தமிழ்நாடு மத்தியப் பல்கலைக்கழகம் | CENTRAL UNIVERSITY OF TAMIL NADU | तमिलनाडु केन्द्रीय विश्वविद्यालय

ESTABLISHED BY AN ACT OF PARLIAMENT IN 2009

# Department of Physics
# School of Basic and Applied Sciences

# Syllabus

# M. Sc. Physics
# 2023 onwards

## Table of Contents:

# 1. PROGRAM OUTLINE

**A. Preamble:**

1. **Started**: 2010.
2. **Programmes offered**: Integrated M.Sc. M.Sc., and Ph.D in Physics
3. **Vision and Thrust areas of the Department in brief**:
   The department of Physics of CUTN envisages itself to be a centre of excellence in basic and applied aspects of Physics, both in teaching and research, in 20 years
4. **Unique feature of the department**:

   The department is established with well-equipped teaching and research laboratories, at par with international standards. All the classrooms are equipped with audio visual aids and a few with smart classrooms with interactive/communicative teaching aids for effective teaching and learning. In order to kindle students' creative learning, E-magazine, prevega (outreach program) Spark and other extra- curricular/co- curricular activities are inculcated through our perturbations club. The performance of all the students is being monitored constantly through Gurukula mentoring and a group of students are assigned to each faculty member for getting guidance for their academic/career development.

**B. Title:** The title of the program is Master's of Science in Physics. The Rules and Regulations of the Central University of Tamil Nadu apply to this program.

**C. Objectives of the Program:**

On completion of the program, the students will be able to:

- Understand the fundamental laws of Physics and its advancement so far.
- Develop the insight into the nature, scope, and objective of Physics.
- Develop logical and rational thinking.
- Develop the art of innovation, making strategies, and solving scientific problems.
- Develop the scientific spirit.

**D. Duration**

The duration of the MSc program shall be two academic years. Each academic year consists of two semesters. Each semester will consist of 19 weeks of instruction, excluding admission and examination.

**E. Eligibility for admission**

As per notification by the Examination Branch, Central University of Tamil Nadu.

**F. Medium of instruction**

Medium of instruction shall be English.

**G. Methods of transaction**

A list of suggestive methods of curriculum transaction are as follows:

- Lectures - cum- discussion.
- Lecture - cum - demonstration.

- Individual projects.
- Project reviews.
- Using library & ICT resources.

**H. Attendance:**

75% attendance is compulsory.

**I. Course outline**

The total credits of the program at the end of two years are 90 plus credits earned through MOOC/SWAYAM/NPTEL. The program offers an exit option with a B.Sc Hons/PG-Diploma degree at the end of first year.

The course is designed to provide teaching to the students at par with top institutes both at national and international level. Moreover, it will train them to take various national and international level examinations to enter into the field of research, to become professional physicists, excel in various interdisciplinary fields, and service sectors other than Physics. This syllabus is an attempt to balance all these requirements. The course is divided as follows.

**(a) Core papers:**

Total 16 number of core papers (theory + practical) at the end of two years. These are mandatory papers covering essential components of physics.

**(b) Discipline Specific Elective (DSE):**

DSEs will be offered by the department as listed in Table 2.

**(c) Open Elective (OE):**

Open elective offered by other departments.

**(d) Skill Enhancement Courses (SEC):**

**(e) Value Added Courses (VAC):**

Students have to choose a VAC provided by the department or University.

## J. PANORAMA OF COURSE STRUCTURE:

**Table - 1**

| **FIRST YEAR** | | | | | | |
|---|---|---|---|---|---|---|
| **SEMESTER I** | | | | | | |
| **Course Code** | **Course Title** | **Course Type** | **Credits** | **Hours / week** | **Marks** | |
| | | | | | **Int** | **Ext** |
| PHY2011 | Classical Mechanics | CC | 04 | 04 | 40 | 60 |
| PHY2012 | Mathematical Physics -I | CC | 04 | 04 | 40 | 60 |
| PHY2013 | Quantum Mechanics -I | CC | 04 | 04 | 40 | 60 |
| PHY2014 | Computational Condensed Matter Physics | CC | 04 | 04 | 40 | 60 |
| PHY2015 | Computational Condensed Matter Physics Lab | CCP | 02 | 04 | 100 | |
| PHY2016 | Digital Electronics & Microprocessor Lab | CCP | 02 | 04 | 100 | |
| PHYEC07 | Digital Electronics & Microprocessor | DSE/MOOCS | 04 | 04 | 40 | 60 |
| | Research Methodology and Publication Ethics | VAC | 02 | 02 | 40 | 60 |
| **Total** | | | **26** | **30** | | |
| **Cumulative Total** | | | **26** | **30** | | |
| **SEMESTER II** | | | | | | |
| **Course Code** | **Course Title** | **Course Type** | **Credits** | **Hours / week** | **Marks** | |
| | | | | | **Int** | **Ext** |
| PHY2021 | Mathematical Physics -II | CC | 04 | 04 | 40 | 60 |
| PHY2022 | Quantum Mechanics -II | CC | 04 | 04 | 40 | 60 |
| PHY2023 | Statistical Mechanics | CC | 04 | 04 | 40 | 60 |

| | | | | | | |
|---|---|---|---|---|---|---|
| PHY2024 | Experimental Methods in Physics | CC | 04 | 04 | 40 | 60 |
| PHY2025 | Experimental Technique Lab | CCP | 02 | 04 | 100 | |
| | MOOCs/SWAYAM/NPTEL | DSE | 02 | 02 | 100 | |
| | Courses can be chosen from the Times Group (Online) | VAC (should be shifted to here) | 2 (not included) | * | | |
| | **Total** | | **20** | **22** | | |
| | **Cumulative Total** | | **46** | **52** | | |
| | **For students exiting after four years (Bachelor's Degree – Honours/Research)** | | | | | |
| | * Internship will be conducted in continuous mode for 160 hrs (1 credit = 40hrs) | | | | | |
| | | | | | | |

## SECOND YEAR

| **SEMESTER III** | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **Course Title** | **Course Type** | **Credits** | **Hours / week** | **Marks** | |
| | | | | | **Int** | **Ext** |
| PHY2031 | Condensed Matter Physics | CC | 04 | 04 | 40 | 60 |
| PHY2032 | Nuclear And Particle Physics | CC | 04 | 04 | 40 | 60 |
| PHY2033 | Electromagnetic Theory | CC | 04 | 04 | 40 | 60 |
| PHY2034 | Condensed Matter Physics Lab | CCP | 02 | 04 | 100 | |
| PHY2035 | Advanced Physics Lab | CCP | 02 | 04 | 100 | |
| PHYEC05 | Atomics And Molecular Spectroscopy | DSE | 04 | 04 | 40 | 60 |
| | SEC | SEC | 03 | 03 | 40 | 60 |
| | Open Elective | OE | 03 | 03 | 40 | 60 |
| **Total** | | | **26** | **30** | | |

| Cumulative Total | | | | 72 | 82 | | |
|---|---|---|---|---|---|---|---|
| **SEMESTER IV** | | | | | | | |
| **Course Code** | **Course Title** | **Course Type** | **Credits** | **Hours / week** | **Marks** | | |
| | | | | | **Int** | **Ext** | |
| PHY2041 | Research Project/Dissertation | CC | 12 | **24** | | | |
| PHY2042 | DSE-IV | Internship | 02 | .. | | | |
| | Self Study Course | DSE | 04 | 04 | | | |
| | **Total** | | **18** | 28 | | | |
| **Total credits (after 2 years)** | | | **90** | **110** | | | |

**List of Discipline Specific Elective (DSE) Courses**

**Table - 2**

| COURSE CODE | COURSE TITLE |
|---|---|
| PHYEC01 | ADVANCED MATHEMATICAL PHYSICS |
| PHYEC02 | ADVANCED PARTICLE PHYSICS |
| PHYEC03 | ADVANCED QUANTUM MECHANICS |
| PHYEC04 | ASTROPHYSICS |
| PHYEC05 | ATOMIC & MOLECULAR SPECTROSCOPY |
| PHYEC06 | CRYSTAL GROWTH & THIN FILM PHYSICS |
| PHYEC07 | DIGITAL ELECTRONICS & MICROPROCESSOR |
| PHYEC08 | GENERAL THEORY OF RELATIVITY & COSMOLOGY |
| PHYEC09 | INTRODUCTION TO NONLINEAR DYNAMICS |
| PHYEC10 | LASER PHYSICS AND ITS APPLICATIONS |
| PHYEC11 | MICROWAVE PHYSICS |
| PHYEC12 | NANOMATERIALS AND NANOTECHNOLOGY |
| PHYEC13 | NUMERICAL METHODS AND COMPUTER PROGRAMMING |

| | |
|---|---|
| PHYEC14 | PHYSICS OF MAGNETISM & SPINTRONICS |
| PHYEC15 | PLASMA PHYSICS |
| PHYEC16 | PROPERTIES OF MATERIALS |
| PHYEC17 | QUANTUM OPTICS |
| PHYEC18 | QUANTUM COMPUTATION AND QUANTUM INFORMATION |
| PHYEC19 | QUANTUM FIELD THEORY |
| PHYEC20 | SEMICONDUCTOR PHYSICS |
| PHYEC21 | SOLAR ENERGY AND ITS APPLICATION |
| PHYEC22 | VACUUM SCIENCE & NANO TECHNOLOGY |

**List of Open Elective course:**

| **COURSE CODE** | **COURSE TITLE** |
|---|---|
| PHYOE01 | APPLIED OPTICS |
| PHYOE02 | GENDER CONCERNS IN STEM STUDIES |
| PHYOE03 | INTRODUCTION TO ASTRONOMY & ASTROPHYSICS |
| PHYOE04 | MEDICAL PHYSICS |
| PHYOE05 | PHYSICS OF ARTS |

**List of Skill Enhancement Courses (SEC):**

| **COURSE CODE** | **COURSE TITLE** |
|---|---|
| PHYSE01 | MACHINE SHOP |
| PHYSE02 | NANOSCIENCE AND NANOTECHNOLOGY |
| PHYSE03 | RENEWABLE ENERGY TECHNOLOGIES |

**List of Value-Added Courses (VAC):**

| COURSE CODE | COURSE TITLE |
|---|---|
| PHYVA01 | DATA ANALYSIS TECHNIQUES |
| PHYVA02 | COMPUTATIONAL MODELING OF MATERIALS |

**K. EVALUATION:**

The performance of each student enrolled will be assessed at the end of each semester. Evaluation of the student will be done as per the Grading System adopted by the Central University of Tamil Nadu. The final result in each course will be determined based on (a) continuous assessment, and (b) performance in the Term End Examination which will be in the ratio of 40:60 (40 Continuous Assessment and 60 Term End Exam) in case of a theory paper. In the case of Practical, the result will be determined on the basis of continuous evaluation only. The passing minimum in the course shall be 50% in theory and 50% in Practical components separately, and an overall 50%. The student who fails in either theory or practical examination, he/she has to clear the same in the subsequent supplementary examination notified by the examination section, CUTN. Please note that the evaluation process has to be followed as per the University.

# 2. VISION, MISSION, AND OBE PATTERN

**A.** Vision statement of the department:

The Department of Physics of CUTN envisages itself to be a center of excellence in basic and applied aspects of Physics, both in teaching and research, in next 20 years.

**B. Mission statement of the department:**

| | |
|---|---|
| **M-1** | To establish a world class Department of Physics while being sensitive to the location of the University and the demographics of the student input. |
| **M-2** | To establish a world class research laboratory with cutting edge technology in multi and trans disciplinary areas of Physics and to train students to develop the high level of global competence in core/ Applied areas of Physics. |
| **M-3** | To collaborate with Institutes of eminence and Industries for enhanced learning experience through ICT integrated teaching-learning process. |

**C. Program Outcomes**

On the successful completion of the program, the student will be able to

| | |
|---|---|
| **PO-1** | Develop and establish advance knowledge and apply theories and principles of Physics/Applied Physics in the domain of industry, research and development. |
| **PO-2** | Successfully acquiring jobs after pursuing research in advanced laboratories around the globe and build perform as professional teachers in Physics and other science disciplines. |
| **PO-3** | Provide professional services to industry, research organizations and institutes in India and overseas. |
| **PO-4** | Develop, create and apply appropriate techniques, resources and relevant IT tools to find complex scientific solutions related to academic and research activities with clear understanding of its advantages and limitations. |
| **PO-5** | Provide value based and ethical leadership in the professional and social life. |

**D. Specific Outcomes (PSO)**

| | |
|---|---|
| **PSO-1** | Apply the knowledge gained in fundamental and applied Physics in solving scientific problems at varied complexity, analyze the same to formulate/ develop substantiated solutions. |
| **PSO-2** | Apply the research-based knowledge and advanced method to design new experiments, analyze resulting data and interpret the same to provide valid conclusions. |
| **PSO-3** | Gain broad understanding of ethical and professional skill in scientific applications in the context of local, global, economic, environmental and societal realities and to develop sustainable practical solutions for academic and research problems within professional and ethical boundaries. |

| | |
|---|---|
| **PSO-4** | Educate scientifically the new development in Science and Technology and make them critical thinkers and innovators. |
| **PSO-5** | Engage in independent and lifelong learning in the broadest context of technological change and pursue his/her career either in higher studies or in various sectors. |

**E. Graduate Attributes**

(a) Disciplinary/ interdisciplinary knowledge
(b) Computational and ICT skills/ digital literacy.
(c) Communication skills.
(d) Ethics/ moral awareness.
(e) Problems solving/ Analytical/ reflective thinking.
(f) Critical thinking
(g) Cooperation/ teamwork.
(h) Self-directed learning.
(i) Research related skills

**F. PSO to Mission Statement Mapping:**

| | **PSO-1** | **PSO-2** | **PSO-3** | **PSO-4** | **PSO-5** |
|---|---|---|---|---|---|
| **M-1** | 3 | 2 | 2 | 3 | 3 |
| **M-2** | 2 | 3 | 3 | 3 | 2 |
| **M-3** | 1 | 3 | 2 | 3 | 1 |

**G. PO to PSO Mapping:**

| | **PO-1** | **PO-2** | **PO-3** | **PO-4** | **PO-5** |
|---|---|---|---|---|---|
| **PSO-1** | 3 | 2 | 3 | 3 | 1 |
| **PSO-2** | 3 | 3 | 3 | 3 | 1 |
| **PSO-3** | 2 | 1 | 3 | 2 | 3 |
| **PSO-4** | 3 | 3 | 3 | 3 | 1 |
| **PSO-5** | 2 | 2 | 3 | 1 | 3 |

# SEMESTER - I

**Course Code: PHY2011**
**Course Title: Classical Mechanics**
**Course Type: Theory (Core)**
**Credits: 04**

**Unit 1:**
**LAGRANGIAN DYNAMICS:** Lagrangian Formulation-System of particles-Constraints and degrees of freedom, Generalized Coordinates, Concept of virtual work, Conservation Laws -Conservation of Linear and Angular momenta- Symmetric properties-D'Alembert Principle, Lagrange equation from D'Alembert principle, Application of Lagrange equations of motion -free particle in Space -Atwood's machine – bead sliding in rotating wire, velocity dependent potential, cyclic coordinates, symmetry properties and conservation theorems.

**(12 Hours)**

**Unit 2:**
**HAMILTONIAN DYNAMICS:** Calculus of Variation-Hamiltonian's Variation principle-Lagrange's equation from Hamilton's principle-Hamilton's principle for nonholonomic system-Hamilton's equations from Variational principle, phase space diagrams, Legendre transformation and Hamilton's equations of motion-Cyclic co-ordinates and conservation theorem, Noether's theorem, Liouville's theorem.

**(12 Hours)**

**Unit 3:**
**CENTRAL FORCE PROBLEM:** Central force and motion in a plane, Reduction of a two-body central force to equivalent one body problem, Equation of motion and first integral, Differential equation for an orbit, Equivalent one-dimensional problem and classification of orbits for some specific potential. Integral power law potential, Virial theorem, Relation between kinetic and potential energy. Keplers Problems: Equation of orbit and the kind of the orbit, Scattering in a central force field-transformation of Scattering to Laboratory co-ordinates, Relativistic Lagrangian and Hamiltonian for a particle.

**(12 Hours)**

**Unit 4:**
**KINEMATICS OF RIGID BODY:** Independent co-ordinate of a rigid body, Orthogonal transformation, Formal properties of transformation matrix, Euler angles, Euler's theorem, Finite rotation, Infinitesimal rotations (contact transformation). Angular momentum, Moment of inertia tensor, Product of inertia, Inertia tensor, Principal moment of inertia: Principal axis, Kinetic energy of motion of a rigid body about a point. Moment of inertia tensor-Euler's equation of motion-Torque free motion of a rigid body-heavy Symmetrical top.

**(12 Hours)**

**Unit 5:**
**CANONICAL TRANSFORMATION & HAMILTON-JACOBI THEORY**: Canonical transformation, Legendre transformation, Generating functions, Conditions for canonical transformation, Poisson's brackets, Langrange brackets, Invariance of Poission bracket under canonical transformation, Angular momentum Poission bracket relation. Hamilton Jacobi equation for Hamilton's principal function, Harmonic oscillator problem by Hamilton Jacobi method, Hamilton's characteristic function. Harmonic oscillations-Small oscillations-Normal co-ordinates-Normal frequencies of vibrations -Vibrations of linear triatomic molecule

**(12 Hours)**

**Reference Books::**

1. H. Goldstein: Classical Mechanics, Narosa Publishing House, 2001.
2. N. C. Rana and P. S. Joag: Classical Mechanics, Tata Mc-Graw Hill, New Delhi, 1991.
3. J. C. Upadhyaya: Classical Mechanics, Himalaya Publishing, 2006.
4. P. V. Panat: Classical Mechanics, Narosa Publishing House, 2000.
5. S. L. Gupta, V. Kumar, H. V. Sharma: Classical Mechanics, Pragati Prakashan, Meerut, 2009.

| Course Outcomes | | Level |
|---|---|---|
| **CO-1** | To gain deeper understanding of the basic classical mechanics principles such as constraints, generalised coordinates, D'Alemberts principle, Lagrangian and Hamiltonian formulations. | **Remember** |
| **CO-2** | To be able to formulate and solve the problems on canonical transformations, Poisson brackets and Harmonic oscillators. | **Understand** |
| **CO-3** | To understand the theory of small oscillations which is important in several areas of physics e.g., motion of masses connected by springs –vibrations of linear triatomic molecule and coupled mechanical oscillators. | **Apply** |
| **CO-4** | To understand the motion of rigid body and essential features of a problem (like motion under central force, rigid body dynamics, periodic motions), use them to set up and solve the appropriate mathematical equations. | **Analyze** |
| **CO-5** | To solve the Central Force Problem and understanding the concept of special theory of relativity. | **Skill** |

## Mapping of Program Outcomes with Course Outcomes

| Course Outcomes | Program Outcomes | | | | |
|---|---|---|---|---|---|
| | **PO-1** | **PO-2** | **PO-3** | **PO-4** | **PO-5** |
| **CO-1** | 3 | 2 | 0 | 3 | 3 |
| **CO-2** | 3 | 1 | 3 | 3 | 3 |
| **CO-3** | 3 | 3 | 3 | 3 | 2 |
| **CO-4** | 2 | 1 | 3 | 2 | 3 |
| **CO-5** | 0 | 3 | 3 | 3 | 2 |

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**Course Code: PHY2012**
**Course Title: Mathematical Physics -I**
**Course Type: Theory (Core)**
**Credits: 04**

**Unit 1:**
**FUNCTION OF REAL VARIABLES:** Features of a function, sketching functions, interpreting graph of functions using the concepts of calculus. Functions represented by integrals -, Gaussian integral in 1, 2 and 3 dimensions, step function □, Dirac delta function – Defining relation, sequences of function tending to □-function, relation between □ and □ function, properties of Dirac delta function, derivative of □-function.

