2		
		3														1

TEXTBOOK:

Frederick K. Lutgens, Edward J. Tarbuck& Dennis G. Tasa: Essentials of Geology (11th edition), Prentice Hall, 8 March, 2012.

REFERENCE:

Graham R. Thompson & Jonathan Turk: Introduction to Physical Geology (2nd Edition), Brooks Cole, 23 June, 1997.

18PHY636 FIBRE OPTIC SENSORS AND APPLICATIONS 3 0 0 3 Unit

1

MM and SM fibers for sensing, Lasers & LEDs suitable for sensing, PIN & APDs for fiber optic sensing. Principles of electro optic modulators bulk & integrated optic modulators. Optical sensor types, advantages and disadvantages of fiber optic sensors, Sensor system performance: basic specifications, Intensity modulated sensors, reflective concept, micro-bend concept, evanescent fibers sensors, polarization modulated sensors.

Unit 2

In-fiber Bragg grating based sensors – sensing principles – temperature and strain sensing, integration techniques, cross sensitivity, FB Gmultiplexing techniques. Long period fiber grating sensors - temperature and stain sensing, refractive index sensing, optical load sensors and optical bend sensors.

Unit 3

Interferometric sensors, Mach-Zehnder& Michelson interferometric sensors, theory-expression for fringe visibility, Fabry-perot fiber optic sensors – theory and configurations, optical integration methods and multiplication techniques, application– temperature, pressure and strain measurements, encoded sensors.

Unit 4

Sagnac interferometers for rotation sensing fiber gyroscope sensors – Sagnac effect – open loop biasing scheme – closed loop signal processing scheme – fundamental limit – performance accuracy and parasitic effects – phase-type bias error – shupe effect – anti-shupe winding methods – applications of fiber optic gyroscopes. Faraday effect sensors. Magnetostriction sensors - Lorentz force sensors.

Unit 5

Biomedical sensors, sensors for physical parameters, pressure, temperature, blood flow, humidity and radiation loss, sensors for chemical parameters. pH, oxygen, carbon, dioxide, spectral sensors. Distributed fiber optic sensors – intrinsic distributed fiber optic sensor – optical time domain reflectometry based Rayleigh scattering – optical time domain reflectometry based Raman scattering

– optical time domain reflectometry – quasi – distributed fiber optic sensors. An overview on the optical fiber sensors in nuclear power industry, fly-by light aircraft, oil field services, civil and electrical engineering, industrial and environmental monitoring.

Course Outcome:

On Successful completion of the course, the student will be able to

CO1: Understand and gain knowledge on the technical aspects of electro-optic modulators and different types of fiber optical sensors

CO2: Acquire knowledge on the working principle of grating based and interferometricfiber optic sensors

CO3: Understand the basic concepts of biomedical and distributed fiber optic sensors and their industrial applications

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	1				2			1		1	3	2		1
CO2	3	3	1				2			1		1	3	2		1
CO3	3	3	1				2			1		1	3	2		1

TEXTBOOKS:

1. *Francis T.S Yu, Shizhuo Yin (Eds), Fiber Optic Sensors, Marcel Dekker Inc., New York, 2002*
2. *Dakin J and Culshow B., (Ed), Optical fiber sensors, Vol. I, II, III, Artech House, 1998*
3. *Pal B.P, Fundamentals of fiber optics in telecommunication and sensor systems, Wiley Eastern, 1994*

REFERENCES:

1. *Jose Miguel Lopez-Higuera (Ed), Handbook of optical fiber sensing technology, John Wiley and Sons Ltd., 2001*
2. *Eric Udd (Ed), Fiber optic sensors: An introduction for engineers and scientists, John Wiley and Sons Ltd., 1991*
3. *B.D Gupta, Fiber optic Sensors: Principles and applications, New India Publishing Agency, New Delhi., 2006*
4. *Bio-medical sensors using optical fibers, Report on progress in physics Vol 59.1,1996*

18PHY637 FIBRE OPTICS AND TECHNOLOGY 3 0 0 3

Unit 1

Classification of fibers: based on refractive index profiles, modes guided applications and materials. Fibers for specific applications: polarization maintaining fibers (PMF), dispersion shifted and dispersion flattened fibers, doped fibers. Photonic crystal fibers, holly fibers.

Fiber specifications: Numerical aperture of SI and GI fibers, Fractional refractive index difference, V–parameter, Cut off wavelength, dispersion parameter, bandwidth, rise time and Non linearity coefficient.

Unit 2

Impairment in fibers: group velocity dispersion (GVD), wave guide and modal dispersions. Polarization mode dispersion (PMD), Birefringence – liner and circular.

Fiber drawing and fabrication methods: modified chemical vapor deposition (MCVD) and VAD techniques.

Unit 3

Mode theory of fibers – different modes in fibers. Dominant mode, Derivations for modal equations for SI and GI fibers. Approximate number of guided modes in a fiber (SI and GI fibers). Comparison of single mode and multimode fibers for optical communications. LED and LD modulators. Coupling of light sources to fibers – (LED and LD) – Derivations required. Theory and applications of passive optical components: connectors, couplers, splices, Directional couplers, gratings: FBGs and AWGs, reflecting stars: Optical add drop multiplexers and SLMs.

Unit 4

Active components: Optical Amplifiers (OAS) - Comparative study of OAS - SLAs, FRAs, FBAs EDFAs and PDFAs based on signal gain, pump efficiency, Noise Figure, Insertion loss and bandwidth. Design and Characterization of forward pumped EDFAs.

Unit 5

Fiber measurements: Attenuation measurement – cut back method. Measurement of dispersion – differential group delay, Refractive index profile measurement.

Numerical aperture (NA) measurement, diameter measurement, mode field diameter (MFD) measurement, V-Parameter, Cut off wavelength Measurement, splicing and insertion losses, OTDR – working principle and applications. OSA - Basic block schematic and applications in measurements. (John M senior).

Course Outcome:

By completion of the course, the student will able to

CO1: Acquire knowledge on the fiber classification and characteristics of optical fibers.

CO2: Describe the optical fiber fabrication process, theory of different modes and the modulators.

CO3: Understand and Gain knowledge on the passive and active components of fiber optic technology and the methods to determine the fiber quality.

Course Articulation Matrix:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO8	PO 9	PO 10	PO1 1	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	3	1				2			1		1	3	2		1
CO2	3	3	1				2			1		1	3	2		1
CO3	3	3	1				2			1		1	3	2		1

TEXTBOOKS:

1. *Gerd Keiser, Optical Fiber communications, McGraw Hill, 200*
2. *Maynbav, Optical Fiber Technology, Pearson Education, 2001*
3. *John M senior, Optical fiber communications, PHI, 1992*

REFERENCES:

1. *Joseph C Palais, Optical Fiber communications, Pearson Education.1998.*
2. *Dennis Deriikson, Fiber optic test and measurement, Prentice hall,1998.*
3. *David Bailey and Edwin wright, practical Fiber optics, Elsevier 2003.*
4. *Franz and Jain, optical Fiber communication systems and Components, Naros Publishers, 2004.*
5. *AjoyGhatak and K.Thyagarajan, Introduction to Fiber optics: Cambridge university press,1999.*

18PHY638 NANOPHOTONICS 3 0 0 3

Unit 1

Introduction to nanoscale interaction of photons and electrons. Near field interaction and microscopy - near field optics and microscopy - single molecule spectroscopy - nonlinear optical process.