**(12 Hours)**

**Unit 2:**
**SPECIAL FUNCTIONS:** Error function, complementary error function, Gamma functionLegendre, Hermite, Laguerre function Generating function, Recurrence relations and their differential equations Orthogonality of eigenfunctions Bessel's function of first kind, Spherical Bessel function, Associated Legendre function, Spherical harmonics.

**(12 Hours)**

**Unit 3:**
**LINEAR VECTOR SPACES:** Linear Vector Spaces and its dual, Linear Dependence and Independence of vectors, Basis and Dimensions, Infinite dimensional vector space- Hilbert space, subspace, Rank and Nullity of a Matrix, Examples from Real Function Space and Polynomial Space, Orthogonal Vectors, Orthogonal Basis, Gram- Schmidt process of generating an Orthonormal Basis, Change of basis, singular value decomposition. Linear Transformations. Representation of Linear Transformations by Matrices. Hermitian and Skew- Hermitian Matrices. Orthogonal and Unitary Matrices. Similar Matrices. Inner Product. Properties of Eigenvalues and Eigen Vectors of Orthogonal, Hermitian and Unitary Matrices similarity transformation. Exponential of a Matrix.

**(12 Hours)**

**Unit 4:**
**CURVILINEAR COORDINATES & TENSORS:** Orthogonal coordinate systems, Gradient, Curl, Divergence and Laplacian in orthogonal coordinate systems, Spherical, Polar and Cylindrical co-ordinates, Poisson's and Laplace Equations. Coordinates Transformation in N- dimensional Space, Einstein's summation convention, Tensors, . Contravariant, covariant and mixed tensor, tensors of rank greater than 2, Algebra of Tensors: Sum, Difference and Product of Two Tensors. Contraction, Quotient Law of Tensors, Symmetric and Anti-symmetric Tensors, Kronecker and Alternating Tensors Jacobian, Pseudo tensors, Fundamental operations with tensors, line element and metric tensor, tensor form of gradient, divergence, and curl, Covariant derivative, Christoffel's symbol, relative and absolute tensors.

**(12 Hours)**

**Unit 5:**
**GROUP THEORY:** Definition of group symmetry elements, homomorphisms; isomorphism; Subgroups and cyclic groups; Cosets; Abelian groups, Reducible and irreducible representation –Character table. O(3), SU(2) groups.

**(12 Hours)**

**Reference Books::**
1. Mathematical methods in physical sciences, Mary L Boas
2. Mathematical methods for physicists: G.B.Arfken, Hans Webber
3. Mathematical methods for physics and engineering: K.F.Riley, M.P.Hobson et. al.
4. Mathematical Physics, V. Balakrishnan

| Course Outcomes | | Level |
|---|---|---|
| **CO-1** | To get an idea of functions used in most of the physical systems, their basic properties and behaviour. Acquire the skill to get qualitative features of functions which can be used while analysing solutions of a physical problem. | Understand, Analyze, Skill |
| **CO-2** | Students will get to know about special functions which appear in many particle problems | Analyze, Apply |
| **CO-3** | To learn the abstract way of defining quantities like space, dimensionality of spaces etc which can be applied in various branches of physics. | Understand, Apply |
| **CO-4** | Learn the technique of tensor notation. Application of tensor notation in analysing various physical systems. | Skill, Apply, Analyse |
| **CO-5** | Get the idea of Group theory and its application in many branches of physics | Skill |

**Mapping of Program Outcomes with Course Outcomes**

| Course Outcomes | Program Outcomes | | | | |
|---|---|---|---|---|---|
| | **PO-1** | **PO-2** | **PO-3** | **PO-4** | **PO-5** |
| **CO-1** | 4 | 4 | 4 | 1 | 4 |
| **CO-2** | 4 | 4 | 3 | 2 | 3 |
| **CO-3** | 4 | 3 | 3 | 2 | 2 |
| **CO-4** | 4 | 3 | 2 | 2 | 2 |
| **CO-5** | 4 | 3 | 2 | 2 | 2 |

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**Course Code: PHY2013**
**Course Title: Quantum Mechanics -I**
**Course Type: Theory (Core)**
**Credits: 04**

**Unit 1:**
**GENERAL FORMALISM:** Historical background, Stern-Gerlach experiment leading to concept of vector space, Ket and bra notation for vector space, Inner product, Norm of a vector, Orthonormality and linear independence, Basis and dimension, Outer product, Projection operator, Completeness (closure property), Hilbert space, Operator, Hermitian operator, Eigen value and eigen function, Representation theory, Change

of basis, Unitary operator, Matrix elements, Unitary transformation, Diagonalization, Coordinate and momentum representation.

**(12 Hours)**

**Unit 2:**

**MEASUREMENTS IN QUANTUM MECHANICS**: Expectation values, Compatible and incompatible observable, Base kets as simultaneous eigen kets of maximal set of commuting observables, Examples, Heisenberg uncertainty principle, Gaussian wave packet, Schrödinger picture, Heisenberg picture and interaction picture, density matrix, pure and mixed states, evolution. Invariance Principle and Conservation Laws: Symmetry and conservation laws, Displacement in space- conservation of linear momentum, Displacement in time –conservation of energy, Rotations in space- conservation of angular momentum, Space- inversion parity.

**(12 Hours)**

**Unit 3:**

**SOLUTION OF SCHRODINGER EQUATION:** One dimensional simple harmonic oscillator: Eigen function and Eigen value by solving Schrödinger equation and also by operator method, Creation and annihilation operators. Two beads on a wire and a particle in a two-dimensional box. Two dimensional harmonic oscillators. Linear combination of atomic orbitals (LCAO) approximation. Periodic lattice, Bragg reflection.

**(12 Hours)**

**Unit 4:**

**ANGULAR MOMENTUM:** Angular Momentum: Orbital Angular Momentum, Spherical harmonics, Operators Orbital angular momentum operators L , Lx, Ly and Lz, Spin angular momentum and total angular momentum, Commutation relations, Ladder operators, Matrix representation of Operators Jx, Jy, Jz, and J , Pauli spin matrices, Addition of two angular momentums, Clebsch- Gorden coefficients. Selection Rules and simple applications.

**(12 Hours)**

**Unit 5:**

**THREE DIMENSIONAL PROBLEMS:** Free particle in Cartesian coordinates, free particle in spherical polar coordinates, radial wave functions, radial momentum, particle in a three-dimensional box, degeneracy, density of states, charged particle in magnetic field, Fermi energy and Landau levels, Two-particle problem, effective potential, angular momentum barrier, Solution of Schrödinger equation for Hydrogen atom-energy levels and stationary state wave functions

**(12 Hours)**

**Reference Books::**


1. D. J. Griffiths and D. F. Schroeter, Introduction to Quantum Mechanics, Cambridge University Press, 2018, 3rd Ed.
2. R.L. Liboff, Introdunctory Quntum Mechanics, Pearson Education, 2003, 4th Edition.
3. J. J. Sakurai, Modern Quantum Mechanics, Pearson Education, 2005.
4. N. Zettili, Quantum Mechanics Concepts and Applications, John Wiley, 2009, 2nd edition.
5. P. M. Mathews and Venkatesan, A Text Book of Quantum Mechanics, Tata McGraw Hill, 2010.
6. Quantum Mechanics – A. K. Ghatak and S. Lokanathan (Macmillan, Delhi).
7. Quantum Mechanics – J. L. Powell and B. Crasemonn, (Oxford, Delhi).
8. C. Cohen-Tannoudji, Quantum Mechanics (vol.2), John Willey & sons, 2005.
9. Aruldhas G, "Quantum Mechanics", Printice-Hall of India Pvt. Ltd. 2002
10. R. Eisberg and R. Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, Wiley India Pvt. Ltd., 2006.
11. Basic Quantum Mechanics , J. M. Cassels.
12. Quantum Mechanics, S. P. Singh.

| Course Outcomes | | Level |
|---|---|---|
| **CO-1** | Understand basic concepts of Quantum mechanics, | Remember, Understand |
| **CO-2** | Study the different pictures of quantum dynamics and conservation laws | Apply, Understand |
| **CO-3** | Applying the Quantum mechanics concepts to solve one and two dimensional problems. | Apply |
| **CO-4** | Concept of spin and angular momentum operator algebra | Understand, Apply, Analyze |
| **CO-5** | Applying the Quantum mechanics concepts to solve three dimensional problems. | Apply |

**Mapping of Program Outcomes with Course Outcomes**

| Course Outcomes | Program Outcomes | | | | |
|---|---|---|---|---|---|
| | **PO-1** | **PO-2** | **PO-3** | **PO-4** | **PO-5** |
| **CO-1** | 3 | 3 | 3 | 3 | 1 |
| **CO-2** | 3 | 3 | 2 | 1 | 1 |
| **CO-3** | 3 | 3 | 2 | 1 | 1 |
| **CO-4** | 3 | 3 | 1 | 2 | 1 |
| **CO-5** | 3 | 3 | 1 | 2 | 1 |

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**Course Code: PHY2014**
**Course Title: Computational Condensed Matter Physics**
**Course Type: Theory (Core)**
**Credits: 04**

**Unit 1:**
**INTRODUCTION & BASIC CONCEPTS:** Theoretical Background, Basic equations for interacting electrons and nuclei, Coulomb interaction in condensed matter, independent electron approximations,

Exchange and correlation, Periodic solids and electron bands, Structures of crystals: lattice + basis, The reciprocal lattice and Brillouin zone, Excitations and the Bloch theorem.

**(12 Hours)**

**Unit 2:**

Time reversal and inversion symmetries, Integration over the Brillouin zone and special points Density of states Uniform electron gas and simple metals. Non-interacting and Hartree-Fock approximation, The correlation hole and energy. Density functional theory: foundations, Thomas-Fermi-Dirac approximations: example of a functional. The Hohenberg-Kohn theorems, Constrained search formulation of density functional theory, Extensions of Hohenberg-Kohn theorems, The Kohn-Sham ansatz. Replacing one problem with another: The Kohn-Sham variational equations Exc, Vxc and the exchange correlation hole Meaning of the eigenvalue. Intricacies of exact Kohn-Sham theory.

**(12 Hours)**

**Unit 3:**

Functionals for exchange and correlation, The local spin density approximation (LSDA), Generalized-gradient approximation (GGAs) , LDA and GGA expressions for the potential Vxc(r), Non-collinear spin density, Non-local density formulations: ADA and WDA, Orbital dependent functionals I: SIC and LDA+U. Orbital dependent functional II: OEP and EXX, Hybrid functionals , Tests of functionals Solving Kohn-Sham equations – Self-consistent coupled Kohn.Sham equations - Total energy functionals, Achieving self-consistency – Numerical mixing schemes, Force and stress.

**(12 Hours)**

**Unit 4:**

Determination of electronic structure – Atomic sphere approximation in solids, Plane waves and grids: basics - The independent particle Schrodinger equation in a plane wave basis. The Bloch theorem and electron bands - Nearly free-electron-approximation - Form factors and structure factors. Plane-wave method - ‘Ab initio’ pseudopotential method - Projector augmented waves (PAWs) - Simple crystals: structures, bands, - Supercells: surfaces, interfaces, phonons, defects - Clusters and molecules. Localized orbitals: tight-binding – Tight-binding bands: illustrative examples - square lattice and CuO2 planes - Examples of bands: semiconductors and transition metals - Electronic states of nanotubes. Localized orbitals: full calculations – Solution of Kohn-Sham equations in localized bases. Analytic basis functions: gassians - Gassian methods: ground state and excitation energies - Numerical orbitals - Localized orbitals: total energy, force, and stress - Applications of numerical local orbitals - Green’s function and recursion methods - Mixed basis.

**(12 Hours)**

**Unit 5:**

Augmented plane waves (APW’s) and ‘muffin-tins’ – Solving APW equations: examples Muffin-tin orbitals (MTOs). Linearized augmented plane waves (LAPWs) - Applications of the LAPW method - Linear muffin-tin orbital (LMTO) method - Applications of the LMTO method - Full potential in augmented methods - Molecular dynamics (MD): forces from the electrons - Lattice dynamics from electronic structure theory - Phonons and density response functions - Periodic perturbations and phonon dispersion curves - Dielectric response functions, effective charges - Electron-phonon interactions and superconductivity.

**(12 Hours)**

**Reference Books::**

1. H.Skriver, The LMTO Methods, Springer (1984).
2. Electronic Structure Basic Theory and Practical Methods Richard M. Martin, Cambridge University Press (2004).
3. Modeling Materials Continuum, Atomistic and Multiscale Techniques ELLAD B. TADMOR, Cambridge University Press (2012).
4. Atomic and Electronic Structure of Solids, Efthimios Kaxiras, Cambridge University Press (2003).
5. Computational Chemistry of Solid State Materials, *Richard Dronskowski*, WILEY-VCH (2005).
6. Mizutani U. Introduction to the Electron Theory of Metals (CUP,2001).
7. Roessler U. Solid State Theory.. An Introduction (2ed., Springer, 2009)

| Course Outcomes | | Level |
|---|---|---|
| **CO-1** | Introduce students to modelling of solids and predict as well as interpret their various properties using computational modelling. | Acquire, Understand, |
| **CO-2** | Show how these modelling methods can be used to understand fundamental material structure and properties as well as the relationships between material structure and material behaviour. | Evaluate, Analyse, Skill |
| **CO-3** | Develop an understanding of the assumptions and approximations that are involved in the modelling frameworks at the various time and length scales. | Remember, Understand, Analyse, Apply |
| **CO-4** | Students will be introduced to the basis for the simulation techniques, learn how to use computational modelling, and how to present and interpret the results of simulations. | Understand, Apply, Skill |
| **CO-5** | The students will learn various computational parameters and practical knowledge involve in modelling functional properties of solids and with that knowledge they can design materials in the computational lab for various applications. | Understand,Analyse, and Apply |

## Mapping of Program Outcomes with Course Outcomes

| Course Outcomes | Program Outcomes | | | | |
|---|---|---|---|---|---|
| | **PO-1** | **PO-2** | **PO-3** | **PO-4** | **PO-5** |
| **CO-1** | 3 | 3 | 2 | 2 | 1 |
| **CO-2** | 3 | 2 | 3 | 2 | 1 |
| **CO-3** | 3 | 3 | 3 | 2 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| **CO-4** | 3 | 3 | 2 | 3 | 1 |
| **CO-5** | 2 | 2 | 2 | 2 | 1 |

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**Course Code: PHY2015**
**Course Title: Computational Condensed Matter Physics Laboratory**
**Course Type: Practical (Core)**
**Credits: 02**

**List of Experiments:**

1. Introduction to Quantum Espresso simulation software package (GUI-BURAI) and plotting software
2. Optimizing crystal structure of Si and GaAs.
3. Analyzing band structure of Si, GaAs and graphene.
4. Plotting the total and partial density of states (DOS) and analyzing the bonding interaction present in Si, GaAs and graphene.
5. Plotting and analyzing the band structure, total DOS and partial density of states of TiO2. Explain why it is a transparent conductor.
6. Absorption spectra for Si, GaAs and TiO2.
7. Band structures of n-type and p-type semiconductors.
8. Finding optimized magnetic ordering of Fe.
9. Charge density and Electron localized function of NaCl, Si and Fe.
10. Calculating phonon spectra of graphene.

**Reference Books::**


1. H.Skriver, The LMTO Methods, Springer (1984).
2. Electronic Structure Basic Theory and Practical Methods Richard M. Martin, Cambridge University Press (2004).
3. Modeling Materials Continuum, Atomistic and Multiscale Techniques ELLAD B. TADMOR, Cambridge University Press (2012).
4. Atomic and Electronic Structure of Solids, Efthimios Kaxiras, Cambridge University Press (2003).
5. Computational Chemistry of Solid State Materials, *Richard Dronskowski*, WILEY-VCH (2005).
6. Mizutani U. Introduction to the Electron Theory of Metals (CUP,2001).
7. Roessler U. Solid State Theory.. An Introduction (2ed., Springer, 2009)


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**Course Code: PHY2016**
**Course Title: Digital Electronics & Microprocessor Laboratory**
**Course Type: Practical (Core)**
**Credits: 02**

**List of Experiments:**

1. Design of various types of active filters
2. Construction of seven segment display.
3. Voltage regulator using IC723
4. Study of gate ICs – NOT,OR,AND, NOR,NAND, XOR, XNOR
5. Half adder / Half subtractor using basic logic gate ICs

6. NAND as universal building block
7. NOR as universal building block
8. Construction of Op-Amp- 4 bit Digital to Analog converter (Binary Weighted and R/2R ladder type)
9. Study of R-S, clocked R-S and D-Flip flop using NAND gates
10. Study of J-K, D and T flip flops using IC 7476/7473
11. Construction of Encoder and Decoder circuits using ICs
12. Microprocessor 8085 – addition, subtraction, multiplication, division (8bit only)
13. Microprocessor 8085 – square, square root, largest/smallest of numbers, ascending/descending order, Fibonacci series (8 bit only)

**Reference Books:**


1.Analog Electronics: Analog and Digital Circuit Systems- Jacob Milman & Halkias, TMH

2. A practical introduction to Analog and Digital circuits by Daniel M Kaplan, and Christopher G. White, Cambridge University Press 2010.

3. Integrated Electronics by Jacob Milman & Halkias, TMH.


| Course Outcomes | | Level |
|---|---|---|
| **CO-1** | Conduct the experiments on application of OP-Amps | **Remember** |
| **CO-2** | Construction of voltage stabilizer and logic gates using ICs | **Understand** |
| **CO-3** | Analyze the applications of counters and registers | **Apply** |
| **CO-4** | Able to implement logic gates in flip-flops | **Analyse** |
| **CO-5** | Able to write the program/code in microprocessor | **Skill** |

## Mapping of Program Outcomes with Course Outcomes

| | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 3 | 1 |
| **CO2** | 3 | 3 | 2 | 1 | 2 |
| **CO3** | 2 | 3 | 2 | 2 | 1 |
| **CO4** | 3 | 3 | 1 | 3 | 2 |
| **CO5** | 3 | 3 | 2 | 3 | 1 |

# SEMESTER - II

**Course Code: PHY2021**
**Course Title: Mathematical Physics -II**
**Course Type: Theory (Core)**
**Credits: 04**

**Unit 1:**
**COMPLEX ANALYSIS:** Complex Numbers and their Graphical Representation. Euler's formula, De-Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Equations. Examples of analytic functions. Sequence and series of functions, convergence tests, absolute and uniform convergence, Taylor and Laurent series, analytic continuation.

**(12 Hours)**

**Unit 2:**
**SINGULARITIES:** poles, removable singularity, essential singularity, branch points, branch cut. Integration of a function of a complex, variable. Cauchy's Integral formula. Simply and multiply connected region. Residues and Residue Theorem. Application of Contour Integration in solving Integrals.

**(12 Hours)**

**Unit 3:**
**FOURIER SERIES, TRANSFORM, & APPLICATION:** Fourier series, orthogonality of functions, Dirichlet conditions. Application: Summing of Infinite Series. Fourier integral theorem, Fourier transform, Parseval's identity, convolution theorem, transform of derivates, Fourier transforms of simple function occurring in physical application.