Unit 2

Materials for nanophotonics - quantum confinement - optical properties with examples - dielectric confinement - super lattices - organic quantum confined structures.

Unit 3

Plasmonics - metallic nanoparticles and nanorods - metallic nanoshells - local field enhancement - plasmonic wave guiding - applications of metallic nanostructures.

Unit 4

Nanocontrol of excitation dynamics - nanostructure and excited states - rare earth doped nanostructures - up converting nanophores - quantum cutting. Growth and characterization of nanomaterials – epitaxial – PLD – nanochemistry – XRD – XPS – SEM – TEM – SPM.

Unit 5

Concept of photonic band gap – photonic crystals – theoretical modeling – features optical circuitry - photonic crystal in optical communication - nonlinear photonic crystal - applications. Nanoelectronic devices – Introduction - single electron transistor. Basic ideas of nanolithography and biomaterials - nanophotonics for Biotechnology and Nanomedicine – nanophotonics and the market place.

Course outcomes:

After completion of the course, students will have knowledge and skills to:

CO 1 Understand the nanoscale interaction of photons and electrons and familiarize with near field optics and microscopy techniques.

CO 2 Apply the knowledge of quantum confinement to understand nanostructures used in photonics.

CO 3 Understand nanocontrol of excitation dynamics and various growth and characterization techniques of nanomaterials.

CO 4 To comprehend the concept of photonic band gap in crystals to apply for various

applications. **CO-PO Mapping:**

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	3	3				2	1			3	3		2
CO2	3	3	3	3	3				2	1			3	3		2
CO3	3	3	3	3	3				2	1			3	3		2
CO4	3	3	3	3	3				2	1			3	3		2

TEXTBOOKS:

1. *Paras N. Prasad, Nanophotonics, Wiley Interscience, 2004*
2. *Lukas Novotny and Bert Hecht, Principles of Nano-Optics, Cambridge University Press, 2006*

REFERENCE:

1. *HerveRigneault, jean-Michel Lourtioz, Claude Delalande, Juan Ariel Levenson, Nanophotonics, ISTE Publishing Company, 2006.*
2. *Surface Plasmon Nanophotonics, Mark L. Brongersma, Pieter G. Kik, Springer-Verlag, 2006.*
3. *Photonic Crystals, by John D. Joannopoulos, Robert D. Meade, Joshua N. Winn Prienceton University Press.*

18PHY639 NONLINEAR DYNAMICS 3 0 0 3

Unit 1

Introduction, Phase Space, and Phase Portraits: Linear systems and theirclassification; Existence and uniqueness of solutions; Fixed points and linearization; Stability of equilibria; Pendulum and Duffing oscillator, Lindstedt's method; Conservative and reversible systems.

Unit 2

Limit Cycles: The van der Pol oscillator, Method of Averaging; Relaxationoscillators; Weakly nonlinear oscillators; Forced Duffing oscillator, Method of Multiple Scales; Forced van der Pol oscillator, Entrainment; Mathieu's equation, Floquet Theory, Harmonic Balance.

Unit 3

Bifurcations: Saddle-node, transcritical, and pitchfork bifurcations; Center manifoldtheory; Hopf bifurcation; Global bifurcations; and Poincaré maps.

Unit 4

Nonlinear Normal Modes: Nonlinear Normal Mode manifolds of multidegree-of-freedom systems; external and internal resonances; and Energy transfer through nonlinear interactions.

Unit 5

Chaotic Dynamics: Lorentz equations; Lorentz map; Logistics map; LyapunovExponents; fractal sets and their dimensions; box, pointwise and correlation dimensions; strange attractors; and forced two-well oscillator.

Course outcomes

At the end of the course students

CO1: will gain understanding about sources and propagation of optical electromagnetic waves
CO2: will be able to find fixed points and determine their stability, analyze limit cycles and their stability.
CO3: will be able to analyze the various types of bifurcations in one dimension (saddle node, transcritical, and pitchfork) and two dimensions (homoclinic, degenerate, and Hopf),
CO4: Gain an understanding of the properties of the most important strange attractors in discrete and continuous time

CO-PO Mapping:

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3											2	3		
CO2	3	3											2	3		
CO3	3	3											2	3		
CO4	3	3		1									2	3		

TEXTBOOKS:

1. Richard H. Rand, Lecture Notes on Nonlinear Vibrations, version 52, 2005. Available online athttp://audiophile.tam.cornell.edu/randpdf/nlvibe52.pdf
2. S.H. Strogatz, Nonlinear Dynamics and Chaos with Applications to Physics, Biology, Chemistryand Engineering, Perseus Books Publishing, 2000.

REFERENCE BOOKS:

1. J.C. Sprott, Chaos and Time-Series Analysis, Oxford University Press, 2003.
2. G.L. Baker and J.P. Gollub, Chaotic Dynamics, 2nd edition, Cambridge University Press, New York, 1996.
3. Edward Ott, Chaos in Dynamical Systems, Cambridge, 1993.
4. K.T. Alligood, T.D. Sauer, and J.A. Yorke, CHAOS - An Introduction to Dynamical Systems, Springer, 1996.
5. D. Kaplan and L. Glass, Understanding nonlinear dynamics, Springer-Verlag, New York, 1995.
6. J.M.T. Thompson and H.B. Stewart, Nonlinear dynamics and chaos, John Wiley and Sons, New York, 1986.

18PHY640 NUCLEAR PHYSICS 3 0 0 3

Unit 1

Two-nucleon scattering - partial wave analysis, effective range theory, coherent scattering, spin-flip and polarization, comparison of n-n and p-p scattering.

Unit 2

Nuclear reactions - reaction and scattering cross sections, compound nuclear reactions, resonance reactions, Breit-W eigner formula, experimental determination of resonance widths and shapes, statistical theory, optical model, transfer reactions, pick-up and stripping reactions, spectroscopic factors.

Unit 3

Heavy ion reactions - salient features at low, intermediate and high energies, classical dynamical model, heavy ion fusion, fusion excitation function, deep inelastic collision.

Unit 4

Some aspects of nuclear measurement techniques: (i) Detectors and electronics for high resolution gamma and charge particle spectroscopy; (ii) Fast neutron, detection (iii) Neutrino detection, (iv) Drift chambers, RICH, calorimeter.

Course Outcomes:

After completion of the course students should be able to

CO1: Get familiarize with the key ideas and application of scattering theory.

CO2: Developed analytical skills to solve problem related to nuclear reactions.

CO3: Learn basic principles and techniques related to nuclear detector and their application. **CO-PO Mapping:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3												3			
CO2		3												3		
CO3		3													2	

BOOKS RECOMMENDED:

1. *Nuclear Physics: L.R.B Elton*
2. *Nuclear reactions: Blatt and Weisskopf*
3. *Nuclear Theory - Roy and Nigam*
4. *Nuclear Physics - B. Cohen*
5. *Nuclear Physics - Preston and Bhaduri*
6. *Nuclear structure - Bohr and Mottelson*
7. *Nuclear structure - M. K. Pal*
8. *Techniques in experimental nuclear physics - Leo*
9. *Techniques in experimental nuclear physics - Knoll*
10. *Techniques in experimental nuclear physics - S.S. Kapur*

18PHY641 OPTOELECTRONIC DEVICES 3 0 0 3

Unit 1

Introduction: Semiconductor materials; Crystal lattices; Bulk Crystal growth, epitaxial growth.

Unit 2

Energy bands and Charge carriers in Semiconductors: direct and indirect semiconductors; variation of Energy bands with alloy composition. Charge carriers in semi-conductors-electrons, holes, effective mass; intrinsic and extrinsic materials. Drift of carriers in electric and magnetic fields.

Unit 3

Excess carries in Semiconductors: Optical absorption; luminescence – photoluminescence, electroluminescence. Carrier lifetime and photoconductivity, diffusion of carriers.P-N Junction Diode: Current-Voltage Characteristics; hetrojunctions.

Unit 4

Optoelectronic Devices: Principle of diodes, lasers, photo detectors, solar systems in optoelectronic devices.operation and characteristics; Light emittingcells. Relevance of III-V and IV-VI material-

Unit 5

Integrated Optics: Optical waveguides - passive, electro-optical; optical modulatorsand switches; optical storage devices.

Course Outcomes:

On completion of the course, students will be able to

CO1: Understand the nature of semiconducting materials, their growth and the energy bands

CO2: Acquire knowledge on the carrier dynamics and the mechanism of absorption, photoluminescence and photoconductivity in semiconductors.

CO3 Understand the theory of p-n junction and heterojunctions

CO4 Gain knowledge on the theory and operation of optoelectronic devices, optical wave guides, optical switches and modulators.

TEXTBOOK:

1. Pallab Bhattacharya, “Semiconductor Optoelectronic Devices”, 2nd Edition.

REFERENCE BOOKS:

1. Street B G and Banerjee S, “Solid State Electronic Devices”, PHI New Delhi, (2004)
2. Sze S M, “Physics of Semiconductors Devices”, Wiley Eastern Limited, New Delhi.
3. Wilson and Hawkes, “Optoelectronics; An Introduction”, 2nd Ed., PHI.
4. Hummel R E, “Electronic Properties of Materials”, Narosa Publishing House, New Delhi.

18PHY642 PHYSICS OF COLD ATOMS AND IONS 3 0 0 3

Unit 1

Two level atom in a radiation field, Laser light pressure, Atoms in motion, Travelling wave and standing wave - Multilevel atoms, Alkali metal atoms, metastable noble gas atoms, Polarization and interference, Angular momentum and selection rules and Optical transitions in Multilevel atoms.

Unit 2

Temperature and Thermodynamics in Laser Cooling, Kinetic Theory and the Maxwell-Boltzmann Distribution, Random Walks, The Fokker-Planck Equation and Cooling Limits, Phase Space and Liouville's Theorem.

Unit 3

Optical Molasses: Introduction, Low-Intensity Theory for a Two-Level Atom in One Dimension, Atomic Beam Collimation, Low-Intensity Case, Experiments in One- and Two-Dimensions, Experiments in Three-Dimensional Optical Molasses.

Unit 4

Cooling below the Doppler limit - Magnetic trapping of neutral atoms. Optical Traps Magneto optical traps - Evaporative cooling.

Unit 5

Applications to atom mirrors, lenses, atomic fountain, nano fabrication, atomic clocks and nonlinear optics - Optical lattices - Bose Einstein condensation Entangled states and quantum computing.

Course Outcomes:

At the end of the course students should be

CO1 Able to define the concept of temperature at the level of few atoms.

CO2 Able to distinguish between classical and quantum phenomenona of multibody systems.

CO3 Able to demonstrate the usefulness of the cold atom and cold ion techniques in spectroscopy over conventional methods.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3												3			
CO2		3											2			
CO3		1											2			
CO4																
CO5																

TEXTBOOKS:

1. *Laser cooling and trapping by H J Metcalf and Peter Van der Straten Springer-VerlagNew York 1999.*
2. *Laser Manipulation of atoms and ions – Proceedings of the international school of Physics "Enrico Fermi" Course CXVII, Amsterdam (1993) North Holland.*

18PHY643 QUANTUM ELECTRODYNAMICS 3 0 0 3

Unit 1

Lorentz Covariance of the Dirac Equation: Covariant form of the Dirac equation, Proof of Covariance, Space Reflection, Bilinear Covariants, Solution of the Dirac Equation for a free particle: Plane wave Solutions, Projection Operators for Energy and Spin, Physical Interpretations of Free-particle solutions and packets.

Unit 2

The Foldy-Wouthuysen Transformation: Introduction, Free-particle Transformation, The Hydrogen atom Hole Theory: The problem of Negative Energy Solutions, Charge Conjugation, Vacuum Polarization, The time Reversal and other Symmetries.

Unit 3

General Formulation of the Quantum Field Theory: Implication of the Description in Terms of Local Fields, Canonical Formulation and Quantization Procedure for particles, Canonical Formulation and Quantization for Fields, The Klein-Gordon Field: Quantization and Particle Interpretation, Symmetry of the States, Measurability of the Field and Microscopic Causality, Vacuum Fluctuations, The Charged Scalar Field, Feynman Propagator.

Unit 4

Second Quantization of the Electromagnetic Field: Quantum Mechanics of N-identical Particles, The Number Representation for Fermions, The Dirac Theory, Momentum Expansions, Relativistic Covariance, The Feynman Propagator.

Quantization of the Electromagnetic Field: Introduction, Quantization, Covariance of the Quantization Procedure, Momentum Expansions, Spin of the Photon, The Feynman Propagator for Transverse Photons.

TEXTBOOKS:

1. *Bjorken&Drell: "Relativistic Quantum Mechanics"*
2. *Bjorken&Drell: "Relativistic Quantum Fields"*

REFERENCE BOOKS:

1. *Schweber, Bethe and Hoffmann: Mesons and Fields*
2. *Sakural: Advanced Quantum Mechanics*
3. *Lee: Particle Physics and Introduction to Field Theory*

18PHY644 QUANTUM OPTICS 3 0 0 3

Unit 1

Correlation functions of light waves. Spectral representation of mutual coherence function.Calculation of mutual intensity and degree of coherence, propagation of mutual intensity.Rigorous theory of partial coherence. Coherency matrix of a quasi-monochromatic plane wave. Stochastic description of light and higher order coherence effects.

Unit 2

Quantization of the radiation field, Quantum mechanical harmonic oscillator, the zero point energy, states of the quantized radiation field, single mode number states and phase states, coherent photon states.