**(12 Hours)**

**Unit 4:**
**LAPLACE TRANSFORM & ITS APPLICATION:** Laplace Transform (LT) of Elementary functions. Properties of LTs, Change of Scale, Shifting. LTs of Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Periodic Functions. Convolution Theorem. Inverse LT. Evaluation of inverse Laplace transform using counter integration. Application of Laplace Transforms to 2nd order Differential Equations, Coupled differential equations of 1st order.

**(12 Hours)**

**Unit 5:**
**PROBABILITY & STATISTICS:** Independent and dependent events, Conditional Probability. Bayes' Theorem, Independent random variables, Probability distribution functions, special distributions: Binomial, Poisson and Normal, moment generating functions,
Experiment, sample and population, sample statistics – moments and moment generating functions, covariance and correlation, maximum likelihood estimator, method of least squares, Hypothesis testing.

**(12 Hours)**

**Reference Books::**
1.Mathematical methods in physical sciences, Mary L Boas
2. Mathematical methods for physicists: G.B.Arfken, Hans Webber
3. Mathematical methods for physics and engineering: K.F.Riley, M.P.Hobson et. al.
4. Mathematical Physics, V. Balakrishnan

| | Course Outcomes | Level |
|---|---|---|
| **CO-1** | To get an idea of complex variables and its uses in physical problems. | **Understand, Analyze** |

| | | |
|---|---|---|
| **CO-2** | To use the idea of complex analysis in solving physical problems. | **Apply, skill** |
| **CO-3** | Learn the techniques of Fourier Series and Fourier transform.To apply the idea of Fourier Series and transform in various branches of Physics, Chemistry, Finance etc. | **Understand, Analyze, Apply** |
| **CO-4** | Learn Laplace transformation technique and its application. | **Understand, Analyze, Apply** |
| **CO-5** | Learn statistical methods and techniques. | **Skill** |

**Mapping of Program Outcomes with Course Outcomes**

| **Course Outcomes** | **Program Outcomes** | | | | |
|---|---|---|---|---|---|
| | **PO-1** | **PO-2** | **PO-3** | **PO-4** | **PO-5** |
| **CO-1** | 3 | 3 | 3 | 1 | 3 |
| **CO-2** | 3 | 3 | 2 | 2 | 3 |
| **CO-3** | 3 | 2 | 2 | 2 | 2 |
| **CO-4** | 3 | 2 | 1 | 2 | 2 |
| **CO-5** | 3 | 2 | 1 | 2 | 2 |

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**Course Code: PHY2022**
**Course Title: Quantum Mechanics -II**
**Course Type: Theory (Core)**
**Credits: 04**

**Unit 1:**
**TIME INDEPENDENT PERTURBATION THEORY:** Time independent perturbation **theory** for non-degenerate energy levels – Degenerate energy levels – Stark effect in Hydrogen atom – Ground and excited state – Variation method – Helium atom – WKB approximation – Connection formulae (no derivation) – WKB quantization – Application to simple harmonic oscillator.

**(12 Hours)**

**Unit 2**
**TIME DEPENDENT PERTURBATION THEORY:** Constant perturbation, Transition to continuum, Fermi's golden rule, Harmonic perturbation, Radiative transitions; Adiabatic approximation, Sudden approximation. Semi-Classical Theory of Radiation: Einstein coefficients, Atom field interaction, Interaction energy, Dipole matrix elements, Stimulated emission rate, Spontaneous emission rate, Selection rules

**(12 Hours)**

**Unit 3:**
**IDENTICAL PARTICLES:** Principle of indistinguishability, Symmetry of wave functions, Spin and statistics, Pauli's exclusion principle, Construction of wave function of two electrons in L-S and j-j coupling,

Allowed states, Ortho and para helium; Exchange force; Scattering of identical particles, Cases of spin half and spin zero particles.

**(12 Hours)**

**Unit 4:**

**SCATTERING:** The scattering experiments, Relationship of cross-section and wave function, Scattering amplitude; Partial wave analysis: Expansion of a plane wave in terms of partial waves, Scattering by central potential, Zero energy scattering; Scattering by a square well potential, Effective range, Resonant scattering, Optical theorem, Born approximation, Integral equation for scattering, Born's first approximation, Spherically symmetric potential, Criterion for validity of Born approximation, Scattering of electrons by atoms, Rutherford scattering.

**(12 Hours)**

**Unit 5:**

**RELATIVISTIC WAVE EQUATION:** Klein Gordan equation, Dirac equation, Properties of Dirac matrices, Free Dirac particle, Equation of continuity, Interpretation Of Negative Energy States – Antiparticle, Covariant form of Dirac Equation – Properties of the gamma matrices – Traces – Relativistic invariance of Dirac equation – Probability Density – Current four vector – Bilinear covariant CLASSICAL FIELDS: Euler Lagrange equation – Hamiltonian formulation – Noether's theorem – Quantization of real and complex scalar fields– Second Quantization of K-G field.

**(12 Hours)**

**Reference Books::**

1. D. J. Griffiths and D. F. Schroeter, Introduction to Quantum Mechanics, Cambridge University Press, 2018, 3rd Ed.
2. R.L. Liboff, Introdunctory Quntum Mechanics, Pearson Education, 2003, 4th Edition.
3. J. J. Sakurai, Modern Quantum Mechanics, Pearson Education, 2005.
4. N. Zettili, Quantum Mechanics Concepts and Applications, John Wiley, 2009, 2nd edition.
5. P. M. Mathews and Venkatesan, A Text Book of Quantum Mechanics, Tata McGraw Hill, 2010.
6. Quantum Mechanics – A. K. Ghatak and S. Lokanathan (Macmillan, Delhi).
7. Quantum Mechanics – J. L. Powell and B. Crasemonn, (Oxford, Delhi).
8. C. Cohen-Tannoudji, Quantum Mechanics (vol.2), John Willey & sons, 2005.
9. Aruldhas G, "Quantum Mechanics", Printice-Hall of India Pvt. Ltd. 2002
10. R. Eisberg and R. Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, Wiley India Pvt. Ltd., 2006.
11. Basic Quantum Mechanics , J. M. Cassels.
12. Quantum Mechanics, S. P. Singh.

| Course Outcomes | | Level |
|---|---|---|
| **CO-1** | Finding the energy levels of quantum systems subject to time independent perturbations. | Understand |
| **CO-2** | Applying the concept of time dependent perturbation theory to study atom-light interactions. | Apply |
| **CO-3** | Apply the concepts of quantum mechanics to the case of identical particles | Apply |
| **CO-4** | Analyze the quantum scattering of identical particles and find the cross section for scattering. | Analyze |
| **CO-5** | Understand the relativistic effects in quantum mechanics | Understand |

## Mapping of Program Outcomes with Course Outcomes

| Course Outcomes | Program Outcomes | | | | |
|---|---|---|---|---|---|
| | **PO-1** | **PO-2** | **PO-3** | **PO-4** | **PO-5** |
| **CO-1** | 3 | 3 | 2 | 2 | 1 |
| **CO-2** | 3 | 3 | 2 | 2 | 1 |
| **CO-3** | 3 | 3 | 2 | 2 | 1 |
| **CO-4** | 3 | 3 | 2 | 2 | 1 |
| **CO-5** | 3 | 3 | 2 | 2 | 1 |

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**Course Code: PHY2023**
**Course Title: Statistical Mechanics**
**Course Type: Theory (Core)**
**Credits: 04**

**Unit 1:**
**REVIEW OF THERMODYNAMICS & PROBABILITY:** Quasistatic and nonquasistatic processes, laws of thermodynamics, entropy of a probability distribution, random walks. Macrostates, microstates, phase space and ensembles. Ergodic hypothesis, postulate of equal a-priori probability and equality of ensemble average and time average. Boltzmann's postulate of entropy. Counting the number of microstates in phase space. Entropy of ideal gas: Sackur-Tetrode equation and Gibbs' paradox. Liouville's Theorem.

**(12 Hours)**

**Unit 2:**
**ENSEMBLE THEORIES:** Canonical Ensemble System in contact with a heat reservoir, expression of entropy, canonical partition function, Helmholtz free energy, fluctuation of internal energy. Grand Canonical Ensemble System in contact with a particle reservoir, chemical potential, grand canonical partition function and grand potential, fluctuation of particle number. Chemical potential of ideal gas. Chemical equilibrium and Saha Ionization Equation. Mean field theory and Van der Wall's equation of state.

**(12 Hours)**

**Unit 3:**
**QUANTUM STATISTICAL MECHANICS:** Density Matrix; Quantum Liouville theorem; Density matrices for microcanonical, canonical and grand canonical systems; Simple examples of density matrices – one electron in a magnetic field, particle in a box; Identical particles – B-E and F-D distributions. Ideal Bose and Fermi gas Equation of state; Bose condensation; Equation of state of ideal Fermi gas; Fermi gas at finite temperature.

**(12 Hours)**

**Unit 4:**
**PHASE TRANSITION:** Phase Transition and Critical Phenomena Ising model – partition function for one dimensional case, Phase transitions – first order and continuous, critical exponents and scaling relations. Calculation of exponents from Mean Field Theory and Landau's theory, upper critical dimension, Rudiments of Real Space Renormalization Group Transformations.

**(12 Hours)**

**Unit 5:**

**INTRODUCTORY NON-EQUILIBRIUM STATISTICS:** Irreversible processes, Classical Linear Response Theory, Brownian Motion, Master Equation, Fokker-Planck Equation, Fluctuation-Dissipation Theorem

**(12 Hours)**

**Reference Books::**

1. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
2. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
3. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W.Sears and Gerhard L. Salinger, 1986, Narosa.
5. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
6.An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press

| **Course Outcomes** | | **Level** |
|---|---|---|
| **CO-1** | Understand concept of ensemble | Understand |
| **CO-2** | Applying the ensemble concepts to open, closed thermodynamics system. | Apply/Analyze |
| **CO-3** | Understand the concept of quantum statistics. | Understand |
| **CO-4** | Solve different thermodynamics systems by using classical and quantum statistics | Skill |
| **CO-5** | Find out the application of ensemble concept in diffusive systems. | Evaluate |

## Mapping of Program Outcomes with Course Outcomes

| **Course Outcomes** | **Program Outcomes** | | | | |
|---|---|---|---|---|---|
| | **PO-1** | **PO-2** | **PO-3** | **PO-4** | **PO-5** |
| **CO-1** | 2 | 1 | 1 | 1 | 1 |
| **CO-2** | 2 | 1 | 1 | 2 | 1 |
| **CO-3** | 2 | 1 | 1 | 2 | 1 |
| **CO-4** | 2 | 2 | 1 | 3 | 1 |
| **CO-5** | 2 | 2 | 1 | 3 | 1 |

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**Course Code: PHY2024**
**Course Title: Experimental Methods in Physics**
**Course Type: Theory (Core)**
**Credits: 04**

**Unit I:**
Measurement of fundamental constants: e, h, c – Measurement of high and low resistances, inductance and capacitance – Detection of X-rays, Gamma rays, charged particles, neutrons – Ionization chamber – Proportional counter – GM counter – Scintillation detectors – Solid State detectors.

**(12 Hours)**

**Unit II:**
Emission and Absorption Spectroscopy – Measurement of Magnetic field – Hall effect – Magnetoresistance – X-ray and neutron Diffraction. **(12 Hours)**

**Unit III:**
Vacuum Techniques – Basic idea of conductance, pumping speed – Pumps: Mechanical Pump – Diffusion pump – Gauges – Thermocouple gauge – Penning gauge – Pirani gauge – Hot Cathode gauge – Low temperature systems – Cooling a sample over a range up to 4 K – Measurement of low temperatures. **(12 Hours)**

**Unit IV:**
Measurement of energy and time using electronic signals from the detectors and associated instrumentation – Signal processing – A/D conversion – multichannel analyzers – Time-of-flight technique – Coincidence Measurements – true to chance ratio – Correlation studies. Error Analysis and Hypothesis testing – Propagation of errors – Plotting of Graph – Distributions – Least squares fitting – Criteria for goodness of fits – Chi square test. **(12 Hours)**

**Unit V:**
Design of experiment – need for experiments (validation of theory/ verification of theory/ addition to database); computer interfacing; Data collection and analysis – errors and accuracy of data collected, types of errors, propagation of errors, reporting data – mean, variance, method of least Bsquares fit, central limit theorem, error bars. Data reproducibility and ethics of data collection.phase sensitive detection; shielding of cables. **(12 Hours)**

**Reference Books:**
1. J.P. Holman, Experimental Methods for Engineers. 7th Edition. McGraw Hill (2000).
2. J. M. Lafferty (Editor) (1998), Foundations of Vacuum Science and Technology, Wiley Interscience.
3. Douglas C. Montgomery, Design and Analysis of Experiments, John Wiley(2004).
**Suggested Reading:**
4. Anthony Kent, Experimental Low-Temperature Physics ,Macmillan Physical Science (1993).
5. T. G. Beckwith, R. D. Marangoni and J. H. Lienhard ,Mechanical Measurements,6th Edition(2006),Prentice Hall.

6. Ernest O Doebelin, Measurement Systems: Application and Design. 5th edition, Tata McGraw Hill.
7. Albert D Helfrick and William D Cooper (1992), Modern Electronic Instrumentation and Measurement Techniques. Prentice Hall.
8. Hermann K P Neubert, Instrument Transducers: An introduction to their performance and design. Oxford University Press(2003).
9. J. A. Blackburn Modern Instrumentation for Scientists and Engineers, Springer (2001).

**Course Outcomes**

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | Different experimental techniques, need for vacuum technology, methods used in the design of experiments. | Remember |
| **CO 2** | Understand the strength and limitation of each technique and choose the right technique for characterization of properties. Understand the methods used in the design of experiments and how these methods are connected to statistical models. | Understand |
| **CO 3** | Approach complex industrial and business research problems and address them through a rigorous, statistically sound experimental strategy. Apply the analytical techniques and graphical analysis to the experimental data. | Apply |
| **CO4** | Analyze the pros and cons of applying the experimental methods to correlate with the Physics theory. | Analyse |
| **CO5** | Design simple experiments him/her self and have a general insight into how data analysis is done in connection to designed experiments. | Skill |

**Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 2 | 2 | 1 |
| **CO2** | 3 | 3 | 2 | 2 | 1 |
| **CO3** | 3 | 2 | 3 | 3 | 2 |
| **CO4** | 3 | 3 | 1 | 3 | 2 |
| **CO5** | 3 | 3 | 2 | 2 | 1 |

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**Course Code: PHY2025**
**Course Title: Experimental Techniques Laboratory**
**Course Type: Practical (Core)**
**Credits: 02**

**List of Experiments:**

1. Solar cell Characteristics
2. Fuel Cell Characteristics
3. Thin films - Electrodeposition by a simple method
4. Thin films-Electro deposition by three-electrode system
5. Thin films-Solution growth method (SILAR)
6. Measurement of Lattice parameters of powder XRD data
7. Find the miller indices - Using Powder XRD
8. Tauc plot-Determination of Bandgap
9. FTIR-Functional group identification
10. Thin film thickness measurement - optical method
11. Particle Size Analysis - SEM / TEM
12. DSC/TG/DTA Analysis
13. RAMAN - Vibrational Characteristics
14. Dielectric and Curie Temperature Measurement of
15. Ferroelectric Ceramics
16. Determination of the band gap of a Semiconductor by Four Probe Method
17. Ultrasonic Diffractometer
18. Hall Effect
19. Ultrasonic Interferometer
20. Specific Heat Capacity of Solid
21. Magnetoresistance in Semiconductor
22. Magnetic Susceptibility of a paramagnetic substance

**Reference Books::**

1. J.P. Holman, Experimental Methods for Engineers. 7th Edition. McGraw Hill (2000).
2. J. M. Lafferty (Editor) (1998), Foundations of Vacuum Science and Technology, Wiley Interscience.
3. Douglas C. Montgomery, Design and Analysis of Experiments, John Wiley(2004).

| Course Outcomes | | Level |
|---|---|---|
| **CO-1** | Verification of characteristics of Solar cell, Fuel Cell | **Fundamental** |
| **CO-2** | Understanding the basics of thin film preparation, having an idea about lattice parameters, find the miller indices using XRD. | **Understanding** |
| **CO-3** | Knowing the specific heat capacity of a solid, liquid, and gas. | **Utilizing** |
| **CO-4** | Analyze and compare the characteristics of a conductor, semiconductor, and insulator. | **Developements** |
| **CO-5** | Acquire knowledge of magnetic susceptibility. | **Higher study** |

**Mapping of Program Outcomes with Course Outcomes**

| Course Outcomes | Program Outcomes | | | | |
|---|---|---|---|---|---|
| | **PO-1** | **PO-2** | **PO-3** | **PO-4** | **PO-5** |
| **CO-1** | 2 | 3 | 2 | 3 | 1 |
| **CO-2** | 3 | 3 | 2 | 1 | 2 |
| **CO-3** | 2 | 3 | 2 | 2 | 1 |
| **CO-4** | 3 | 3 | 1 | 3 | 2 |
| **CO-5** | 3 | 3 | 2 | 3 | 1 |

# SEMESTER - III

**Course Code: PHY2031**
**Course Title: Condensed Matter Physics**
**Course Type: Theory (Core)**
**Credits: 04**

**Unit 1:**
**LATTICE DYNAMICS:** Elastic properties - Quantization of elastic waves,; - Theory of elastic vibrations in mono and diatomic lattices - phonons – vibrations and thermal properties of solids - Dispersion relations - Phonon momentum and inelastic scattering by phonons. - lattice specific heat – Dulong and Petit's law - Vibrational modes - Einstein model - Density of modes in one and three dimensions - Debye Model of heat capacity - Anharmonic Effects - Explanation for Thermal expansion, Conductivity and resistivity – Umklapp process.

**(12 Hours)**

**Unit 2:**
**THEORY OF ELECTRONS:** Free electron theory and electronic specific heat; Response and relaxation phenomena. Drude model of electrical and thermal conductivity - Wiedemann – Franz law.. Hall effect magnetoresistance –and thermoelectric power. Fermi-Dirac distribution – Bloch theorem -Electrons in periodic lattice –Heat capacity of the electron gas – Ohm's law, Matthiessen's rule – nearly free electron - the origin and magnitude of energy gap – Bloch functions - Bloch theorem - Motion of an electron in a periodic potential – Kronig – Penney model - Approximate solution near a zone boundary – Limitations of K-P model – tight binding models band theory of solids: metals, semiconductors and insulators; conductivity, mobility and effective mass - Fermi surfaces: Reduced and periodic zone schemes of construction- de Haas – van Alphen effect - Cyclotron resonance.

**(12 Hours)**

**Unit 3:**
**CRYSTAL IMPERFECTIONS AND ORDERED PHASES OF MATTER**: Defects in Crystal: Point defects, Colour centers, F-centers, Line defects and planer defects – dislocations- Role of dislocations in crystal growth. Concentrations of Vacancy, Frenkel and Schottky imperfections - Burgers Vector – Presence of dislocation – surface imperfections- Ordered phases of matter: Translational and orientation order - Kinds of liquid crystalline order - Quasi crystals .