Unit 3

Quantum theory of the laser: photon rate equations, time dependence of photon coherence, laser threshold condition, rate equations for atoms and laser photons, laser photon distribution, fluctuations in laser light and laser phase diffusion.

Unit 4

Statistical optics of photons: Photon coherence properties, photon counting, photon distribution for coherent and chaotic light, quantum mechanical photon counting distribution.

Unit 5

Super radiance: collective cooperative spontaneous radiation. Diecke's theory. Photon echoes. Quantum beats. Quantum chaos and instability hierarchies of laser light, chaos and its routes. Squeezed states of light.

Course outcomes

1. Comprehend and articulate the connection as well as dichotomy between theory of radiation and their energy quantization.
2. Learn to apply theory of coherence to compute the degree of coherence of light.
3. Understand the concept and technique of statistical optics of photons, quantum counting of photon and their coherence properties.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2		2								3	3		
CO2	3	3	2		2								3	3		
CO3	3	3	2		2								3	3		

REFERENCES:

1. *L. Mandel and E. Wolf, Coherence and Quantum Optics, Plenum (1973). 41*
2. *H. Haken, Light. Vol.1 & 2, North Holland (1981).*
3. *S.M. Kay and A. Maitland, Quantum Optics. Academic Press (1970).*
4. *R. Loudon, Quantum Theory of Light, Clarendon Press (1979).*
5. *J. Fox, (Ed.), Optical Masers, Interscience Publishers (1963).*

6. *R.G. Brewer and A. Mooradian, Laser Spectroscopy, Plenum (1974).*
7. *Laser Theory: Encyl. ofPhy. Vol. 25/2C, Springer-Verlag (1976).*
8. *M.O. Scully, W.E. Lamb and M. Sargent III, Laser Physics, Addison Wesley (1974).*
9. *J. Jacob, M. Sargent III, Laser Applications to Optics and Spectroscopy, Addison Wesley (1975).*
10. *R.H. Pantell and H.E. Puthoff, Fundamentals of Quantum Electronics Wiley (1969).*

18PHY645 THIN FILM TECHNOLOGY 3 0 0 3

Unit 1

Preparation methods: Physical methods: thermal evaporation, cathodicsputtering, Molecular beam epitaxy and laser ablation methods. Chemical methods: electrolytic deposition, chemical vapour deposition.

Unit 2

Thickness measurement and Characterisation: electrical, mechanical, opticalinterference, microbalance, quartz crystal methods. Analytical techniques of characterization: X-ray diffraction, electron microscopy, high and low energy electron diffraction, Auger emission spectroscopy.

Unit 3

Growth and structure of films: General features-Nucleation theories - Effectof electron bombardment on film structure – Post-nucleation growth - Epitaxial film growth - Structural defects.

Unit 4

Properties of films: elastic and plastic behaviour. Optical properties - Reflectanceand transmittance spectra - Absorbing films - Optical constants of film material -Multilayer films - Anisotropic and isotropic films. Electric properties to films: Conductivity in metal, semiconductor and insulating films - Discontinuous films - Superconducting films.

Unit 5

Magnetism of films: Molecular field theory - Spin wave theory - Anisotropy inmagnetic films - Domains in films - Applications of magnetic films. Thin film devices: fabrication and applications.

Course Outcomes

At the end of the course, students will be able

CO1. To understand the principle, differences and similarities, advantages and disadvantages of different thin film deposition methods.

CO2 To evaluate and use models for understanding nucleation and growth of thin films.

CO3 To analyze thin film properties to apply for various applications.

CO4 To improve problems solving skills related to evaluation of different properties of thin films.

TEXTBOOKS:

1. *K.L. Chopra, Thin Film Phenomena, McGrawHill (1983),*
2. *George Hass. Physics of Thin Films: Volumes 1':12. Academic Press (1963).*

REFERENCE BOOKS:

1. K.L. Chopra and I.J. Kaur, Thin Film Solar Cells, Plenum Press (1983).
2. L.I. Maissel and Giang (Eds.), Handbook of Thin film Technology, McGrawHill (1970).
3. J.C. Anderson, The Use of Thin Films in Physical Investigation, Academic Press (1966).
4. J.J. Coutts, Active and Passive Thin Film Devices, Academic Press (1978).
5. R.W. Berry, P.M. Hall and M.T. Harris, Thin Film Technology, Van Nostrand (1968). 47

18PHY646 FUNDAMENTALS OF PLASMA PHYSICS 3 0 0 3

Unit 1

Introduction – Spatial scale of an unmagnetized plasma – Debye Length, time scale plasma period, gyroradius and gyrofrequency of magnetized plasma, single particle motion in prescribed fields-ExB, grad-B, Curvature and polarization drifts, magnetic moment, adiabatic invariants of particle motion, magnetic mirror.

Unit 2

Kinetic theory of plasmas, Boltzmann equation, Maxwell-Boltzmann distribution, Vlasov description of collision less plasmas, Moments of the Boltzmann equation, Systems of macroscopic equations: Cold and Warm plasma models.

Unit 3

Plasmas as fluids - Two fluid description, equation of motion, Drifts perpendicular to B, parallel pressure balance.

Unit 4

Single fluid theory of plasmas: Magneto hydrodynamics (Hydro magnetic, MHD).

Unit 5

Introduction to waves in plasmas, waves in cold magnetized and unmagnetized plasma, Fourier representation, Dispersion relation, Waves in hot (magnetized) plasmas, Landau Damping, CMA diagram, Instabilities, MHD Waves, Alfven Waves, MHD discontinuities.

Course Outcomes:

After completing the course, the student should be able to

CO1 identify, using fundamental plasma parameters, under what conditions an ionised gas consisting of charged particles (electrons and ions) can be treated as a plasma

CO2 distinguish the single particle approach, fluid and kinetic approach to describe different plasma phenomena

CO3 determine the motion of charged particles moving in uniform or slowly varying electric and magnetic fields

CO4 understand the physical mechanism and properties of the electrostatic and electromagnetic waves propagating in magnetised and non-magnetised plasmas

CO5 familiarity with important plasma instabilities and the concept of Landau

damping **CO-PO Mapping:**

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 01	PSO 02	PSO 03
CO1	3	3	2	3	2								3	2	
CO2	3	2	2	2	3								3	3	
CO3	3	3	3	3	3								3	3	
CO4	3	3	3	3	3								3	3	
CO5	3	3	3	3	3								3	3	

TEXTBOOKS/REFERENCES:

1. *Umran S. Inan& Marek Golkowski, Principles of Plasma Physics for Engineers and Scientists, Cambridge, 2011*
2. *Francis F. Chen, Introduction to Plasma Physics and controlled fusion, Springer, 2006*
3. *D.A. Gumett& A. Bhattacharjee, Introduction to Plasma Physics, CUP, 2006*
4. *Boyd, T.J.M., and Sanderson, J.J.: The Physics of plasmas, CUP, 2003*
5. *Krall, N.A, Trivelpiece, A.W., Principles of plasma physics, McGraw Hill, 1973*
6. *Stix, T.H., Waves in plasmas, Springer, 1992*

18PHY336 SPACE PHYSICS 3 0 0 3

Unit 1

Brief history of solar-terrestrial physics – The variables Sun and the heliosphere, Earth's space environment and upper atmosphere.

Unit 2

Space plasma physics - single particle motion, plasma state, Fluid description, MHD & kinetic theory, Applications

Unit 3

Solid wind & Interplanetary Magnetic field (IMF), Shocks and Instabilities in space

Unit 4

Solar wind interactions with magnetized planets - Introduction, planetary magnetic fields, spherical harmonic expansions, geomagnetic field and its measurements, variations in Earth's field.

Unit 5

Magnetosphere - Dynamics, SW-magnetosphere interactions; Ionospheres, Currents in space and Ionosphere; Neutral atmosphere -Dynamics.

Course Outcomes:

After completion of the course students should be able to
CO1: Learn basic and advanced physics concepts in space physics.
CO2: Develop problem solving skills in the field of space physics.
CO3: Develop critical/logical thinking and scientific reasoning in the area of space physics.

CO-PO Mapping:

	P O	PO 2	P O	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3												3			
CO2		3												2		

CO3	3	1

Textbooks/References:

1. Hannu E.J. Koskinen, Physics of Space Storms, Springer, 2011
2. Molwin, M., An Introduction to Space Weather, CUP, 2008
3. Kallenrode, M.B., Space Physics: An introduction to plasmas and particles in the Heliosphere and Magnetosphers, Springer, 3e, 2004
4. Baumjohann, W. &Treumann, R.A., Basic Space Plasma Physics, Imperial College Press, 1997
5. Kivelson& Russell, Introduction to Space Physics, CUP, 1995

18PHY648 Ultrafast lasers and Applications 3 0 0 3

Objectives:

To introduce ultrafast lasers and some of their applications.

UNIT 1:

Ultrafast Light Sources:
Q-switching and modelocking, Nano second, Pico second and Femtosecond Lasers, Synchrotron source.

UNIT 2:

Applications in Time-Domain Spectroscopy:
Need of lifetime measurements in semiconductors/ organic materials. Various methods of lifetime measurements: Oscilloscope method, Time-correlated single photon counting, Fluorescence upconversion, pump-probe spectroscopy.

UNIT 3:

Applications in Nonlinear Optics:
Self-focusing and self-defocusing, Optical rectification, Z-scan and four wave mixing technique, measurement of second and third order optical nonlinear susceptibility, Idea of optical gates.

UNIT 4:

Applications in Fibre optic Communication:
Basics of optical fibre, photodetectors, fibre lasers, semiconductor lasers and optical communication, Group velocity dispersion and dispersion compensation

Unit 5:

Applications in Tunable Lasers and High Harmonic Generation:
White light continuum generation, Transient absorption, Optical parametric oscillators, Petta Watt lasers and other applications

Course outcomes:

After completion of the course, students will have knowledge and skills to:

CO1 Understand the techniques involved in producing ultrafast laser radiation such as Q-switching and modelocking.
CO2 Apply knowledge of ultrafast laser radiation to understand time-domain spectroscopy.
CO3 Comprehend the application of ultrafast laser radiation in non-linear optics.
CO4 Understand the application of ultrafast laser radiation in tunable lasers and high harmonic generation.

CO-PO Mapping

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	3	3	3	3				2	1			3	3		2
CO2	3	3	3	3	3				2	1			3	3		2
CO3	3	3	3	3	3				2	1			3	3		2
CO4	3	3	3	3	3				2	1			3	3		2

Books and references:

1. Few-Cycle Laser Pulse Generation and its Applications, Franz X. Kärtner, SPRINGER, 2004
2. Pulse fluorometry using simultaneous acquisition of fluorescence and excitation, D. J. S. Birch, R. E. Imhof, and A. Dutch, Rev. Sci. Instrum. 55, 1255 (1984).
3. The Principles of Nonlinear Optics, Y. R. Shen, Wiley-Interscience , 2003
4.. Nonlinear Fibre Optics, G. P. Agrawal, Academic Press, 2001

18PHY649 Energy and Environment in the 21st Century 3 0 0 3

Abstract

The energy and related environmental problems, the physics principles of using energy and the various real and hypothetical options are discussed from a physicist point of view. The lecture is intended for students of all ages with an interest in a rational approach to the energy problem of 21st century.

Objective

Scientists and especially physicists are often confronted with questions related to the problems of energy and the environment. The lecture tries to address the physical principles of todays and tomorrow energy use and the resulting global consequences for the world climate.
The lecture is for students which are interested to participate in a rational and responsible debate about the energy problem of 21 Century.

Unit – 1

Introduction: Energy types, energy carriers, energy density and energy usage. How much energy does human needs/uses?
Energy conservation and the first and second law of thermodynamics

Unit – 2

Fossil fuels (our stored energy resources) and their use. Burning fossil fuels and physics of greenhouse effect.

Unit – 3

Physics basics of nuclear fission and fusion energy controlled nuclear fission energy today, the different types of nuclear power plants, uranium requirements and resources, natural and artificial radioactivity and the related waste problems from the nuclear fuel cycle.

Unit – 4

Nuclear reactor accidents and the consequences, a comparison with risks from other energy using methods. The problems with nuclear fusion and the ITER project.
Nuclear fusion and fission: "exotic" ideas.

Unit – 5

Hydrogen as an energy carrier: ideas and limits of a hydrogen economy. New clean renewable energy sources and their physical limits (wind, solar, geothermal etc.)
Energy perspectives for the next 100 years and some final remarks

Course Outcomes

At the end of the course the students will be able

CO1 To demonstrate knowledge of new and renewable energy and their relationship with ecology & environment.
CO2 To describe conventional and non-conventional energy scenario with respect to environment.
CO3 To analyze synergy between energy and environment, global environment issues.
CO4 To explain the Environmental Pollution and their effects on environment
CO5 To apply awareness regarding environmental protection and application of renewable energy.

CO-PO Mapping:

	P O	P O	P O	P O	P O	P O	P O	P O	P O	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3														2	
CO2						2										2
CO3							3								2	
CO4							3									2
CO5							3									2

References

1. http://ihp-lx2.ethz.ch/energy21/
2. Die Energiefrage - Bedarf und Potentiale, Nutzung, Risiken und Kosten:
3. Klaus Heinloth, 2003, VIEWEG ISBN: 3528131063;
4. Environmental Physics: Boeker and Egbert New York Wiley 1999.

18PHY650 Introduction to Solar Physics 3 0 0 3

Unit I

Sun: Solar parameters: Mass, Radius, Distance and Luminosity, Spectral energy distribution, Construction of a Model, Conservation law, Equation of State, Nuclear Energy Source and Energy transport, Chemical composition of the Sun

Unit II

Tools for Solar Observation: High-Resolution Telescope, Spectrographs and Spectrometers, Filters and Monochromators, Polarimetry, Special purpose Instruments

Unit III

Sun's Oscillations and Rotations: Linear Adiabatic Oscillations of Non-Rotating Sun, Helioseismology, Excitation and Damping, The Angular Velocity of Sun, Models of Rotating Convection Zone

Unit IV

Magnetic properties of Sun: Fields and Conducting Matter, Flux tubes, Sunspots and Solar Cycle

Unit V

Chromosphere, Corona and Solar Wind: Empirical Facts, Consequence of High Temperature, Outer Atmosphere, Energy Balance, Explosive Events

Course Outcomes:

After completion of the course students should be able to

CO1 Learn theoretical methods and observational tools for solar system.