**(12 Hours)**

**Unit 4:**
**THEORY OF FERROELECTRICS AND PIEZO ELECTRICS :**Ferroelectricity – Classifications of Ferroelectric crystals - Dipole theory of ferroelectricity – Landau Theory of the phase transition – First and second order transition, Long range order, Short range order and Bragg William model.– Theory of the ferroelectric displacive transitions: Polarization catastrophe, Soft optical phonon, Thermodynamics of ferroelectric transition, –Ferroelectric domains – Ferroelectric domain wall motion -Antiferroelectricity – Piezoelectric and pyroelectric material - Phenomenological Approach to Piezoelectric Effects - Piezoelectric Parameters and Their Measurements.

**(12 Hours)**

**Unit 5:**
**OPTICAL PROPERTIES OF SOLIDS:** Optical constants, dispersion relation of optical constants from Maxwell's equations, Direct and indirect transitions Absorption in insulators, impurity and interband transitions Resume of macroscopic theory -- generalized susceptibility, Kramer's-Kronig relation, optical properties of metals - intra- and inter-band transitions; Conductivity and dielectric function of collision electron gas, Basic Theories and models of luminescence, phosphorescence, thermo-luminescence, electroluminescence and photo-conductivity, photoelectric effect- Moss-Burstein effect-Polorans – Excitons. Brillouin scattering - Raman effect.

**(12 Hours)**

**Reference Books::**


1. Charles Kittel, Introduction to Solid State Physics, 7th Edition, Wiley India Pvt. Ltd. , New Delhi, 2004.
2. J.P. Shrivastava: *Elements of Solid State Physics, 2nd edition*, PHI, New Delhi, 2006.
3. J. Dekker, Electrical Engineering Materials, Prentice Hall of India, 1975.
4. L.V. Azaroff*: Introduction to Solids,* TMH edition, 1996.
5. S.O. Pillai, Problems and Solutions in Solid State Physics, New Age international Publishers, New Delhi, 1994.
6. Rita John, Solid State Physics, Tata Mc Graw Hill Publications, 2014.
7. A.K. Bain, P. Chand, Ferroelectrics, Wiley, 2017.
8. M. A. Wahab, Solid State Physics – Structure and Properties of Materials. Narosa, New Delhi, 1999.
9. J.D. Patterson, B.C. Bailey Solid-State Physics: Introduction to the Theory, Springer Publications, 2007.
10. M. Ali Omar, Elementary Solid State Physics – Principles and Applications, Pearson, 1999.
11. Ajay Kumar Saxena, Solid state physics, , MacMillan Publishers( 2006)
12. J.S.Blackmore Solid state physics, , second edition-Cambridge university press (1974)
13. Solid State Physics : H. Ibach and H. Luth (Springer, Berlin).
14. A Quantum Approach to Solids : P.L. Taylor (Prentice-Hall, Englewood Cliffs).
15. Intermediate Quantum Theory of Solids : A.O.E. Animalu (East- West Press, New Delhi).


| Course Outcomes | | Level |
|---|---|---|
| **CO-1** | Understand the concept of phonons and their role on specific heat of solids. Apply the knowledge to analyze the phonon dispersion relation for simple solids. Gain insight into the origin of thermal conductivity, thermal expansion though phonon scattering processes. | **Understand/Apply** |
| **CO-2** | Understand the electron dynamics in metals through simple concepts and apply it to understand electronic and thermal conductivity in solids. Gain knowledge about wave functions and apply the electronic heat capacity, Hall effect etc. | **Understand/analyse Apply** |
| **CO-3** | Study the role of various defect in solids and understand their stability and their influence on physical properties. Also analyse various ordering phenomena in condensed matter. | **Understand/Analyze** |
| **CO-4** | Understand the concept of electronic polarization and its role on piezoelectricity and ferroelectricity | **Understand/analyse Apply** |
| **CO-5** | Understand the original optical properties in solids and their difference in the insulators and metals. Apply the concept to study various optoelectronic properties. | **Understand/analyse Apply** |

## Mapping of Program Outcomes with Course Outcomes

| Course Outcomes | Program Outcomes | | | | |
|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 |
| **CO-1** | 3 | 3 | 2 | 2 | 1 |
| **CO-2** | 3 | 2 | 2 | 3 | 1 |
| **CO-3** | 3 | 2 | 2 | 2 | 1 |
| **CO-4** | 3 | 3 | 2 | 2 | 1 |
| **CO-5** | 3 | 3 | 1 | 3 | 1 |

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**Course Code: PHY2032**
**Course Title: Nuclear & Particle Physics**
**Course Type: Theory (Core)**
**Credits: 04**

**Unit 1:**
**GENERAL PROPERTIES OF NUCLEUS:** Review of basic concepts, Nuclear radius, shape, spin, parity, Magnetic and electric moments, Nuclear binding energy.
Nuclear Models: Binding energy & mass defect – Weizacker's formula – mass parabola - Liquid drop model - Bohr -Wheeler theory of fission- Activation energy for fission- Shell model, Spin–Orbit coupling and magic number, ground state Spin and Parity of nucleus, Magnetic dipole moments – Schmidt lines, Electric quadrupole moments, Collective model: vibrational and rotational states.
Properties of Nuclear force: Spin dependence-charge independence-tensor nature of nuclear force: deuteron ground state problem, nucleon-nucleon scattering cross section-, Yukaka theory of meson exchange.

**(12 Hours)**

**Unit 2:**
**RADIOACTIVITY:** Half-life and decay rate of radioactive elements, radioactive series, Energy Spectrum of α and β rays: Discrete energy spectrum of α particles, Geiger-Nuttal's law, Gammow theory of α decay, Continuous spectrum of β particles, Pauli's neutrino hypothesis, Fermi theory of β decay, Coulomb correction, Screening effect, Kurie's plot, Selection rules in β decay, Orbital electron capture, Parity violation in β decay. Gamma decay - Multipole radiation – Angular momentum and parity selection rules – Internal conversion – Nuclear isomerism

**(12 Hours)**

**Unit 3:**
**NUCLEAR REACTIONS:** Conservation principles in nuclear reactions, Threshold energy, nuclear reaction cross-sections, Energetic of nuclear reactions, Reaction dynamics, Q-value equation, Scattering and reaction cross sections, Compound nucleus, Reciprocity theorem, Breit-Wigner one level formula, Resonance Scattering, Continuum theory, Optical model.

**(12 Hours)**

**Unit 4:Fission & Fusion**

Types of fission reaction-distribution of fission products – fissile and fertile materials – neutron emission in fission – spontaneous fission - Explanation of nuclear fission using liquid drop model, fission products and energy release. Spontaneous and induced fission transuranic elements, reactors. Nuclear Fusion: Introduction, Thermonuclear reactions and energy production, stellar burning, brief idea about Big-Bang nucleosynthesis.

**(12 Hours)**

**Unit 5:**

**PARTICLE PHYSICS:** Standard model of Particle Physics: Classifications of elementary particles, Isospin, Isospin quantum numbers, Strangeness and hyper charge, Hadrons, Baryons, Leptons, Invariance principles and symmetries, Invariance under charge-parity(CP), time(T) and CPT, CP violation in neutral K-meson decay, Tau- Theta puzzle, Feynman diagrams, Quark model, SU(3) symmetry, Gell-Mann-Nishijma formula, Gell-Mann Okuba Mass formula, Neutrinos of different flavour, Charm, Bottom and Top quarks, Higss Boson, brief idea of Beyond Standard Model Physics, Relativistic kinematics.

**(12 Hours)**

**Reference Books::**

**1.** K.S. Krane: Introductory Nuclear Physics, Wiley, New York. 1987.
2. D. Griffiths: Introduction to Elementary Particle Physics, Harper and Row, New York.1987.
3. R.R. Roy and B.P. Nigam: Nuclear Physics, New Age International, New Delhi, 1983.
4. S. Wong, Introductory Nuclear Physics, Prentice Hall of India
5. Francis Halzen and Alan D. Martin, An Introductory Course in Modern Particle Physics, Wiley, 1984
6. Radiation Detection and Measurement: G. F. Knoll (John Wiley, 1989).

| Course Outcomes | | Level |
|---|---|---|
| **CO-1** | Properties of Strong force, Shell model, properties of radiation, various nuclear reactions, four fundamental forces and their properties, classification of elementary particles, symmetry and different quantum numbers. | **Remember** |
| **CO-2** | Shell model, Quantum mechanical treatment of nucleon system, scattering, Alpha decay, beta decay, interaction of radiation with matter, fission and fusion reaction, Gell-Mann's eight fold way, conservation of different quantum numbers and their relation to symmetry-Noether's theorem | **Understand** |
| **CO-3** | Shell model to find nuclear spin, magnetic moment and electrical quadrupole moments of various nuclei. Apply quantum mechanics to solve alpha-decay and beta-decay process, also to understand nuclear reactions. Theory of interaction of radiation with matter to understand the working principle of radiation detectors. Conservation of various quantum numbers to understand three fundamental forces. | **Apply** |

| | | |
|---|---|---|
| **CO-4** | Liquid drop models give a very simple idea to model a system and explain its properties. Deuteron problem is helpful to solve quantum mechanical systems, and finding out scattering cross sections, solving kinematic problems related to particle decay using invariant mass methods. | **Apply** |

## Mapping of Program Outcomes with Course Outcomes

| **Course Outcomes** | **Program Outcomes** | | | | |
|---|---|---|---|---|---|
| | **PO-1** | **PO-2** | **PO-3** | **PO-4** | **PO-5** |
| **CO-1** | 3 | 2 | 2 | 3 | 1 |
| **CO-2** | 3 | 1 | 3 | 3 | 1 |
| **CO-3** | 3 | 2 | 1 | 2 | 1 |
| **CO-4** | 3 | 2 | 2 | 3 | 1 |

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**Course Code: PHY2033**
**Course Title: Electromagnetic Theory**
**Course Type: Theory (Core)**
**Credits: 04**

**Unit 1:**
Boundary value problems and Laplace equation –uniqueness theorem – Solution of Laplace equation in Cartesian and spherical polar coordinates – Examples of solutions for boundary value problems. Dielectric sphere in a uniform field – Molecular polarizability and electrical susceptibility – Electrostatic energy in the presence of dielectric – Multipole expansion. Method of images, Point charge in the presence of grounded conducting sphere and charge insulated conducting sphere, Point charge near a conducting sphere at fixed potential, conducting sphere in uniform electric field by method of images.

**(12 Hours)**

**Unit 2:**
Electric fields in matter – induced electric dipoles, Polarization of a medium, field due to polarized object – concept of bound and surface charges, field of an uniformly polarized sphere, Gauss's law in the presence of dielectrics, linear dielectrics, dielectric constant, energy stored in dielectric.
Magnetic field in matter- magnetic dipoles, origin of diamagnetism, field due to magnetized object – concept of bound and surface currents, field of an uniformly magnetized sphere, Ampere's law in magnetized materials, linear magnetic media.

**(12 Hours)**

**Unit 3:**
Faraday's laws of Induction - Maxwell's displacement current, Maxwell Equations, Vector and scalar potentials, Gauge transformations, Lorentz gauge, Coulomb gauge, Green's functions for wave Equation, Energy and momentum of the field, Poynting theorem and conservation of energy and momentum for a system of charged particles and electromagnetic fields, Poynting theorem in linear dispersive media with losses, Poynting theorem for harmonic field.

**(12 Hours)**

**Unit 4:**
Radiating Systems, Radiation by Moving Charges: Retarded time and retarded potential, radiation of a localized oscillating source, Electric dipole fields and radiation, Magnetic dipole radiation, Multipole expansion of the electromagnetic fields, Retarded potential and fields of an current carrying wire, Lienard–Wiechert potentials and fields for a moving point charge, power radiated by an accelerated point charge – Larmor formula, Radiation reaction and its physical explanation, Abraham Lorentz formula, Radiation damping

**(12 Hours)**

**Unit 5:**
Plane waves in non-conducting media - Linear and circular polarization, reflection and refraction at a plane interface-normal and oblique incidence – Absorption and dispersion - Waves in a conducting medium, Reflection at a conducting surface, the frequency dependence of permittivity- Waveguides, Propagation of waves in a rectangular wave guide. Coaxial Transmission Line.

**(12 Hours)**

**Reference Books::**

1. J.D. Jackson: Classical Electrodynamics, 2nd edition, John Wiley, 1985.
2. D.J. Griffith: Introduction to Electrodynamics, 3rd edition, Pearson Pub., New Delhi, 2003
3. Panofsky and Phillips: Classical Electricity and Magnetism, 2nd edition, Addison Wesley, 1962.
4. L.D. Landau and E.M. Lifshitz: Classical Theory of Field, 4th edition, Pergamon Press, 2003.
5. L.D. Landau and E.M. Lifshitz: Electrodynamics of Continuous Media, Pergamon Press, 1995.
6. Hans C. Ohanian: Classical Electrodynamics, 2nd edition, Infinity Science Press, 2007.


| **Course Outcomes** | | **Level** |
|---|---|---|
| **CO-1** | Solve Laplace equation for different problems in Electromagnetic Theory | Apply |
| **CO-2** | Understand the effects of electric and magnetic fields applied to matter | Understand |
| **CO-3** | Understand the concept of scalar & vector potentials, Poynting theorem for electromagnetic fields | Understand |
| **CO-4** | Analyze the origin of radiation emission from accelerated charges & currents | Analyze |
| **CO-5** | Understand the concepts of reflection, refraction, absorption, and dispersion of light electromagnetic waves. | Understand |

## Mapping of Program Outcomes with Course Outcomes

| Course Outcomes | Program Outcomes | | | | |
|---|---|---|---|---|---|
| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 |
| CO-1 | 3 | 3 | 1 | 2 | 1 |
| CO-2 | 3 | 3 | 1 | 2 | 1 |
| CO-3 | 3 | 3 | 1 | 2 | 1 |
| CO-4 | 3 | 3 | 1 | 1 | 1 |
| CO-5 | 3 | 3 | 1 | 1 | 1 |

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**Course Code: PHY2034**
**Course Title: Condensed matter Physics Laboratory**
**Course Type: Practical (Core)**
**Credits: 02**

**List of Experiments:**

1. Calculation of Unit cell parameters using X-ray diffraction method
2. Measurement of thermal diffusivity
3. Measurement of DC/AC conductivity of solid samples
4. Determination of resistivity and band gap of a solid/semiconductor using four probe method
5. Study of solar cell characteristics
6. Thermal and Electrical conductivity of metals
7. Experimental analysis of flat plate collector of solar water heater
8. Measurement of magneto-resistance of semiconductor.
9. The variation of Hall Coefficient of a given extrinsic semiconductor as a function of temperature
10. Determination of Curie Temperature of Ferroelectric crystals using dielectric spectroscopy
11. Electron spin resonance and determination of g-factor

**Reference Books::**

| | Course Outcome | Level |
|---|---|---|
| CO 1 | Identification of crystal structure of solids | Remember |
| CO2 | Prediction of the thermal and electrical properties of solids and explanation of their origin | Understand |
| CO3 | Estimation of band gap, charge carriers type and carrier concentration in solids | Apply |
| CO4 | Demonstration of Dielectric and DC/AC conductivities of insulators | Analyse |
| CO5 | Able to convert solar energy into electrical and thermal energy | Apply |

| | | |
|---|---|---|
| **CO6** | Able to understand ferroelectric phase transitions and magneto-resistance behavior of materials | Apply |

**Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | **2** | **2** | **2** |
| **CO2** | 3 | 3 | **1** | 3 | 3 |
| **CO3** | 3 | 3 | 3 | **3** | **2** |
| **CO4** | 3 | 3 | 3 | **2** | **2** |
| **CO5** | 3 | **2** | 3 | 3 | **3** |
| **CO5** | 3 | 1 | 2 | 3 | **1** |
| **CO6** | 2 | 1 | 3 | 1 | **1** |

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**Course Code: PHY2035**
**Course Title: Advanced Physics Laboratory**
**Course Type: Practical (Core)**
**Credits: 02**

**List of Experiments:**

1. Preparation of KDP single crystals.
2. Preparation of BaTiO3 ceramics.
3. Preparation of polymer thin film by spray-pyrolysis.
4. Preparation of metallic film by thermal evaporation.
5. Transmittance spectroscopy of single crystals
6. Experimental analysis of flat plate collector of solar water heater
7. Dielectric spectroscopy of BaTiO3 ceramics
8. P-E loops of KDP crystals.

| | Course Outcome | Level |
|---|---|---|
| **CO 1** | Synthesis of ceramics | Remember |
| **CO2** | Preparation of thin films | Understand |
| **CO3** | Understanding of absorbance and FTIR spectroscopy | Apply |
| **CO4** | Phase transition studies in dielectrics | Analyse |
| **CO5** | Able to characterize the different types of materials | Apply |

**Mapping of Program Outcomes with Course Outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 3 | **2** | **2** | **1** |

| | | | | | |
|---|---|---|---|---|---|
| **CO2** | 3 | 3 | **1** | 3 | 1 |
| **CO3** | 3 | 3 | 3 | **3** | **1** |
| **CO4** | 3 | 3 | 3 | **2** | **2** |
| **CO5** | 3 | **2** | 3 | 3 | **2** |

# SEMESTER - IV

**Courses:**

| | | | | |
|---|---|---|---|---|
| PHY2041 | Research Project | CC | 12 | 24 |
| PHY2042 | DSE-IV | Internship | 2 | |
| PHYXXX | Self-Study Course | DSE | 4 | 4 |

## DISCIPLINE ELECTIVE COURSES:

1) ADVANCED MATHEMATICAL PHYSICS (PHYEC01)
2) ADVANCED PARTICLE PHYSICS (PHYEC02)
3) ADVANCED QUANTUM MECHANICS
4) ASTROPHYSICS
5) ATOMIC & MOLECULAR SPECTROSCOPY
6) CRYSTAL GROWTH AND THIN FILMS
7) DIGITAL ELECTRONICS & MICROPROCESSORS
8) GENERAL THEORY OF RELATIVITY & COSMOLOGY
9) INTRODUCTION TO NON-LINEAR DYNAMICS
10) LASER PHYSICS & ITS APPLICATIONS
11) MICROWAVE PHYSICS
12) NANOMATERIALS AND NANOTECHNOLOGY
13) NUMERICAL METHODS AND COMPUTER PROGRAMING
14) PHYSICS OF MAGNETISM & SPINTRONICS
15) PLASMA PHYSICS
16) PROPERTIES OF MATERIALS
17) QUANTUM OPTICS
18) QUANTUM COMPUTATION AND QUANTUM INFORMATION
19) QUANTUM FIELD THEORY
20) SEMICONDUCTOR PHYSICS
21) SOLAR ENERGY & ITS APPLICATIONS
22) VACUUM SCIENCE AND THIN FILM PHYSICS

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**Course Code: PHYEC01**
**Course Title: Advanced Mathematical Physics**
**Course Type: Theory (DSE)**
**Credits: 04**

**Unit 1:**
**Green's functions :** Definitions and physical significance of Green's functions, Translational invariance, Green's function – expansion using eigen functions, Green's function for ordinary differential operators, first order and second order linear differential operators, solution of forced harmonic oscillator problem using Green's function, Green's function for Sturm-Liouville Problems – Initial value problems – Problems with

mixed and unmixed boundary conditions, Green's functions for partial differential operators, solution of boundary value problems using Green's function for Laplace, Poisson and wave equations

**(12 Hours)**

**Unit 2:**

**Variational Calculus:** Functions and Functionals, Principles of Variational Calculus, Applications of variational calculus – minimal surface of revolution, geodesic on a surface of revolution, Brachistochrone Problem, Relation to the Sturm-Liouville Problem, The RayleighRitz Method, Adding constraints - method of Lagrange multipliers, Sturm-Liouville eigenvalue equation as a variational problem

**(12 Hours)**

**Unit 3:**

**Integral Equations**: Conversion of a differential equation into an integral equation, types of integral equation, linear integral operator, closed-form solutions, separable kernels, integral transform methods, solution of integral equation by differentiation, Neumann series, Fredholm theory, Schmidt–Hilbert theory

**(12 Hours)**

**Unit 4:**

**Introduction to Non-Linear Equations:** Introduction to linear and nonlinear differential equations with few illustrations – The notion of nonlinearity – Superposition principle and its validity – Autonomous and nonautonomous systems – Equilibrium points – Classification of equilibrium points – limit cycle motion – Lyaponov exponents – Poincaré surface of section.

**(12 Hours)**

**Unit 5:**

**Introduction to Statistical Methods:** Random variables, probability density functions (pdf), cumulative distribution functions, joint pdf, marginal pdf, conditional pdf, expectation values, variance, standard deviation, covariance and correlation and regression, correlation coefficient, error propagation, parameter estimation, maximum likelihood and least squares estimation**.**

**(12 Hours)**

**Re Reference Books:**

1.G.B. Arfken and, H.T.Weber, Mathematical methods for physicists, Academic Press; 7th edition, 2012
2. Tulsi Dass and Satish K Sharma, Mathematical methods in classical and quantum physics, Universities Press, First Edition, 1998
3.J.H. Heinbockel, Introduction to the Variational Calculus, Trafford Publishing, 2007.
4. K.F. Riley, M.P. Hobson, and S.J. Bence, Mathematical Methods for Physics and Engineering, Cambridge University Press, Third Edition, 2006.
5. M. Lakshmanan and S. Rajasekar, Nonlinear Dynamics, Integrability, Chaos and Patterns, Springer-Verlag, Berlin, 2003.
6. P.G. Drazin, Nonlinear systems, Cambridge University Press, Cambridge,1992.
7. G. Cowan, Statistical Data Analysis, Clarendon Press, Oxford, 1998
8. R.J. Barlow, Statistics, A Guide to the Use of Statistical in the Physical Sciences, John Wiley, 1989.
9. F. James, Statistical Methods in Experimental Physics, World Scientific, Second Edition, 2006.

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**Course Code: PHYEC02**
**Course Title: Advanced Particle Physics**
**Course Type: Theory (DSE)**
**Credits: 04**

**Unit 1:**

Relativistic Kinematics: Lorentz transformations, four-vectors, relativistic collisions, Two nucleon state vectors, Isospin, Strangeness and Hypercharge, Lepton and Baryon number conservation, Yukawa's theory

**(12 Hours)**

**Unit 2:**
Parity, Parity conservation and nonconservation, Time reversal, Consequences of time reversal invariance, Charge conjugation, G-parity, Statement of CPT theorem and its consequences, Proof of equality of mass and life time for particle and antiparticle.

**(12 Hours)**

**Unit 3:**
Unitary Symmetry and the classification of state, Hadrons and SU (3) multiplets, properties of representations, Young-Tableux method for direct products of representations, Applications of SU(3) flavour symmetry and of broken SU(3) flavour symmetry, Gell-Mann- Okubo mass formula for Baryons and Mesons, Coleman-Glashow relation, Quarks and Gluons, Colour hypothesis, Evidence of colour, Magnetic moment of baryons, Baryon wave functions.

**(12 Hours)**

**Unit 4:**
Quantum Electrodynamics (QED) :
The S-matrix expansion, Time ordered product, Normal ordered product, Wick's theorem, Feynman diagrams in configuration and momentum space, First order terms in S-matrix, Compton scattering, Electron electron scattering, closed loop, Feynman rules (Decays and Scattering), QED Lagrangian and gauge invariance.

**(12 Hours)**

**Unit 5:**
QED processes in lowest order:
Lepton-pair production in electron-positron collisions, Bhabha scattering, Compton Scattering, Scattering by an external field and Mott Scattering Formula, Bremsstrahlung.

**(12 Hours)**

**Reference Books::**

1. Quantum Field Theory - F. Mandl and G. Shaw
2. Introduction to High Energy Physics - D. H. Perkins
3. Elementary Particle Physics - D.J.Griffiths
4. Quarks and Leptons – F.Halzen and A.D. Martin
5. Quantum Field Theory - M.Peskin and Schroeder


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**Course Code: PHYEC03**
**Course Title: Advanced Quantum Mechanics**
**Course Type: Theory (DSE)**
**Credits: 04**

**Unit 1:**
Classical Fields: Brief introduction to Classical scalar fields, Classical Maxwell fields, Vector potential in quantum mechanics, Coulomb Gauge.
Quantum theory of radiation: Quantised radiation field, Rayleigh Scattering, Thomson scattering, Raman effect, Self-energy of a bound electron; the Lamb shift

**(12 Hours)**

**Unit 2:**
**Relativistic Quantum Mechanics:** Klein-Gordon equation and its drawbacks, Dirac equation, Properties of Dirac matrices, Non- relativistic reduction of Dirac equation, magnetic moment, Darwins term, Spin-Orbit coupling, Poincare transformation, Lorentz group, Covariant form of Dirac equation, Bilinear covariants, Gordon decomposition

**(12 Hours)**

**Unit 3:**
Free particle solution of Dirac equation, Projection operators for energy and spin, Physical interpretation of free particle solution, Zitter bewegung, Hole theory, Charge conjugation, space reflection and time reversal

symmetries of Dirac equation. Continuous systems and fields. Transition from discrete to continuous systems, Lagrangian and Hamiltonian Formulations, Noether's theorem.

**(12 Hours)**

**Unit 4:**
Second quantization, Equal Time Commutators, Normal Ordering, covariant quantization of electromagnetic field, Quantization of scalar, e.m, and Dirac fields, Propagators for scalar, spinor and vector fields.

**(12 Hours)**

**Unit 5:**
Covariant Perturbation theory: Formulas and rules, S-matrix expansion; First order process: Mott scattering, Compton Scattering. Feynman's space-time approach to the electron propagator.

**(12 Hours)**

Reference Books:

1. Advanced Quantum Mechanics - J. J. Sakurai.
2. Relativistic Quantum Mechanics - J. D. Bjorken and S. D. Drell
3. Relativistic Quantum Fields - J. D. Bjorken and S. D. Drell
4. Quantum Field Theory - F. Mandl and G. Shaw
5. Quantum Field Theory - L. H .Ryder
6. Quantum Field Theory - S. Weinberg

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**Course Code: PHYEC04**
**Course Title: Astrophysics**
**Course Type: Theory (DSE)**
**Credits: 04**

**Unit 1:**
Astronomical scales (Distance,Mass, Time), Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scales, Distance Modulus, Measurement of astronomical quantities- Distance, Stellar Radii, Masses of stars from binary orbits, Stellar temperature, Color index of stars. Spectral types and their temperature dependence, Hertzsprung-Russell (HR) diagram.

**(12 Hours)**

**Unit 2:**
Celestial Sphere, Geometry of a sphere, Astronomical coordinate systems - Horizon system, Equatorial system, Coordinate transformation between between Horizon and Equatorial system, Diurnal motion of the stars. Measurement of time, Sidereal time, apparent solar time, mean solar time, Equation of time, Julian date.

**(12 Hours)**

**Unit 3:**
Observing through the atmosphere- Atmospheric Windows, optical telescopes, Radio telescopes, telescope mountings, Magnification, Light gathering power, resolving power and diffraction limit, Detection limit of telescope. Derivation of Virial theorem, Basic equations of stellar structure, simple stellar models- Polytropic model, derivation of the Lane-Emden equation, analytic solution of Lane-Emden equation

**(12 Hours)**

**Unit 4:**
Morphological classification of the Galaxies. Basic structure and properties of the Milky way, Nature of rotation of the Milky Way- differential rotation of the Galaxy and Oort constants, rotation curve of the galaxy and the dark matter

**(12 Hours)**

**Unit 5:**
Cosmological observations, The cosmological principle, Homogeneous and isotropic universe, Friedmann model, Evolution of our universe

**(12 Hours)**

**Reference Books:**

1.Theoretical Astrophysics, Vol 1- T. Padmanabhan
2. Fundamental Astronomy, H. Karttunen et. al

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**Course Code: PHYEC05**
**Course Title: Atomic & Molecular Spectroscopy**
**Course Type: Theory (Core)**
**Credits: 04**

**Unit 1:**
General discussion in Hydrogen spectra, Relativistic correction to spectra of Hydrogen atom, Spectra of monovalent atoms, quantum defect, Introduction to electron spin, Spin-orbit interaction and fine structure, Zeeman effect, Stark effect, Spectra of divalent atoms: Singlet and triplet states of divalent atoms, LS and j-j coupling, Branching rule, Hyperfine structure in spectra of monovalent atoms.

**(12 Hours)**

**Unit 2:**
Energy and length scales in molecules, Molecular Binding: covalent bond, multipole interaction, van der Waals interaction, Morse potential, Born-Oppenheimer approximation, Pure rotational spectra of diatomic molecules, Non-rigid rotator, Poly-atomic molecules, Study of linear molecules and symmetric top molecules, Information from rotational spectra

**(12 Hours)**

**Unit 3:**
Vibrational spectroscopy of diatomic and simple polyatomic molecules, Harmonic Oscillator, Anharmonic Oscillator, Rotational vibrators, Normal modes of vibration of polyatomic molecules, IR spectrometer: FTIR Spectrometer, Applications of infrared spectroscopy: H2O and CO2 molecules.

**(12 Hours)**

**Unit 4:**
Raman effect, Classical and Quantum theory of Raman effect, Vibrational Raman spectra, Rotational Raman spectra, Vibrational-Rotational fine structure, Electronic structure of diatomic molecules, Intensity of spectral lines, Frank-Condon principle, Dissociation energy and dissociation products, Rotational fine structure of electronic-vibration transitions, P, Q, R branches, band origin

**(12 Hours)**

**Unit 5:**
Theory of NMR, Relaxation effect, Theory of dipolar interaction and chemical shifts, Indirect spin-spin interactions, Experimental set up of NMR, Applications of NMR to quantitative measurements (Idea only), Quantum mechanical treatment of ESR, Nuclear interaction and hyperfine structure, Relaxation effects, ESR spectrometer, Applications of ESR method.

**(12 Hours)**

**Reference Books::**

1. Physics of Atoms and Molecules, Bransden and Joachain, Longman Scientific & Technical Group Ltd., 1983.
2. Atoms, Molecules and Photons, Wolfgang Demtroder, Springer, 2010.
3. Fundamentals of Molecular Spectroscopy, C. N. Banwell, McGraw-Hill Book Company, 1994.
4. Spectra of Atoms and Molecules, P. F. Bernath, Oxford University Press, 1995.
5.Atomic and Molecular Spectroscopy, Rita Kakkar, Cambridge University Press, 2019.

| Course Outcomes | | Level |
|---|---|---|
| **CO-1** | Understanding basic atomic structure | **Remember** |
| **CO-2** | Understanding gross molecular structures and the effect of molecular rotation | **Apply** |
| **CO-3** | Knowing about vibrational spectroscopy | **Apply** |
| **CO-4** | Learning Raman spectroscopy and electronic spectroscopy | **Apply** |
| **CO-5** | Understanding the working principle of NMR and ESR | **Analyze** |

| Course Outcomes | Program Outcomes | | | | |
|---|---|---|---|---|---|
| | **PO-1** | **PO-2** | **PO-3** | **PO-4** | **PO-5** |
| **CO-1** | 2 | 1 | 1 | 1 | 1 |
| **CO-2** | 3 | 1 | 1 | 1 | 1 |
| **CO-3** | 3 | 1 | 1 | 1 | 2 |
| **CO-4** | 3 | 2 | 1 | 1 | 3 |
| **CO-5** | 2 | 3 | 1 | 2 | 3 |

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**Course Code: PHYEC06**
**Course Title: Crystal Growth and Thin Films**
**Course Type: DSE**
**Credits: 04**

**Unit1:**
**CRYSTAL GROWTH KINETICS:** Basic Concepts, Nucleation and Kinetics of growth Ambient phase equilibrium - super saturation - equilibrium of finite phases equation of Thomson - Gibbs - Types of Nucleation - Formation of critical Nucleus- Classical theory of Nucleation - Homo and heterogeneous formation of 3D nuclei - rate of Nucleation - Growth from vapour phase solutions, solutions and melts - epitaxial growth - Growth mechanism and classification - Kinetics of growth of epitaxial films

**(12 Hours)**

**Unit2:**
**CRYSTALLIZATION PRINCIPLES:** Crystallization Principles and Growth techniques Classes of Crystal system - Crystal symmetry - Solvents and solutions - Solubility diagram - Super solubility - expression for supersaturation - Metastable zone and introduction period - Miers TC diagram -

Solution growth - Low and high temperatures solution growth - Slow cooling and solvent evaporation methods - Constant temperature bath as a Crystallizer.

**(12 Hours)**

**Unit 3:**

**GEL, MELT AND VAPOUR GROWTH:** Gel, Melt and Vapour growth techniques Principle of Gel techniques - Various types of Gel - Structure and importance of Gel - Methods of Gel growth and advantages - Melt techniques - Czochralski growth - Floating zone - Bridgeman method - Horizontal gradient freeze - Flux growth - Hydrothermal growth - Vapour phase growth - Physical vapour deposition - Chemical vapour deposition - Stoichiometry

**(12 Hours)**

**Unit 4:**

**THIN FILM DEPOSITION METHOD**: Thin film deposition methods of thin film preparation, Thermal evaporation, Electron beam evaporation, pulsed LASER deposition, Cathodic sputtering, RF Magnetron sputtering, MBE, chemical vapour deposition methods, Sol Gel spin coating, Spray pyrolysis, Chemical bath deposition.

**(12 Hours)**

**Unit 5:**

**THIN FILM FORMATION:** Thin Film Formation and thickness Measurement Nucleation, Film growth and structure - Various stages in Thin Film formation, Thermodynamics of Nucleation, Nucleation theories, Capillarity model and Atomistic model and their comparison. Structure of Thin Film, Roll of substrate, Roll of film thickness, Film thickness measurement - Interferometry, Ellipsometry, Micro balance, Quartz Crystal Oscillator techniques.

**(12 Hours)**

**Text Books:**

1. V. Markov Crystal growth for beginners: Fundamentals of Nucleation, Crystal Growth and Epitaxy (2004) 2nd edition
2. A. Goswami, Thin Film Fundamentals (New Age, New Delhi, 2008)
3. M. Ohora and R. C. Reid, "Modeling of Crystal Growth Rates from Solution"
4. 4. D. Elwell and H. J. Scheel, "Crystal Growth from High Temperature Solution"
5. Heinz K. Henish, 1973, "Crystal Growth in Gels", Cambridge University Press. USA.

**Reference Books:**

1. J.C. Brice, Crystal Growth Process (John Wiley, New York, 1986)
2. P. Ramasamy and F. D. Gnanam, 1983, "UGC Summer School Notes".
3. P. Santhana Raghavan and P. Ramasamy, "Crystal Growth Processes", KRU Publications.
4. H.E. Buckley, 1951, Crystal Growth, John Wiley and Sons, New York
5. B.R. Pamplin, 1980, Crystal Growth, Pergman Press, London.

**WEB SOURCES:**

1. https://www.youtube.com/playlist?list=PLbMVogVj5nJRjLrXp3k MtrIO8kZl1D1Jp
2. https://www.youtube.com/playlist?list=PLFW6lRTa1g83HGEihgw cy7KeTLUuBu3WF
3. https://www.youtube.com/playlist?list=PLADLRin7kNjG1Dlna9M DA53CMKFHPSi9m
4. https://www.youtube.com/playlist?list=PLXHedI-xbyr8xIl_KQFs_R_oky3Yd1Emw
5. https://www.electrical4u.com/thermal-conductivity-of-metals/

**COURSE OUTCOMES:**
**At the end of the course, the student will be able to:**

| | | |
|---|---|---|
| | Acquire the Basic Concepts, Nucleation and Kinetics of crystal Growth | **K1** |
| **CO2** | Understand the Crystallization Principles and Growth techniques | **K2, K4** |
| **CO3** | Study various methods of Crystal growth techniques | **K3** |
| **CO4** | Understand the Thin film deposition methods | **K2** |
| **CO5** | Apply the techniques of Thin Film Formation and thickness Measurement | **K3, K4** |
| **K1 - Remember; K2 – Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate;** | | |

**MAPPING WITH PROGRAM OUTCOMES:**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 1 | 2 | 1 | 3 | 2 | 2 | 2 | 2 |
| **CO2** | 3 | 3 | 1 | 3 | 1 | 2 | 3 | 2 | 2 | 1 |
| **CO3** | 3 | 2 | 1 | 3 | 1 | 2 | 3 | 3 | 3 | 1 |
| **CO4** | 3 | 2 | 1 | 2 | 1 | 2 | 3 | 3 | 3 | 1 |
| **CO5** | 2 | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 2 |

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**Course Code: PHYEC07**
**Course Title: Digital Electronics & Microprocessors**
**Course Type: Theory (DSE)**
**Credits: 04**

**Unit 1:**

**ACTIVE FILTERS & TIMER AND PHASE LOCKED LOOPS:** Introduction, Butterworth filters – 1st order, 2nd order low pass and high pass filters, band pass, band reject and all pass filters. TIMER AND PHASE LOCKED LOOPS: Introduction to IC 555 timer, description of functional diagram, monostable and astable operations and applications, Schmitt trigger, PLL - introduction, basic principle, phase detector/comparator, voltage-controlled oscillator (IC 566), low pass filter, monolithic PLL and applications of PLL

**(12 Hours)**

**Unit 2:**

**VOLTAGE REGULATOR & D-to-A AND A-to-D CONVERTERS:** VOLTAGE REGULATOR: Introduction, Series Op-Amp regulator, IC Voltage Regulators, IC 723 general purpose regulators, Switching Regulator. D to A AND A to D CONVERTERS: Introduction, basic DAC techniques - weighted resistor DAC, R-2R ladder DAC, inverted R-2R DAC, A to D converters -parallel comparator type ADC, counter type ADC, successive approximation ADC and dual slope ADC, DAC and ADC Specifications.

**(12 Hours)**

**Unit 3:**

**NUMBER SYSTEMS AND LOGICAL GATES:** Decimal, binary, octal, hexadecimal numbers systems and their conversions – codes: BCD, gray and excess-3 codes –code conversions –complements (1's, 2's, 9's and 10's) –binary addition, binary subtraction using 1's & 2's complement methods – Boolean laws – De-Morgan's theorem –basic logic gates -universal logic gates (NAND & NOR) –standard representation of logic functions (SOP & POS) – minimization techniques (Karnaugh map: 2, 3, 4 variables). Adders: half & full adder, Subtractors: half &full subtractor –parallel binary adder – magnitude comparator – multiplexers (4:1) &demultiplexers (1:4), encoder (8-line-to-3- line) and decoder (3-line-to-8-line), BCD to seven segment decoder**.**

**(12 Hours)**

**Unit 4:**

**SEQUENTIAL CIRCUITS AND LOGIC FAMILIES**: S-R Flip-flop , J-K Flip-flop, T and D type flip-flops, master-slave flip-flop, truth tables, registers:- serial in serial out and parallel in and parallel out – counters asynchronous:-mod-8, mod-10, synchronous - 4-bit &ring counter – general memory operations, ROM, RAM (static and dynamic), PROM, EPROM, EEPROM, EAROM. IC – logic families: RTL, DTL, TTL logic, CMOS NAND & NOR Gates, CMOS Inverter, Programmable Logic Devices – Programmable Logic Array (PLA), Programmable Array Logic (PAL).