CO2 Apply theoretical models to solve problems related to solar system.

CO3 Develop critical/logical thinking and scientific reasoning of solar system.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3												3			
CO2		3												3		
CO3		3														1

Text Book:

Michael Strix, The Sun : An Introduction,2nd edition, Springer, 2012.

18PHY651 MICRO AND NANO MAGNETISM-MATERIALS AND ITS APPLICATIONS 3 0 0 3

Required Knowledge

Scholars are expected to have completed the course Quantum Mechanics, Mathematical physics, Electrodynamics and Atomic physics. They should be familiar with the motivations of quantum mechanics and its historical development such as the ultraviolet catastrophe; Young's double-slit experiment etc. They should be familiar with the concept of a wave function; wave function collapse, and the expression of observables as operators. They should be able to apply the Schrödinger Equation to simple potentials and also familiarity with mathematical concepts such as vector spaces and Fourier series. This course will have some overlap with Atomic Physics.

Intended Learning Outcomes

The aim of this course is to provide an introduction to the physics underlying properties of strongly correlated systems. The course also provides examples of how Quantum Mechanics, Mathematical physics, Electrodynamics and Atomic physics can be applied in order to understand phenomena emergent in complex systems. By the end of the course, students should be able to: describe the key physical principles of magnetism; demonstrate a knowledge and understanding of the theory and applications of ferromagnetism and the macroscopic behavior of ferromagnets. Also by the end of the course, students should have acquired the problem solving skills, such as

1. Calculation of susceptibilities for different magnetic orderings;
2. Calculate spin wave dispersions for different magnetic structures;
3. Estimate reduction of magnetization
4. Estimate energies of nucleating a domain and forming a magnetic domain wall etc.

Course Outline:

Details of the course content are listed below:

Unit 1

Magnetism of electrons
Introduction:-A brief history of magnetism; Magnetism and hysteresis; Magnet applications;Magnetostatics:- The magnetic dipole moment; Magnetic fields; Maxwell's equations; Magnetic field calculations; Magnetostatic energy and forces
Orbital and spin moments; Magnetic field effects; Theory of electronic magnetism; Magnetism of electrons in solids; Magnetism of localized electrons on the atom: The hydrogenic atom and angular momentum; The many-electron atom; Paramagnetism; Ions in solids; crystal-field interactions

Unit 2

Ferromagnetism; Anti-ferromagnetism and other magnetic order
Mean field theory; Exchange interactions; Band magnetism; Collective excitations; Anisotropy; Ferromagnetic phenomena
Molecular field theory of antiferromagnetism; Ferrimagnets; Frustration; Amorphous magnets; Spin glasses; Magnetic models

Unit 3

Micro and Nano-magnetism, domains and hysteresis
Micromagnetic energy; Domain theory; Reversal, pinning and nucleation.
Nanoscale magnetism; Characteristic length scales; Thin films; Thin-film heterostructures; Wires and needles; Small particles; Bulk nanostructures; Magnetic resonance:- Electron paramagnetic resonance; Ferromagnetic resonance; Nuclear magnetic resonance; Other methods
Experimental methods: Materials growth; Magnetic fields; Atomic-scale magnetism; Domain-scale measurements; Bulk magnetization measurements; Excitations; Numerical methods

Unit 4

Magnetic materials

Introduction; Iron group metals and alloys; Rare-earth metals and inter-metallic compounds; Interstitial compounds; Oxides with ferromagnetic interactions; Oxides with anti-ferromagnetic interactions

Applications of soft and hard magnets

Soft magnetic materials; applications:- Low-frequency and High-frequency applications

Magnetic circuits; Permanent magnet materials; Static and Dynamic applications with mechanical recoil; Dynamic applications with active recoil; Magnetic microsystems

Unit 5

Spin electronics and magnetic recording

Spin-polarized currents; Materials for spin electronics; Magnetic sensors; Magnetic memory; Magnetic recording

Special topics:- Magnetic liquids; Magneto-electrochemistry; Magnetic levitation; Magnetism in biology and medicine; Planetary and cosmic magnetism.

Course Outcomes

The aim of this course is to provide an introduction to the physics underlying properties of strongly correlated systems. The course also provides examples of how Quantum Mechanics, Mathematical physics, Electrodynamics and Atomic physics can be applied in order to understand phenomena emergent in complex systems.

By the end of the course, students should be able to:

CO1 Describe the key physical principles of magnetism

CO2 Demonstrate a knowledge and understanding of the theory and applications of ferromagnetism and the macroscopic behavior of ferromagnets

CO3 Acquire the problem solving skills, such as

(i) Calculation of susceptibilities for different magnetic orderings;

(ii) Calculate spin wave dispersions for different magnetic structures;

(iii) Estimate reduction of magnetization

(iv) Estimate energies of nucleating a domain and forming a magnetic domain wall etc.

CO-PO Mapping

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3													2		
CO2				3											3	
CO3		3													3	

Text books

1. Magnetism and Magnetic Materials; J. M. D. COEY; CAMBRIDGE UNIVERSITY PRESS.

2. Text Book Of MagnetismBy R.K. Verma, DPH
3. Magnetism Fundamentals, edited by Etienne Du Trémolet de Lacheisserie, Damien Gignoux, Michel Schlenker, Springer
4. Magnetism: From Fundamentals to NanoscaleDynamicsBy Joachim Stöhr, Hans ChristophSiegmann; Springer
5. Introduction to Magnetism and Magnetic Materials, Second EditionBy David C. Jiles; Taylor and Francis
6. The Quantum Theory of Magnetism;By Norberto Majlis; World Scientific Publishing Co. Pte. Ltd

18PHY652 X-RAY DIFFRACTION AND ITS APPLICATIONS 3 0 0 3

UNIT I

X-RAY BASICS
The scattering of X-rays, Diffraction from a crystal
X-ray interaction with matter, X-ray sources, X-ray optics, X-ray detectors

UNIT II

X-RAY DIFFRACTOMETERS
High-Resolution Diffractometers; Powder Diffractometers

UNIT III

APPLICATIONS TO MATERIALS SCIENCE: STRUCTURE ANALYSIS; PHASE ANALYSIS; PREFERRED ORIENTATION (TEXTURE) ANALYSIS

UNIT IV

APPLICATIONS TO MATERIALS SCIENCE: LINE BROADENING ANALYSIS
Line Broadening due to Finite Crystallite Size; Line Broadening due to Microstrain Fluctuations; Williamson-Hall Method; The Convolution Approach Instrumental Broadening; Relation between Grain Size-Induced and Microstrain-Induced Broadenings of X-Ray Diffraction Profiles.