**(12 Hours)**

**Unit 5:**

**MICROPROCESSOR & MICROCONTROLLER BASICS:** introduction to microprocessor – INTEL 8085 architecture – register organization –pin configuration of 8085, interrupts and its priority – Program Status Word (PSW) –instruction set of 8085 –addressing modes of 8085 –assembly language programming using 8085 –programmes for addition (8-Bit & 16-Bit), subtraction (8-Bit & 16-Bit), multiplication (8- Bit), division (8- Bit) – largest and smallest number in an array – BCD to ASCII and ASCII to BCD.

**(12 Hours)**

**Reference Books::**


1. Modern Digital Electronics, 2/e (Tata McGraw Hill Education)
2. Digital Logic Design- Morries Mano, PHI.
3. Electronic devices and circuits,Jacob Millman, and C. C. Halkias, TMH Publications.
4. Linear Integrated Circuit, D. Roy Choudhury, Shail B. Jain,4th edition, New Age International Pvt. Ltd., New Delhi, India
5. OP-AMP and Linear Integrated Circuits, Ramakant A. Gayakwad, 4th edition, Prentice Hall / Pearson Education, New Delhi. Optics, Ajoy Ghatak (McGraw Hil)
6. A Textbook of Electrical technology, B.L. Theraja and A.K. Theraja, S. Chand & Co.
7. Digital Principles and Applications, Malvino and Leach 5th Edition, Tata McGraw Hill, New Delhi
8. Digital Fundamentals, Floyd, Jain 8th edition, Pearson Education, New Delhi.

| Course Outcomes | | Level |
|---|---|---|
| **CO-1** | Develop skills to design active filter circuits using operational amplifiers. | Remember |
| **CO-2** | Learn about various techniques to develop A/D and D/A converters | Uderstand |
| **CO-3** | Gain knowledge about logic gates and their implementation in construction of adders and substractors | Apply |
| **CO-4** | Acquire the knowledge about the logic, combinational and sequential circuit | Apply |
| **CO-5** | Assembly language programming on 8085 microprocessor | Skill |

| Course Outcomes | Program Outcomes | | | | |
|---|---|---|---|---|---|
| | **PO-1** | **PO-2** | **PO-3** | **PO-4** | **PO-5** |
| **CO-1** | 1 | 1 | 2 | 1 | 1 |
| **CO-2** | 1 | 1 | 3 | 1 | 1 |
| **CO-3** | 1 | 1 | 3 | 1 | 1 |
| **CO-4** | 3 | 2 | 2 | 1 | 1 |
| **CO-5** | 3 | 2 | 2 | 1 | 2 |

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**Course Code: PHYEC08**
**Course Title: General Theory of Relativity & Cosmology**
**Course Type: Theory (DSE)**
**Credits: 04**

**Unit 1:** Special relativity & Flat space-time, Equality of gravitational and intertial masses, Equivalence principle, Principle of general covariance.Tensor Analysis: covariant and contravariant tensors. Tensors of arbitrary rank. Metric tensor. Parallel transport and covariant differentiation. Affine connection and its relation to metric tensor. Curvature tensor and its symmetries. Bianchi identities. Weyl tensor and conformal invariance.

**(12 Hours)**

**Unit 2:** Energy momentum tensor for a perfect fluid, equation of motion from field equation for equation for dust. Action principle for field equations. Conservation laws in curved space and pseudo energy tensor for gravitational field

**(12 Hours)**

**Unit 3:** General static isotropic metric, Schwarzschild solution, Orbital equations, constants of motion, deflection of light by a mass object (sun), precision of perihelia, radar echo delay.

**(12 Hours)**

**Unit 4:** Cosmological principle, maximally symmetric spaces, Killing vectors, Robertson- Walker metric. Redshift of galaxies and Hubble's law. Magnitude-red shift relation, Measures of distances – parallax distance, luminosity distance, angular diameter distance, relation among the measures of distance, Horizons and the Hubble radius Hubble's constant and deceleration parameter, source counts. Einstein's equations, content of the universe – photons, baryons, dark matter neutrinos, dark energy- critical densities, pressure, matter-radiation equality, CMBR, problems of Friedmann cosmology, inflationary universe

**(12 Hours)**

**Unit 5:** Gravitational Radiation- Weak field approximation and linear wave equation. Plane waves, their polarization, helicity and energy momentum tensor. Emission of radiation by a rotating source. Effect of radiation on a test particle. Detection of gravitational radiation**.**

**Reference Books::**

1.Introducing Einstein's Relativity, Ray D'Inverno
2. Principles of Gravitation and Cosmology, M. Berry
3. Introduction to General Relativity & Cosmology, Steven Weinberg
4. The Classical Theory of Fields, L.D. Landau and E. M. Lifshitz
5. Classical Fields: General Relativity and Gauge Theory, Moshe Carmeli
6. General Theory of Relativity, P.A. M. Dirac
7. Introduction to Cosmology, J.V.Narlikar
8. Cosmology, S.Weinberg

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**Course Code: PHYEC09**
**Course Title: Introduction to Non-Linear Dynamics**
**Course Type: Theory (DSE)**
**Credits: 04**

**Unit 1:**

Linear and Nonlinear systems - Mathematical models examples – Mathematical Implications of Nonlinearity: superposition principle and its validity - Examples and problems - linear and nonlinear oscillators - Resonance and Hysteresis - Examples and problems - Autonomous and nonautonomous systems - Phase plane trajectories - stability, attractors and repellers - limit cycle - Examples and problems - Phase space - classification of equilibrium points - stability of fixed points - Examples and problems.

**(12 Hours)**

**Unit 2:**

Bifurcation - the logistic map - period doubling phenomenon- onset of chaos- other routes to chaos -Lorentz systems - Sensitive dependence on initial condition - controlling of chaos - bifurcation scenario in Duffing oscillator- Examples and problems.

**(12 Hours)**

**Unit 3:**
Linear and nonlinear dispersive wave propagation - Fourier transformation and solution of initial value problem - wave packet and dispersion - Nonlinear dispersive system – Korteweg-de Vries equation and the solitary waves and Cnoidal waves - Scott Russel's phenomenon and Korteweg-de Vries equation - Fermi-Pasta-Ulam lattice problem - FPU recurrence phenomenon - numerical experiment of Zabusky and Kruskal - birth of soliton.

**(12 Hours)**

**Unit 4:**
Integrability and methods to solve soliton equations - The notion of integrability - multiple scale perturbation method - soliton solutions of perturbed nonlinear Schrödinger equation - Hirota's direct method and 'N' soliton solutions - Painleve analysis and its application to Korteweg-de Vries equation, nonlinear Schrödinger equation- Lax pair for Korteweg-de Vries equation.

**(12 Hours)**

**Unit 5:**
Applications of Nonlinear dynamics - soliton applications in all optical communication - Energy transfer in protein and DNA - Function of soliton in neuronal microtubules - Ionacoustic solitons in plasma: an application to Saturn's magnetosphere - Pulse solitons in blood circulatory systems

**(12 Hours)**

**Reference Books::**

1. M. Lakshmanan and S. Rajasekar, Nonlinear Dynamics, Integrability, Chaos and Patterns, Springer-Verlag, Berlin, 2003.
2. P.G. Drazin, Nonlinear systems, Cambridge University Press, Cambridge.
3. P.G. Drazin and R.S. Johnson, Solitons: An introduction Cambridge University Press, Cambridge, 1989.
4. M.J. Ablowitz and P.A. Clarkson, Solitons, Nonlinear Evolution Equations and Inverse Scattering, Cambridge University Press, Cambridge, 1991.
5. R. Dodd, J. Eilbeck, J. Gibbson and H. Morris, Solitons and Nonlinear Wave Equations, Academic, New York, 1982.


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**Course Code: PHYEC10**
**Course Title: LASER Physics & its applications**
**Course Type: Theory (DSE)**
**Credits: 04**

**Unit 1:**
**Principles of Lasers:** Interaction of radiation with matter – Absorption, spontaneous and stimulated emission – Einstein coefficients – relation between spontaneous and stimulated emission rates, Light amplification – Threshold condition for laser action, Line broadening mechanisms – Natural, Collision and Doppler broadening. Laser operations – Two level system, Population inversion in three level and four level systems- Threshold pump power, relative merits and de-merits of three and four level system.
**(12 Hours)**

**Unit 2:**
**Laser Types** - Mathematical description of Gaussian beams using Maxwell's equations. Propagation of Gaussian beams through optical elements. ABCD law for Gaussian beams. Hermite-Gaussian beams. Laser Systems - Gas lasers: He-Ne laser, Carbondioxide laser, Nitrogen gas laser, Argon ion gas laser – Solid state lasers: Ruby laser, Nd-YAG laser, Dye lasers - Optically pumped laser systems

**(12 Hours)**

**Unit 3:**
**Laser Operations:** Resonant cavities, modes of a rectangular cavity, quality factor of an optical resonator, ultimate laser line width , Longitudinal and Transverse mode selection, Pulsed lasers - Q-switching and Mode

locking concepts and techniques. - Resonator configurations - Stability of resonators, - Characteristics of Gaussian beam.

**(12 Hours)**

**Unit 4:**

Fiber Lasers: Erbium doped fiber laser – basic equations for amplification and its steady state solutions, derivation for doped fiber length, threshold pump power and laser output power, Erbium doped fiber amplifier, mode locking using non-linear polarization, semiconductor lasers, optical gain in semiconductors, density of states, interaction of semiconductor with light, light amplifcation and gain coefficient in semiconductors, QuasiFermi levels, Gain in diode laser, Quantum-Well lasers – derivation for gain c

**(12 Hours)**

**Unit 5:**

**Laser Applications:** Holography, Basic Principle – Holographic interferometry – Speckle Metrology, Material processing- welding, cutting, and drilling. laser tracking, pollution monitoring using lasers, lasers in isotope separation, lasers in precision length measurement, lasers in information storage, bar-code scanner, Biological and Medical applications of lasers

**(12 Hours)**

**Reference Books::**

1. Lasers Theory and Applications: K. Thyagarajan and A.K. Ghatak (McMillan).
2. C.O. Shea, W.R. Callen and N.T. Rhodes, "An Introduction to Lasers and their Applications"", Addison Wesley, 1969.
3. J. Verdeyen, 'Laser Electronics', Second Edition, Prentice Hall, 1990.
4. Goldman and Rockwell, 'Lasers in Medicine', Gordon and Breach, New York, 1985.
5. B.B. Laud, 'Laser and Non-Linear Optics', Second Edition, New Age International (p) Limited publishers, 1996.
6. Optics and Atomic Physics – B. P. Khandelwal (Siblal Agarwala).
7. Optical Electronic – A. K. Ghatak and K. Tyagrajan.
8. Introduction to Fibre Optics - R. A. Shotwell (EEE, Prentice Hall).

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**Course Code: PHYEC11**
**Course Title: Microwave Physics**
**Course Type: Theory (DSE)**
**Credits: 04**

**Unit 1:**

Introduction to microwaves: Microwave frequencies and the band names. Role of microwaves in the history of communications and the world wars. Microwave systems. Review of interaction of electrons and fields. Electron motion in electric field, magnetic field and electromagnetic fields. Review of guided waves and the modes of rectangular, circular and coaxial waveguides.

**(12 Hours)**

**Unit 2:**

Microwave Sources: Vacuum tubes, solid state microwave generators. Vacuum tubes: Klystron, Magnetron and TWT. Solid state devices: Classification of solid-state devices. Conditions for radiation of microwaves. Transit time effects. Power-frequency limitations. Transferred electron effects – concept of negative resistance. Working of special diodes – Gunn, tunnel, IMPATT, TRAPATT, BARITT.

**(12 Hours)**

**Unit 3:**

Microwave components: Guided wave vs. free space propagation. Forward wave and backward wave in waveguides. Analysis of microwave networks. Basics of S parameters. Impedance and admittance. ABCD parameters. Impedance matching. VSWR and Smith Charts.

**(12 Hours)**

**Unit 4:**

Waveguide components: directional couplers, attenuators, E-bend and H-bend, slotted sections, T and Y circulators. Introduction to planar waveguides.

**(12 Hours)**

**Unit 5:**

Applications of microwaves: Material characterization using microwaves – broadband dielectric spectroscopy and microwave rotational spectroscopy. ESR. Microwave synthesis of material. Radar. Satellite and Cellular communications. Defense applications. Navigation and GPS. Microwave Ovens. Radio Astronomy and CMBR and COBE.

**(12 Hours)**

**Reference Books::**


1. Microwave Devices and Circuits – S Liao, Pearson Education India, 1990


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**Course Code: PHYEC12**
**Course Title: Nanomaterials and nanotechnology**
**Course Type: Theory (DSE)**
**Credits: 04**

**Unit 1:**

Introduction to nanotechnology, physics of low-dimensional materials, quantum effects, 1D, 2D and 3D confinement, Density of states, Excitons, Coulomb blockade, Zero-, One-, Two- and Three- dimensional structure, Size control of metal nanoparticles and their properties: optical, electronic, magnetic properties; surface plasmon resonance, change of bandgap; Application: catalysis, electronic devices.

**(12 Hours)**

**Unit 2:**

Importance of size distribution control, size measurement and size selection, assembling and self-organization of nanostructures, Nanofabrication: patterning of soft materials by self-organisation and other techniques, chemical self-assembly, artificial multilayers, cluster fabrication, Langmuir-Blodget growth, Nanolithography, Scanning probe lithography, Micro contact printing.

**(12 Hours)**

**Unit 3:**

Advantages of nano electrical and electronic devices, micro and nano-electromechanical systems – sensors, actuators, optical switches, bio-MEMS diodes and nano-wire transistors - data memory lighting and displays, filters (IR blocking) – quantum optical devices – batteries - fuel cells and photo-voltaic cells – electric double layer capacitors – lead-free solder – nanoparticle coatings for electrical products.

**(12 Hours)**

**Unit 4:**

Nanocatalyts, smart materials, heterogenous nanostructures and composites, nanostructures for molecular recognition (quantum dots, nanorods, nanotubes) – molecular encapsulation and its applications – nanoporous zeolites – self-assembled nanoreactors - organic electroluminescent displays.

**(12 Hours)**

**Unit 5:**

Drug deliveries, drug delivery system, nanoparticle in drug delivery- available applications, nanotechnology future application understanding for treatment. manufacture of nanoparticles, nanopowder and nanocrystals, targeting ligands applications of nanoparticle in drug delivery, cancer treatment, tissue regeneration, growth and repair, impact of drug discovery and development.

**(12 Hours)**

**Reference Books::**
1. Nanocomposite science and technology, Pulikel M. Ajayan, Wiley-VCH 2005
2. Nanolithography and patterning techniques in microelectronics, David G. Bucknall, Wood head publishing 2005
3. Transport in Nanostructures, D.K. Ferry and S.M. Goodmick, Cambridge university press 1997.
4. Optical properties of solids, F. Wooten, Academic press 1972
5. Micro and Nanofabrication, Zheng Cui, Springer 2005
6. Nanostructured materials, Jackie Y. Ying, Academic press 2001
7. Nanotechnology and nanoelectronics, W.R, Fahrner, Springer 2005
8. Nanoengineering of structural, functional and smart materials, Mark J. Schulz, Taylor & Francis 2006.
9. Hand book of Nanoscience, Engineering, and Technology, William A. Goddard, CRC press 2003.
10. Nanoelectronics and Information Technology, Rainer Waser, Wiley-VCH 2003.
11. The MEMS Handbook Frank Kreith, CRC press 2002.
12. Pradeep T "Nano: The Essentials", Mc Graw Hill Publishing Co. Ltd., 2007
13. Mick Wilson et al, "Nanotechnology", Overseas Press (India) Pvt. Ltd., 2005.
14. Charles P. Poole, Jr., Frank J. Owens, "Introduction to nano technology", Wiley, 2003.
15. Gunter Schmid, "Nanoparticles: From Theory to Applications", Wiley-VCH Verlag GmbH & Co., 2004.

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**Course Code: PHYEC13**
**Course Title: Numerical Methods and Computer Programing**
**Course Type: Theory (DSE)**
**Credits: 04**

**Unit I**
**Programming Language:** Introduction to Unix System, and languages, variable types, operators, function, conditional statements (if, for loop, do while), array, for C++: pointer and references, basic idea of Class.)

**Unit II**
Approximations and round off errors: Significant digits, true/absolute and truncation errors, Taylor Series – Taylor polynomial error formula. Determination of roots of polynomials and transcendental equations: Bisection methods, Newton-Raphson method, Secant method and Bairstow's method.
**(12 Hours)**

**Unit III**
Solutions of linear simultaneous linear algebraic equations by Gauss Elimination and Gauss-Siedel iteration methods. **(12 Hours)**

**Unit IV**
Backward, Forward and Central difference relations and their uses in Numerical differentiation and integration, Application of difference relations in the solution of partial differential equations. Numerical solution of ordinary differential equations by Euler, Modified Euler, Runge-Kutta and Predictor-Corrector method. **(12 Hours)**

**Unit V**
Numerical integration: midpoint rule, trapezeoidal method, Simpson's method, Newton--Cotes method, Gaussian rules. Least squares approximation, fitting data to a straight line, fitting data to

linear combinations of functions. Interpolation: Direct method, Newtons's divided difference method, Lagrange method.

**(12 Hours)**

## Reference Books:


1. Venkatraman, M. K., "Numerical Methods in Science and Engineering", National Publishing Company, Madras, 1996.
2. Schaum's Outline of Programming with C++, McGraw-Hill; 2nd Edition
3. Numerical Recipes in C++: The Art of Scientific Computing , Cambridge University Press; 2nd
4. Numerical methods by Balaguruswami - TMH.


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**Course Code: PHYEC14**
**Course Title: Physics of magnetism & spintronics**
**Course Type: Theory (DSE)**
**Credits: 04**

**Unit 1:**
**Fundamental of Magnetism:** Origin of permanent magnetic dipoles; Quantum theory of the magnetic moment; Hund's rules. Classical and quantum aspects of diamagnetism; paramagnetism; Curie law; formula of Van Vleck; Crystal field: d-f- metals, magnetic anisotropy; adiabatic demagnetization; Ferromagnetism; Weiss theory; domains; Bloch wall; Hysteresis.

**(12 Hours)**

**Unit 2:**
**Magnetic Interactions and Relaxation:** Exchange interaction, super-exchange, double exchange. Band magnetism. Collective excitation; Long-range order: Mean field theory: the theory of Weiss (Neel). Molecular field. Order parameter. Ferro-, antiferro-, iron-magnetism, other types of order. Spin glass, Magnetic domains. Hard & soft materials. Domain Theory; Exchange bias. Spin –latttice relaxation; spin-spin relaxation

**(12 Hours)**

**Unit 3:**
**Nano-magnetism:** Single-domain particle; Super-paramagnetism; Nanoparticles & molecular magnets.Stoner Wohlfarth model; Landau-Lifschitz-Gilbert Model; Neel-Brown model. Nanoscale magnetisam in small particles; thin films; wires; needles and bulk nanostructures

**(12 Hours)**

**Unit 4:**
**Spintronics:** Spin polarized currents; magnons; Spin-orbit interaction; Spin relaxation; Spin dependent Scattering and Transport; Spin dependent tunneling and Transport; Spin valve; Giant Magneto Resistance; Magnetic Random-Access Memory; spin torque; Spin transfer oscillators; spin transistors

**(12 hours)**

**Unit 5:**
**Molecular magnetism:** High-spin, low spin molecules; quantum theory of molecular magnetism: tunneling of magnetization; other functionalities of molecular nanomagnets: magneto caloric effect;

**(12 Hours)**

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**Course Code: PHYEC15**
**Course Title: Plasma Physics**
**Course Type: Theory (DSE)**
**Credits: 04**

**Unit 1:**
**Basics of Plasma:** Plasma as the fourth state of matter, macroscopic neutrality, Debye shielding, plasma frequency, the occurrence of plasma in nature, collisions, dc conductivity, ac conductivity, diffusion, production of plasma: dc discharge, rf discharge, using particle beam, laser produced plasma, overview of some plasma devices.

**(12 Hours)**

**Unit 2:**
**Single particle motion:**Motion of charged particle in electromagnetic field, Uniform E and B fields, Nonuniform fields, Diffusion across magnetic fields, Time varying E and B fields, Adiabatic invariants, First, second and third adiabatic invariant.

**(12 Hours)**

**Unit 3:**
**Plasma as Fluids:** Fluid description of plasma, equation of continuity, the fluid equation of motion, the convective derivative, the stress tensor, collisions, comparison with ordinary hydrodynamics, fluid drifts perpendicular to B, fluid drifts parallel to B, the plasma approximation

**(12 Hours)**

**Unit 4:**
**Waves in Plasmas:** Plasma oscillations, Electron plasma waves, sound waves, Ion acoustic wave, validity of the plasma approximation, phase velocity, group velocity, cut-offs, resonance for electromagnetic wave propagating parallel and perpendicular to the magnetic field, propagation through ionosphere and magnetosphere

**(12 Hours)**

**Unit 5:**
**Laser plasma interaction:** Ponderomotive energy, Keldysh parameter, multi-photon ionization, optical field ionization, high harmonic generation, Laser absorption processes: inverse bremsstrahlung, resonance absorption, Landau damping; Parametric decay processes, two plasmon decay, stimulated Brillouin scattering, stimulated Raman scattering.

**(12 Hours)**

**Reference Books:**

1.Principles of Plasma Physics, Nicholas A. Krall and Alvin W. Trivelpiece (McGraw-Hill Book Company).

2. Introduction to Plasma Physics and Controlled Fusion, Francis F. Chen (Springer).
3. The Physics of laser-plasma interaction, W. L. Kruer (Addison-Wesley Publishing Co.).
4. Short pulse laser interaction with matter- an introduction, Paul Gibbon (Imperial College Press).
5. Fundamentals of Plasma Physics, J. A. Bittencourt (Springer).
6. The Physics of Plasmas, T. J. M. Boyd and J. J. Sanderson (Cambridge University Press).

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**Course Code: PHYEC16**
**Course Title: Properties of materials**
**Course Type: Theory (DSE)**
**Credits: 04**

**Unit 1:**

**Mechanical properties**: Factors affecting mechanical properties - mechanical tests - tensile, hardness, impact, creep and fatigue - Plastic deformation by slip - shear strength - work hardening and recovery - fracture - Griffith's theory - slip and twinning - creep resistant materials - diffusion – Fick’s law.

Electrical Properties: Electrical conductivity – Free electron theory of metals, effective mass, drift current, mobility and conductivity Drude-Lorentz theory of metals (qualitative), Fermi Dirac distribution - density of states - electronic specific heat. Boltzmann transport equation - Sommerfeld's theory of electrical conductivity. Review of Band theory of solids, distinction between conductor, semiconductor and insulator based on band theory. Factors affecting resistivity of metals - temperature, alloying, strain and magnetic field with respective applications. Hall effect - Band model of semiconductors - carrier concentrations in intrinsic and extrinsic semiconductors - effective mass - electron & holes mobilities, Fermi level - variation of conductivity and mobility with temperature.

**(12 Hours)**

**Unit 2:**

**Thermal Properties:** Thermal conduction - Thermal conductivity, Flow of heat through compound media. Determination of thermal conductivity of conductors by Forbe’s method, Lattice vibrations, harmonic approximation, dispersion relations and normal modes, quantization of lattice vibrations and phonons. thermal expansion and need for anharmonicity. Transport properties of solids. Boltzmann transport equation. Wiedemann-Franz law. Lattice vibrations, phonons, adiabatic & harmonic approximations, lattice heat capacity, Einstein and Debye models,

Thermoelectricity : Seebeck, Peltier, and Thomson effects - laws of thermoelectricity - thermoelectric curve - neutral and inversion temperature, thermoelectric power **.**

**(12 Hours)**

**Unit 3:**

**Dielectric and Ferroelectric Properties:** Dielectric constant and polarizability - Static dielectric constant, electronic, ionic and orientation polarizations - Internal or local fields in dielectrics Clausius- Mossatti equation - complex dielectric constant - determination of dipole moment for polar substances - dielectric losses - frequency dependence of electronic, ionic, orientation polarisabilities - dielectric loss. General properties of ferroelectrics- Curie Weiss behavior - classification of ferro electric materials - dipole theory of ferro electricity - ferro electric domains - applications - piezoelectric and pyroelectric materials and applications.., Ferroelectric materials- Pervoskite crystal structure (eg.BaTiO3 and PZT ).

**(12 Hours)**

**Unit 4:**

**Magnetic Properties**: Classification - dia, para, ferro, antiferro and ferrimagnetism – Langevin and Weiss theories - Heisenberg's theory of exchange interaction - magnetic aniostrophy - magnetic domains - Weiss molecular field theory – Classical and quantum theory of paramagnetism, Curie’s law, spontaneous magnetization and domain structure, spontaneous magnetization and its temperature dependence. Curie-Weiss law, explanation of hysteresis. - hard and soft magnetic materials - ferrite structure and uses - - magnetoresistance - GMR materials - dilute magnetic semiconductor (DMS) materials. Spin waves and magnons.

**(12 Hours)**

**Unit 5:**

**Optical Properties**: Electrons in electromagnetic field, Optical absorption in insulators, semiconductors and metals – band to band absorption –Inter band and intra band transitions Charge injection and radiative recombination – The continuity equation: Diffusion length, Charge injection and band gap recombination. Excitonic effects and modulation of optical properties. Luminescence – photoconductivity, photoelectricity, LED and liquid crystal displays. Non-linear optics - wave propagation in Non-linear dielectrics - Electrooptic and Nonlinear optic co-efficients -The nonlinear susceptibility - Optical second Harmonic generation.

**(12 Hours)**

**Reference Books::**


1. V. Raghavan, “Materials Science and Engineering: A First Course", Prentice Hall, 2006.
2. S. O. Pillai,“ Solid state physics”, New age International Pvt Ltd, 6th edition, 2005
3. Wahab, M. A.,“ Solid State Physics”, Narosa Publishing, 2nd Edition, 2005
4. C. Kittel, "Introduction to Solid State Physics" Wiley Eastern Ltd., 2005.
5. N.W. Ashcroft and N.D. Mermin Solid state physics, India edition IE, Thomsom books, Reprint, 2007.
6. John Singleton: Band theory and Electronic properties of Solids (Oxford University Press; Oxford Master Series in Condensed Matter Physics).
7. Electricity and Magnetism: Brijlal & Subrahmanyam Ratan Prakashan Mandir Publishers -1995.
8. Harald Ibach and Hans Lüth “ An Introduction to principles of Materials Science”, Springer, 2003.
9. James D. Patterson, Bernard C. Bailey,“ Solid State Physics: Introduction to the theory”, Springer-Verlag, edition 1, 2005
10. Jasprit Singh, “Semiconductor Optoelectronics Physics and Technology”, McGraw Hill Co., 1998
11. H.P.Myers, Introductory Solid State Physics, 2nd edition, Viva Books Pvt. Ltd (1998)
12. M.Ali Omar, Elementary Solid State Physics, revised printing Pearson Education (2000)
13. M.S. Rogalski and S.B. Palmer, Solid Statae Physics, Gordon Breach Science Publishers (2000)
14. Y.K. Lim, Problems and solutions on Solid State Physics, Sarat Book Publishers (2002)
15. Fundamentals of Electricity and Magnetism: R.G.Mendiratta and B.K.Sawhney East - West Press( 1976)
16. E. Lines and A.M.Glass, Principles and applications of ferroelectrics materials, Clarendon press, Oxford ,1979.
17. K.V.Keer, Principles of solid state physics, Wiley - Eastern, 1993.


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**Course Code: PHYEC17**
**Course Title: Quantum Optics**
**Course Type: Theory (DSE)**
**Credits: 04**

**Unit 1:**

**FIELD QUANTIZATION:** Quantization of electromagnetic field in a cavity, electromagnetic fields in free space - box normalization, electromagnetic field as a harmonic oscillator, fock states of field, vacuum state – fluctuations of field in vacuum, effects of vacuum fluctuations, Lamb shift, Casmir effect – derivation of energy shifts, quadrature operators, coherent and squeezed states of field, photon number statistics.

**(12 Hours)**

**Unit 2:**

**COHERENC OF ELECTROMAGNETIC FIELDS:** Classical theory of coherence, definition of first and second order coherence, quantum theory of coherence – effects of first order coherence – Young’s double slit experiment, Hanbury Brown Twiss experiment (HBT) – Classical treatment – effects of second order coherence, quantum treatment of HBT experiment – calculation of second order coherence, Interference of light emitted from two atoms.

**(12 Hours)**

**Unit 3:**

**BEAM SPLITTERS & INTERFEOMETERS** :Quantum theory of Beam splitter – transformation of fields, relation between input and output fields, Beam splitter transformations on number state and coherent state inputs, MachZehnder interferometer, interaction free measurements, quantum treatment of Michelson interferometer – measurement of photon statistics, Detection of squeezed light – Homodyne measurement scheme, Interferometry with coherent light, phase measurement using entangled light sources and squeezed light. Quantum interferometric lithography

**(12 Hours)**

**Unit 4:**
**ATOM FIELD INTERACTION:** Interaction of an atom with a classical field – Rabi oscillations, interaction of an atom with a quantized single mode field – Jaynes-Cummings model, single mode field in thermal state – effects on population distribution, dressed states of atom-field interaction, Jaynes-Cummings model with large detuning – dispersive atom-field interaction, Schmidt decomposition and von Neumann entropy for the Jaynes-Cummings model, Atom's interaction with a multimode vacuum field – Weiskopf Wigner theory of spontaneous emission.

**(12 Hours)**

**Unit 5:**
**QUANTUM COMPUTATION** :Quantum bits, single qubit gates, phase gates, generation of single qubit states, Multiple qubits – Controlled Not gate, Swap gate, Toffoli gate, Bell states, No-Cloning theorem, Quantum Teleportation, Deutsch's Algorithm, Deutsch-Jozsa Algorithm, Quantum Fourier transform. Search Algorithms, Quantum key distribution.

**(12 Hours)**

**Reference Books:**

1. Christopher Gerry and Peter Knight, Introductory Quantum Optics, Cambridge University Press; First Edition, 2005.
2. Mark Fox, Quantum Optics An Introduction, Oxford University Press, First Edition, 2006.
3. Marlan O. Scully and M. Suhail Zubairy, Quantum Optics, Cambridge University Press, First Edition, 1997.
4. Girish S. Agarwal, Quantum Optics, Cambridge University Press, First Edition, 2013.
5. Michael A. Nielsen & Isaac L. Chuang, "Quantum Computation and Quantum Information", First Edition, Cambridge University Press, 2010.


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**Course Code: PHYEC18**
**Course Title: Quantum Computation and Quantum Information**
**Course Type: Theory (DSE)**
**Credits: 04**

**Unit I:** Quantum Correlations: Bipartite entanglement measures such as concurrence, entanglement entropy, entanglement witness, Mixed state entanglement , PPT criterion. Multipartite entanglement: tangle; mutual information; monogamy of correlations.Quantum Discord: definition and properties

**Unit II:** Quantum Computation, Quantum bits, single qubit gates, phase gates, generation of single qubit states, Multiple qubits – Controlled Not gate, Swap gate, Toffoli gate, Bell states, No-Cloning theorem, Quantum Teleportation, Deutsch's Algorithm, Deutsch-Jozsa Algorithm, Quantum Fourier transform. Search Algorithms, Quantum key distribution.

**Unit III:** Introduction to Shannon entropy - classical information-classical information from measurements - von Neumann entropy - properties-subadditivity and concavity- quantum data compression - classical information in quantum mechanics- Holevo bound. Quantum Information.

**Unit IV:** Quantum noise and quantum operations - Operator-sum representation -qubit channels, decoherence. Distance measures - trace distance - fidelity, Quantum state tomography, unbiased measurements, mixed state reconstruction.

**Unit V:** Quantum error-correction: Shor code - Quantum error correction -Stabilizer codes -fault tolerant quantum computation, decoherence free subspace. Quantum state discrimination, error probability analysis, the quantum-Chernoff bound. Introduction to quantum illumination.

**Books Recommended:**

1. Michael A. Nielsen & Isaac L. Chuang, "Quantum Computation and Quantum Information", First Edition, Cambridge University Press, 2010.
2. Quantum Information and Computation, CIT Lecture Notes by J. Preskill
3. Asher Peres, "Quantum Theory: Concepts and Methods", Springer, 1995.
4. Ingemar Bengtsson and Karol Zyczkowski, "Geometry of Quantum States: An Introduction to Quantum Entanglement", First Edition, Cambridge University Press, 2007
5. Mark M. Wilde, "Quantum Information Theory", Second Edition, Cambridge UniversityPress, 2017.
6. Daniel A. Lidar and Todd A. Brun, "Quantum Error Correction", First Edition, Cambridge University Press, 2013.

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**Course Code: PHYEC19**
**Course Title: Quantum Field Theory**
**Course Type: Theory (DSE)**
**Credits: 04**

**Unit 1:**
Quantum mechanics of many particle systems the need for QFT (relativity, many-body and interactions) Review of Lagrangian of continuous systems. Canonical fields as generalized coordinates. Euler-Lagrange equations, Noether's theorem.

**12 Hours**

**Unit 2:**
Canonical quantization of the free scalar field Commutation relations, Energy-momentum tensor, Normal ordering Propagators, Causality n-point Green's function of elementary and composite operators.

**12 Hours**

**Unit 3:**
Interacting scalar fields Perturbation Expansion of correlation functions Time-ordering and Wick's theorem S-matrix and Cross-sections Feynman diagrams and calculation of cross-sections Crossing symmetry.

**12 Hours**

**Unit 4:**
Quantizing the Maxwell-field in a covariant gauge; physical state condition; spectrum; The Dirac field as a representation of SO(3,1) (notion of SL(2,C)) Weyl, Majorana and Dirac fermions Quantization of the Dirac field.

**12 Hours**

**Unit 5:**

Quantum Electrodynamics; Feynman rules, S-matrices and tree-level cross-sections for simple processesGaussian integrals and power series expansion; Path integrals in Quantum Mechanics and Field Theory; Functional differentiation and integration (free scalar, vector and spinor)

**12 Hours**

**Reference Books:**

1. An Introduction To Quantum Field Theory by Peskin & Schroeder
2. Quantum Field Theory by Mandl and Shaw
3. Quantum Field Theory by I. Ryder

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**Course Code: PHYEC20**
**Course Title: Semiconductor Physics**
**Course Type: Theory (DSE)**
**Credits: 04**

**Unit 1:**
**Semiconducting Materials:** Origin of band gap in solids - Concept of effective mass of electron and hole – carrier concentration in an intrinsic semiconductor – electrical conductivity – band gap determination – carrier concentration in n-type and p-type semiconductors – Fermi level – Variation of Fermi level with temperature and impurity concentration – Compound semiconductors – Hall effect – Determination of Hall coefficient. Semiconductor types: crystalline and amorphous, inorganic and organic, elemental and compound. Preparation and characteristics. Semiconductors – direct and indirect gaps – carrier statistics (intrinsic and extrinsic) – law of mass action and chemical potential of semiconductors. III - V and II – VI compound semiconductors**.**

**(12 Hours)**

**Unit 2:**
**Band structure aspects:** Band model of semiconductors - Effects of temperature and electric field on the band structure. Frank 'Keldysh effect. Localized states of impurities: theoretical models and experimental probes (Capacitive and spectroscopic techniques). Optical properties: allowed and forbidden . and phonon-assisted transitions and their spectral shapes. Burstein Moss effect. Excitons : free and bound excitons.

**(12 Hours)**

**Unit 3:**
**Doping And Carrier Transport:** Doping: Extrinsic carrier density – Heavily doped semiconductors – Modulation doping (MODFET) – Transport: Scattering of electrons – Photon and ionized impurity scattering – Low field and high field transport in Si and GaAs – Transport of holes – Very high field transport: Break down phenomena – Avalanche break down (APD) – Carrier transport by diffusion - generation and recombination processes, thermionic emission process, tunneling process.

**(12 Hours)**

**Unit 4:**
**Metal-semiconductor contacts:** Schottky barrier. P-N junctions: theory of carrier transport in p-n junctions. Characteristics of practical junctions and deviations from ideality. Capacitance effects: Space charge and diffusion capacitances. Impurity profiling through capacitance measurements. Tunnel diode and applications. , Physical model of p-n junction , junction capacitance and width , Breakdown phenomena , Metal-Semiconductor Junction , Rectification at metal-semiconductor Junction , Schottky-diffusion theory.

**(12 Hours)**

**Unit 5:**
**Properties Of Semiconductors**: Density of states for a 3 dimensional system and in sub 3 dimensional system – Holes in semiconductors, Band structures of some semiconductors. Modification of band structure by alloying and by hetero structures. Quantum well structures, Intrinsic carrier concentration, Electronic properties of defects: shallow and deep impurity levels; Photoconductivity. Role of traps and recombination. Luminescence. Light emitting diodes and laser action in p-n junction diodes.

**(12 Hours)**

**Reference Books::**
1. Sze S M, "Physics of Semiconductor Devices", John Wiley and Sons, 2001.
2. Kevin F Brennan, "The Physics of Semiconductors", Cambridge University Press, 1999.
3. Micheal Shur, "Physics of Semiconductor Devices", Prentice Hall of India, 1999.
4. Jasprit Singh, "Semiconductor Optoelectronics Physics and Technology", McGraw Hill Co., 1998.
5. P. Y. Yu and M Cardona, Fundamentals of Semiconductors, Springer, 1992.
6. K. Seeger, Semiconductor Physics, 9th Edition, Springer, 2004.

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**Course Code: PHYEC21**
**Course Title: Solar Energy & its applications**
**Course Type: Theory (DSE)**
**Credits: 04**

**Unit 1:**
**Introduction:** Energy scenario current, energy future, energy sources - Energy demand and availability; Conventional, Nonconventional, and Renewable energy resources; Environmental impacts of conventional energy usage.