UNIT V

APPLICATIONS TO MATERIALS SCIENCE:RESIDUAL STRAIN/STRESSMEASUREMENTS
Strain Measurements in Single-Crystalline Systems; Residual Stress Measurements in Polycrystalline Materials.
IMPACT OF LATTICE DEFECTS ON X-RAY DIFFRACTION

Course Outcomes:

At the end of the course the students will be able

CO1 To work with the fundamentals and applications of x-ray diffraction.
CO2 To apply the knowledge on x-ray sources and optics to explain experimental arrangements in the field of modern x-ray physics.
CO3 To apply the knowledge on x-ray interaction with matter to explain different types of analytical methods that use x-ray radiation as a probe.
CO4 To acquire skills for independent research and presentation.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3												1			
CO2		3												3		
CO3					3										3	
CO4						3										3

Text books and References

1. Emil ZolotoyabkoBasic Concepts of X-Ray Diffraction; John Wiley & Sons, 21-Apr-2014 - Science
2. M. M. Woolfson; An Introduction to X-ray Crystallography; Cambridge University Press
3. Werner Massa; Crystal Structure Determination; (March 31, 2004) ISBN-10: 3540206442
4. Crystal Structure Analysis by: Jenny Glusker and Kenneth Trueblood (August 1992) ISBN-10: 0195035313
5. Crystal Structure Analysis: Principles and Practice (International Union of Crystallography Monographs on Crystallography) by Peter Main, William Clegg, Alexander J. Blake, Robert O. Gould. (January 28, 2002) ISBN-10: 019850618X
6. The Determination of Crystals Structures by: H. Lipson & W. Cochran (June 1966) ISBN-10: 080140276X
7. Fundamentals of Powder Diffraction and Structural Characterization of Materials by: VitalijPecharsky and Peter Zavalij (March 3, 2005) ISBN-10: 0387241477
8. Structure Determination by X-ray Crystallography by: Mark Ladd and Rex Palmer (September 30, 2003) ISBN-10: 0306474549
9. X-ray Structure Determination by: George Stout and Lyle Jensen (April 24, 1989) ISBN-10: 0471607118
10. X-ray Analysis and the Structure of Organic Molecules by: Jack Dunitz (December 16, 1996) ISBN-10: 3906390144

18PHY653 Solar Energy Conversions 3 0 0 3

Unit I

Introduction to Semi conductors: Types of semiconductors;, Density of States, electron and hole currents, Electron distribution function, Fermi Dirac Statistics, Drift and Diffusion currents, Semiconductor transport equations; Calculation of carrier and current densities, General solution for current density,Metal semiconductor junction, Semiconductor –semiconductor junctions, Analysis of the P-N-Junctions, p-n junction under dark and under illumination. The Solar Resource and types of solar energy converters, Requirements of an ideal photoconverter, Photovoltaic cell and power generation, Characteristic of the Photovoltaic Cell, Material and design issues; Shockley–Queisser limit, Beyond the limit. Optics in solar energy conversion, antireflection coatings, concentration of light: Light confinement, photon recycling, multiple exciton generation.

Unit II

Silicon Solar cell, Mono -crystalline and poly–crystalline cells, Metallurgical Grade Si, Electronic Grade Si, wafer production, Mono–crystalline Si Ingots, Poly–crystalline Si Ingots, Si–wafers, Si–sheets, Solar grade Silicon, Si usage in solar PV, Commercial Si solar cells, process flow of commercial Si cell technology, Process in solar cell technologies, Sawing and surface texturing, diffusion process, thin film layers, Metal contact.

Unit III

2nd generation solar cell, Thin film solar cell,Advantage of thin film, Thin film deposition techniques, Evaporation, Sputtering, LPCVD and APCVD, Plasma Enhanced, Hot Wire CVD, closed space sublimation, Ion Assisted Deposition, Substrate and Super -state configuration, Thin film module manufacturing, Thin film and Amorphous Si Solar cell, Cadmium Telluride Solar Cell, CIGS solar Cell, CZTS solar cell, New materials for thin film solar cell.

Unit IV

3rd generation Solar cell; **Advances in Photovoltaics**, Photochemical and photosynthetic energy conversion; DSSC, Solution processed thin film, Organic Solar Cell, Hydride Perovskite solar cell and multi junction tandem solar cells.

Solar PV modules: Series and Parallel connections, Mismatch between cell and module, Design and structure, PV module power output, PV system configuration, standalone system with DC / AC load with and without battery, Hybrid system, Grid connected systems.

Course Outcomes:

On completion of the course, the student will able to

CO1: Understand the basics of semiconductor physics and working principle of solar photovoltaics.

CO 2: Acquire knowledge on the fabrication of different types of solar cell and methods to enhance the efficiency of solar cell.

CO 3: Understand recent trends and current research focus on the fabrication of solar cell.

CO 4: Acquire basic practical knowledge for the use of solar cell and grid connectivity.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	2			3						3	3		2
CO2	3	2	2	2	3	3	3					3	3	3	3	2
CO3	3	1	2	2	3	3	3					3	3	3		2
CO4	1	3	3	3		3	3		3		2	3				

TEXT BOOKS / REFERENCES:

1. Physics of Solar cells-Jenny Nelson, Imperial College Press (2006).
2. Solar Energy Conversion (Second Edition):Richard C. Neville; Elsevier Science (1995).
4. Physics of solar cells: P. Wurfel (Wiley-VCH, 2013).
5. Solar cell device physics;J. Fonash(AP, 2010).
6. Solar Energy: The Physics and Engineering of Photovoltaic Conversion, Technologies and Systems: UIT Cambridge, (2016).

18PHY654 Fabrication of Advanced Solar cell: Understanding the device physics 3 0 0 3

Unit- I

The Solar Resource and types of solar energy converters, Requirements of an ideal photoconverter, Principles of a solar cell design, material and design issues; Revisions of Semiconductor Physics, Physics of semiconductor Junctions; p-n junction under dark and under illumination, effect on junction characteristics, Other device structures. Photovoltaic cell and power generation, Characteristic of the Photovoltaic Cell.

Unit-II

Silicon Solar cell, Mono -crystalline and poly–crystalline cells, Metallurgical Grade Si, Electronic Grade Si, wafer production, Mono–crystalline Si Ingots, Poly–crystalline Si Ingots, Si–wafers, Si–sheets, Solar grade Silicon, Si usage in solar PV, Commercial Si solar cells, process flow of commercial Si cell technology, Process in solar cell technologies, Sawing and surface texturing, diffusion process, thin film layers, Metal contact.

Unit-III

2nd generation solar cell, Thin film solar cell,Advantage of thin film, Thin film deposition techniques, Evaporation, Sputtering, LPCVD and APCVD, Plasma Enhanced, Hot Wire CVD, closed space sublimation, Ion Assisted Deposition, Substrate and Super -state configuration, Thin film module manufacturing, Thin film and Amorphous Si Solar cell, Cadmium Telluride Solar Cell, CIGS solar Cell, CZTS solar cell, New materials for thin film solar cell.

Optics in solar energy conversion: antireflection coatings, concentration of light: Light confinement, photon recycling, multiple exciton generation.

Unit-IV

3rd generation Solar cell; **Advances in Photovoltaics**, Photochemical and photosynthetic energy conversion; DSSC,, Solution processed thin film, Organic Solar Cell, Hydride Perovskite solar cell and multijunction tandem solar cells;

Solar PV modules: Series and Parallel connections, Mismatch between cell and module, Design and structure, PV module power output, PV system configuration, standalone system with DC / AC load with and without battery, Hybrid system, Grid connected systems.

Unit-V

Hand on experience on solar cell fabrication, DSSC fabrication, Perovskite solar cell fabrication, Thin film solar cell fabrication.

Course Outcomes:

On completion of the course, the student will able to

CO1: Understand the basics of semiconductor physics and working principle of solar photovoltaics.

CO 2: Acquire knowledge on the fabrication of different types of Si solar cell and methods to enhance the efficiency of solar cell.

CO 3: Understand recent trends and current research focus on the fabrication of solar cell.

CO 4: Acquire knowledge on the fabrication of different types of advanced solar cell

CO 5: Acquire basic practical knowledge for the use of solar cell and grid connectivity.

Course Articulation Matrix:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO1 1	PO 12	PS O1	PS O2	PS O3	PS O4
CO1	3	2	2	2			3						3	3		2
CO2	3	2	2	2	3	3	3					3	3	3	3	2
CO3	3	1	2	2	3	3	3					3	3	3		2
CO4	3	1	2	2	3	3	3					3	3	3		2
CO5	3	3	3			3	3		3	3	3	3	3	3		2

TEXT BOOKS / REFERENCES:

1. Physics of Solar cells-Jenny Nelson, Imperial College Press(2006)
2. Crystalline Silicon Solar Cells, by A. Goetzberger, J. Knobloc h, and B. Voss (Wiley, 1998)
3. Third Generation Photovoltaics: Advanced Solar Energy Conversion, by M. A. Green (Springer, 2006)
4. Semiconductor Materials for Solar Photovoltaic Cells; Paranthaman, M.P. (et al.) (Eds.) (2016)

18PHY655 Astrophysics and Cosmology 3 0 0 3

Unit I

<u>Introduction to Astrophysics:</u> Mass, length and time scales in astrophysics, Magnitude scale, Source of astronomical information, Astronomical nomenclature, Theory of radiative transfer, Basic characteristics of thermodynamical equilibrium in stars

Unit II

<u>Stellar Structure and Dynamics:</u> Basic equations of stellar structure, Constructing stellar models, Stellar quantities, Stellar observational data, HR Diagram star clusters, Main nuclear reactions in stellar interior, Stellar evolution, Stellar Winds

Unit III

<u>Compact Stars and Interstellar Matter:</u> Supernovae, Degeneracy pressure of a Fermi gas, White Dwarf and Chandrasekhar mass limit, Neutron stars, Pulsars, Blackholes, Event Horizon and Schwarzchild radius, Phases of Interstellar Matter, Interstellar cloud and dust

Unit IV

Properties and Classification of Galaxies: The shape and size of our galaxy, Galactic rotation and Oort's constant, Missing mass problem and Dark matter, Morphological classification and physical characteristics of normal galaxies, Active galaxies, Unified model of active galaxies

Unit V

Cosmology: Hubble's law and the age of the Universe, Early Universe and Nucleosynthesis, Cosmic Microwave Radiation, Big Bang and Steady State model of the Universe, The horizon problem and inflation, Baryogenesis, Evidence and Nature of Dark matter and Dark energy

Course Outcomes

After completion of the course student should be able to

CO1 Acquaint scientific and observational tools in astrophysics and cosmology

CO2 Apply various mathematical models in astrophysics and cosmology

CO3 Develop critical/logical thinking, scientific reasoning, and problem solving skills in the area of astrophysics and cosmology.

Text Book:

1. "Astrophysics for Physicists" by AranbRaiChoudhuri

Ref. Book:

1. "Introduction to Astronomy and Cosmology" by Ian Morison

18PHY656 Special Theory of Relativity 3 0 0 3

Pre-requisites:

Electrodynamics & Intermediate Mechanics (both are compulsory Int. M.Sc. courses)
Level: **UG final year / PG I or II** – Elective or Core

Aim:

To have a comprehensive physical idea and mathematical understanding of Special theory of Relativity and its applications in Electrodynamics, Fluid Dynamics etc using four-dimensional covariant analysis.

UNIT 1

Classical Mechanics and Relativity:
Galilean Relativity, Newtonian Mechanics, Electrodynamics and Galilean Relativity, Ether, Michelson–Morley experiment, Attempts by Lorentz & Poincare.
7 hrs

UNIT 2

Special Theory of Relativity:
Einstein's postulates, Lorentz's transformation, Length contraction,
Time dilation. Relativistic Kinematics, Doppler shift, Minkowski Diagrams, Boosts and Minkowski space.
14 hrs

UNIT 3
Four dimensional Space-Time geometry:
Space-time continuum, Lorentz transformations as coordinate transformations, tensors, contravariant and covariant objects, four vectors

Relativistic Dynamics:
Four velcocity, Four momentum, Four acceleration, Relativistic Collisions, Conservation of four-momentum, Equivalence of Mass and Energy. Central force problem in relativity.
14 hrs

UNIT 4
Electromagnetic Theory in covariant form:
Maxwell's equations in covariant form, Four dimensional vector potential, Energy-Momentum Tensor and Conservation Laws, Lagrangian formulation of Electrodynamics, Radiation.
13 hrs

UNIT 5
Covariant formulation Fluid Dynamics:
Perfect fluids, Pressure and proper density, Energy-Momentum tensor, Relativistic Euler equations, Equation of state, Speed of sound.

The Lorenz & Poincare groups:
The The Lorentz and Poincare algebras and their representations.

The Principle of Equivalence and preamble to General Theory of Relativity. 1
2 hrs

Course Outcomes:

After completing the course, the student should be able to:

CO1 Demonstrate an understanding of the basic necessity and principles of the special theory of relativity in four dimensional Minkowski space-time.
CO2 Apply tensor notation in relativity theory and perform basic calculations in relativistic kinematics and dynamics
CO3 Understanding of covariant formulation of classical theories like electromagnetism & fluid dynamics

CO-PO Mapping:

	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO1	PO1	PO1	PS	PS	PS

	1	2	3	4	5	6	7	8	9	0	1	2	O 01	O 02	O 03
CO1	3	2	2	3	3								3	3	
CO2	3	3	3	3	3								3	2	
CO3	3	2	3	2	3								3	3	

Text Books:

1. N. M. J. Woodhouse, Special Theory of Relativity, Springer, 2003
2. Steven Weinberg, Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity, Wiley India, 2008

Reference Books:

1. Landau &Lifshitz, Classical Field Theory, University Science Books, 1E, 2004
2. Ashok Das, Lectures on Electromagnetism, Hindustan Book Agency – World Scientific, 2013
3. A. Einstein, Relativity: The Special and the General Theory