**(15 Hours)**

**Unit 2:**
**Solar Collector, Thermal Technology, and Applications:** Solar radiation and electromagnetic spectrum, solar radiation entering the earth system, Solar angle of incidence on tilted surface - measurement and estimation on horizontal and tilted surfaces - flat plate collector thermal analysis - testing methods - evacuated tubular collectors - concentrator collectors – compound parabolic concentrators - parabolic trough concentrators – performance of the collectors. Solar water heaters – Solar cooker – desalination - Solar Air heaters - Application of solar air heaters. Solar Drying with various driers – Heating and Drying of Agricultural products – moisture content and its measurement – solar ponds – Application of solar ponds – Solar pumping

**(15 Hours)**

**Unit 3:**
**Solar Photovoltaic System and Applications**: Basic principle of solar photovoltaic conversion, Solar cell parameters and characteristics. Block diagram of general PV conversion system and their characteristics,– Photovoltaic (PV) cell technologies - p-n junction under equilibrium and biasing, open circuit voltage and short circuit current, I-V and P-V curves, calibration and efficiency measurement – PV cell, modules, and array, - Array design, peak power point operation - Load estimation, Selection of inverters, Battery sizing, array sizing. Voltage regulation - maximum tracking - centralized and decentralized PV systems - stand alone - hybrid and grid connected system - System installation - operation and maintenances - field experience – Applications - PV market analysis and economics of PV systems.

**(15 Hours)**

**Unit 4:**
**Solar refrigeration and Air-conditioning:** Potential and scope of solar cooling, Types of solar cooling systems, solar collectors and storage systems for solar refrigeration and airconditioning, solar operation of

vapor absorption cycle, temperature concentration diagram, enthalpy concentration diagram, steady flow process with binary mixtures, Energy balance for various components of vapor absorption cycle, Analysis of absorption system using concentration chart. Solar Passive Architecture - passive cooling concepts: evaporative cooling - radiative cooling

**(15 Hours)**

**Reference Books:**

1. S.P. Sukhatme, Solar Energy, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997. 42
2. S Sukhatme and J Nayak: Solar Energy: Principles of Thermal Collection and Storage, Third Edition (Tata McGraw Hill, 2008)
3. G.N.Tiwari, Solar Energy: Fundamentals, design, Modeling and Applications: 2002, Narosa Publishing house
4. Fonash Solar Cell Devices : (Academic Press, New York)(1981)
5. Stooker W.F, Refrigeration And Air Conditioning, Tata McGraw-Hill
6. C.P.Arora, Refrigeration And Air Conditioning Tata McGraw-Hill(2000)
7. Kreider, J.F. and Frank Kreith, Solar Energy Handbook, McGraw Hill, 1981.
8. Tiwari G.N., Tiwari A.K., Solar Distillation Practice, Anamaya Publishers, New Delhi
9. VVN Kishore, Renewable Energy Engineering and Technology – A Knowledge Compendium, ed. (TERI Press, 2008).
10. Goswami, D.Y., Kreider, J. F. and & Francis., Principles of Solar Engineering, 2000.
11. G.D. Rai, Non Conventional Energy Sources, Khanna Publishers, New Delhi, 1999.
12. G. D. Rai , Solar Energy Utilisation, ,, Khanna Publishers,Delhi.(1996)
13. Volker Quaschning, Understanding Renewable Energy Systems, Vol.1 (2005) 14. Marcelo Godoy Simmoes Renewable Energy Systems CRC Press (2004)
15. John Twidell Renewable Energy Resources Taylor and Francis (2006)
16. Renewable Energy Sources and Their Environmental Impact Abbasi & Abbasi Prentice Hall of India (2004).

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**Course Code: PHYEC22**
**Course Title: Vacuum Science and Thin Film Physics**
**Course Type: Theory (DSE)**
**Credits: 04**

**Unit 1:**

**Basic concepts of vacuum and its generation:** Brief history of vacuum; kinetic theory; gas transport and pumping of gases; conductance; Physico and chemical phenomenon in vacuum; basic principles and processes for production of vacuum and ultra-high vacuum; vacuum generation; diaphragm pumps; vacuum blowers; vacuum jet pumps; cryogenic pumps; turbo molecular pumps etc

**(12 Hours)**

**Unit 2:**

**Measurement of vacuum and leak detection:** Mechanical gauges; gauges using liquids, molecular gauges, kundsenguage, thermal conductivity gauges; Ionization gauges; calibration of gauges; sealing techniques and leak detection

**(12 Hours)**

**Unit 3:**

**Introduction and preparation of thin films:**Crystal structures of thin films; defects in thin films (vacancies and interstitials, dislocations, grain boundaries etc.) nanocrystalline, polycrystalline and epitaxial thin films; thermal dynamics and diffusion mechanisms in thin films; thin film surface, nucleation and growth models (2D, 3D, and 2D-3D combination);preparation of thin films; physical vapor deposition techniques includes thermal evaporation, sputtering, pulsed laser deposition, molecular beam epitaxy; e-bean evaporation; chemical vapor deposition; solution based techniques.

**(12 Hours)**

**Unit 4:**

**Characterization of thin films:** Measurement of film thickness; structural characterization; x-ray diffraction, grazing incidence small angle x-ray scattering technique; transmission electron microscopy; scanning electron microscopy; ellipsometry; chemical characterization x-ray photoelectron spectroscopy; Rutherford back scattering; secondary ion mass spectroscopy

**(12 Hours)**

**Unit 5:**

**Thin film properties and applications:**Conduction in metallic thin films; electrical transport in insulating films; semiconductor contacts; superconductivity in thin films; magnetic film size effects; thin film optics; thin films for electrical and optical devices (LED), Solar Cells, thin film transistors and memories

**(12 Hours)**

**Reference Books:**


1. Hand book of thin film technology by H. Frey, H. R. Khan, 2015
2. Materials science of thin films: deposition and structure, by M. Ohring, 2002.
3. L.B. Freund and S. Suresh; Thin film materials: Stress, defect formation and surface evolution, 2004
4. Hand book of thin film deposition, third edition by Krishna Seshan 2012
5. Vacuum technology by A Roth 2012
6. Hand book of vacuum science and technology by D. Hoffman, B. Singh, J.H. Thomas 1997

# OPEN ELECTIVE COURSES:

1. APPLIED OPTICS
2. INTRODUCTION TO ASTRONOMY & ASTROPHYSICS
3. GENDER CONCERNS IN STEM STUDIES
4. MEDICAL PHYSICS
5. PHYSICS OF ARTS

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**Course Code: PHYOE01**
**Course Title: Applied Optics**
**Course Type: Theory (OE)**
**Credits: 03**

**Unit 1:**
**Geometrical Optics I:** What is light? The rectilinear propagation of light, the refractive index, optical path, introduction to geometrical optics, Fermat's principle, refraction and refraction, the principle of reversibility, color dispersion, paraxial approximation, ray theory, focusing and imaging, sign convention, thin lenses, real and virtual images, total internal reflection, Prisms, minimum deviation, combination of prisms

**(09 Hours)**

**Unit 2:**
**Geometrical Optics II**: Basics of mirrors, magnifiers, thick lenses, the composite lens, the eye, apertures, stops, pupils, windows, Matrix method in paraxial optics, thick and thin lenses, unit planes, nodal planes, system of thin lenses, microscopes, telescopes, Aberrations: chromatic, spherical, coma, astigmatism, distortion, curvature of field

**(09 Hours)**

**Unit 3:**
**Wave Optics I**: Introduction to wave theory of light, the wave equation, phasor representation, complex representation, Huygens' principle, superposition of waves, Interference of light waves, concept of coherence, Young's double slit experiment, interference with white light, Fresnel's biprism, interference by thin parallel films, anti-reflection coating, wedge shaped films, Newton's rings, Michelson interferometer and its applications

**(09 Hours)**

**Unit 4:**
**Wave Optics II:** Introduction to diffraction, Fraunhofer diffraction, single, double and multiple slit diffraction, diffraction at a rectangular and circular aperture, diffraction grating, resolving power, Fresnel diffraction, Fresnel half period zones, vibration curve, circular obstacle, zone plates, Fresnel diffraction at a straight edge, diffraction by a narrow obstacle, Babinet's principle, transition from Fresnel to Fraunhofer diffraction

**(09 Hours)**

**Unit 5:**
Lasers and Fiberoptics: What is a laser? Properties of lasers, spot size, collimation, monochromaticity, tuning range, spectral width, efficiency, size and weight, operation of lasers, oscillators, amplifiers, generation of very short pulses, types of lasers, introduction to fiberoptics, light propagation in an optical fiber, Single mode and multimode propagation, Fiber amplifier, Fiberoptics applications in sensors and communications

**(09 Hours)**

**Reference Books:**

1. Optics, Eugene Hecht (Addison Wesley)
2. Optics, Ajoy Ghatak (McGraw Hil)
3. Fundamentals of Optics, Jenkins & White (McGraw-Hill Primls Custom Publishing)
4. Introduction to Fiber Optics, Ghatak and Thyagarajan, (Cambridge University Press)

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**Course Code: PHYOE02**
**Course Title: Introduction to Astronomy & Astrophysics**
**Course Type: Theory (OE)**
**Credits: 03**

**Unit 1:**
Astronomical scales (Distance, Mass, Time), Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scales, Distance Modulus, Measurement of astronomical quantities- Distance, Stellar Radii, Masses of stars from binary orbits, Stellar temperature, Color index of stars. Spectral types and their temperature dependence, Hertzsprung-Russell (HR) diagram.

**(09 Hours)**

**Unit 2:**
Celestial Sphere, Geometry of a sphere, Astronomical coordinate systems - Horizon system, Equatorial system, Coordinate transformation between Horizon and Equatorial system, Diurnal motion of the stars. Measurement of time, Sidereal time, apparent solar time, mean solar time, Equation of time, Julian date.

**(09 Hours)**

**Unit 3:**
Observing through the atmosphere- Atmospheric Windows, optical telescopes, Radio telescopes, telescope mountings, Magnification, Light gathering power, Stellar Photometry - solid state, Photo-multiplier tube and CCD based photometers, Spectroscopy and Polarimetry using CCD detectors.

**(09 Hours)**

**Unit 4:**
Physical Characteristics of sun- basic data, solar rotation, solar magnetic fields, Photosphere - granulation, sunspots, Babcock model of sunspot formation, solar atmosphere – chromosphere and Corona, Solar activity- flares, prominences, solar wind, activity cycle, Helioseismology Morphological classification of the Galaxies. Basic structure and properties of the Milky way

**(09 Hours)**

**Unit 5:**
**The Universe:** Penzias, Wilson and the cosmic microwave background; corroboration of thermal history in big bang cosmology as predicted by Gamow and his collaborators; Big bang model, Zwicky and the dark matter; the observed large scale structure; evidence of dark matter from galactic rotation curves; Type Ia supernovae and accelerating universe; the puzzle of dark energy;

**(09 Hours)**

**Reference Books:**

1. Astronomy, The Evolving Universe, M. Zeilik
2. Introduction to Astronomy & Cosmology, I. Morrison (Wiley, 2008)
3. Telescopes and Techniques, C. R. Kitchin (Springer, 1995)
4. Astronomical Photometry, A. A. Henden & R. H. Kaitchuk
5. An Introduction to Astronomical Photometry, E. Budding
6. Universe, R. A. Freedman & W. J. Kaufmann (W. H. Freeman & Co., 2008)
7. Fundamental Astronomy, H. Karttunen et al. (Springer, 2003)

8. Solar Astrophysics, P. V. Foukal (Wiley-VCH, 2004) 9. Fundamentals of Solar Astronomy, A. Bhatnagar & W.C. Livingston (World Scientific, 2005)

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**Course Code: PHYOE03**
**Course Title: Gender Concerns in STEM studies**
**Course Type: Theory (OE)**
**Credits: 03**

**Unit 1:**
Concepts of Gender: Sex – Gender – Understanding sex and gender – Biological Determinism – Patriarchy – Feminism – Gender Discrimination – Gender Division of labour – Gender Stereotyping – Gender Sensitivity – Gender Equity – Equality

**( 09 Hours)**

**Unit 2:**
Women's Studies vs Gender Studies : UGC's Guidelines – SAKSHAM and its recommendations, VII to XI Plans – Gender Studies : Beijing Conference and CEDAW –Exclusiveness and Inclusiveness.

**(09 Hours)**

**Unit 3:**
Gendering of Science and Technology Masculization of science and technology –examples from agriculture and military technology in ancient and medieval times, knowledge monopoly and modern science

**(09 Hours)**

**Unit 4:**
Low participation of women in S&T: Understanding the reasons – debates on Nature vs. Nurture, leaky pipeline, glass ceiling.

**(09 Hours)**

**Unit 5:**
Affirmative Actions: Governmental initiatives – scholarships, fellowships (SERB initiatives, WIS, KIRAN), special provisions (mobility measures, leave and break in career opportunities), institutional mechanisms (GATI, Gender Policy); Informal and semi-formal initiatives by individuals and collectives – examples from the field of Physics in India.

**(09 Hours)**

**Reference Books::**
1. Kamala Bhasin, Understanding Gender : Gender Basics , New Delhi : Women Unlimited , 2004
2. Kamala Bhasin, Exploring Masculinity: Gender Basics , New Delhi: Women Unlimited, 2004 Londa Schiebinger(ed), Women and Gender in Science and Technology, Routledge,2014
• Francesca Bray, Gender and Technology, Annual Review of Anthropology, Vol. 36, 2007, pp. 37- 53
• Namrata Gupta and A.K. Sharma, 'Gender inequality in the work environment at institutes of higher learning in science and technology in India', Work, Employment & Society, Vol. 17, No. 4 (December 2003), pp.597-616
3. Vineeta Bal, Women Scientists in India: Nowhere near the Glass Ceiling, Economic and Political Weekly, Vol. 39, No. 32 (Aug. 7-13, 2004), pp.3647- 3649+3651-3653
4. Vineeta Bal, Gendered Science: Women as Practitioners and as Targets of Research, Economic and Political Weekly, Vol. 37, No. 52 (Dec. 28, 2002 - Jan. 3, 2003), pp.5163-5167

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**Course Code: PHYOE04**
**Course Title: Medical Physics**
**Course Type: Theory (OE)**
**Credits: 03**

**Unit 1:**

**X-RAYS AND TRANSDUCERS**: Electromagnetic Spectrum – Production of X-Rays – X-Ray Spectrum – Bremsstrahlung – Characteristic X-Ray – X-Ray Tubes – Coolidge Tube – XRay Tube Design – Thermistors – photo electric transducers – Photo voltaic cells – photo emissive cells –Photoconductive cells– piezoelectric transducer

(09 Hours)

**Unit 2:**

**BLOODPRESSUREMEASUREMENTS**: Introduction –sphygmomanometer – Measurement of heart rate – basic principles of electrocardiogram (ECG) –Basic principles of electroneurography (ENG) – Basic principles of magnetic resonance imaging (MRI).

**(09 Hours)**

**Unit 3:**

**RADIATIONPHYSICS:** Radiation Units – Exposure – Absorbed Dose – Rad to Gray – Kera Relative Biological Effectiveness –Effective Dose – Sievert (Sv) – Inverse Square Law – Interaction of radiation with Matter – Linear Attenuation Coefficient – Radiation Detectors –Thimble Chamber – Condenser Chambers – Geiger Counter – Scintillation Counter

**(09 Hours)**

**Unit 4:**

**MEDICALIMAGINGPHYSICS**: Radiological Imaging – Radiography – Filters – Grids – Cassette – X-Ray Film – Film processing – Fluoroscopy – Computed Tomography Scanner – Principal Function – Display – Mammography – Ultrasound Imaging – Magnetic Resonance Imaging – Thyroid Uptake System – Gamma Camera (Only Principle, Function and display).

**(09 Hours)**

**Unit 5:**

**RADIATIONPROTECTION:** Principles of Radiation Protection – Protective Materials – Radiation Effects – Somatic – Genetic Stochastic and Deterministic Effect – Personal Monitoring Devices – TLD Film Badge – Pocket Dosimeter

**(09 Hours)**

## TEXT BOOKS

1. Dr. K. Thayalan, Basic Radiological Physics, Jayapee Brothers Medical Publishing Pvt. Ltd. New Delhi, 2003.
2. Curry, Dowdey and Murry, Christensen's Physics of Diagnostic Radiology: -LippincotWilliams and Wilkins, 1990.
3. FM Khan, Physics of Radiation Therapy, William and Wilkins, 3rd ed, 2003.
4. D. J. Dewhurst, An Introduction to Biomedical Instrumentation, 1st ed, Elsevier Science, 2014.
5. R.S. Khandpur, Hand Book of Biomedical Instrumentations, 1st ed, TMG, New Delhi, 2005.

**Reference Books:**

1. Muhammad Maqbool, An Introduction to Medical Physics, 1st ed, Springer International Publishing, 2017.
2. Daniel Jirák, FrantišekVítek, Basics of Medical Physics, 1st ed, Charles University, Karolinum Press, 2018
3. Anders Brahme, Comprehensive Biomedical Physics, Volume 1, 1st ed, Elsevier Science, 2014.
4. K. Venkata Ram, Bio-Medical Electronics and Instrumentation, 1st ed, Galgotia Publications, New Delhi, 2001. 96
5. John R. Cameron and James G. Skofronick, 2009, Medical Physics, John Wiley Interscience Publication, Canada, 2nd edition.

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**Course Code: PHYOE05**
**Course Title: Physics of Arts**
**Course Type: Theory (OE)**
**Credits: 03**

**Unit 1:**

Physics of Music: Introduction to music and its forms; Physics of pitch, loudness and timbre; melody, symphony and harmony – a basic understanding of western classical and Indian classical music; Time scales and rhythm in music and the handling of time in Physics; acoustics of auditoria – concepts of reverberation, echoes and good acoustics.

**(15 Hours)**

**Unit 2:**

Physics of Dance: History of dance; main elements of western classical dance, Indian classical dance and modern dance; Physics of rotations and their application in western classical dancing; role of centre of gravity in the basic stances (plie and ardhamandala/araimandi) of the two forms; tension and its resolution; projectiles and jumps – elements of velocity, friction and angular momentum.

**(15 Hours)**

**Unit 3:**

Physics of Paintings/Photography: Introduction to electromagnetic spectra; colours and wavelengths; colour wheel, mixing of colours and complementary colors; symmetry and its role in nature; role of symmetry in paintings; the golden ratio; introduction to the Physics of cameras – parts of a camera; lenses and their properties; aperture, shutter speed and iso.

**(15 Hours)**

## VALUE ADDED COURSE

1. **Data Analysis Techniques**
2. **Computational Modeling Of Materials**

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**Course Code: PHYVA01**
**Course Title: Data Analysis Techniques**
**Course Type: VAC**
**Credits: 02**

**Unit 1:**
Introduction to Statistics: Characteristics of a statistical distribution- Mean, variance, skewness, kurtosis, moments and cumulants, percentiles **(6 HOURS)**

**Unit 2:**
Probability theory, various probabilistic distributions (continuous and discrete), Central limit theorem. **(6 HOURS)**

**Unit 3:**
Error analysis: Types of error in statistical analysis, error propagation, Sampling methods. **(6 HOURS)**

**Unit 4:**
Hypothesis testing, confidence interval and margin of error. **(6 HOURS)**

**Unit 5:**
Regression analysis and curve fitting. **(6 HOURS)**

**Reference Books::**
1. Statistical methods by N G Das, McGrawHill.
2. Statistical methods by S.P. Gupta, S. Chand Publication.
3. Statistical methods for Research Workers, R.A Fisher

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**Course Code: PHYVA02**
**Course Title: Computational Modeling Of Materials**
**Course Type: VAC**
**Credits: 02**

**Unit 1**
**Introduction to Computational Materials Science:** Definitions and Terms-Force Field Methods-Molecular Mechanics - Quantum Mechanical Methods: Ab initio methods-Semi empirical methods - Density functional theory methods. **(6 HOURS)**

**Unit 2**

**Ground-state calculations of condensed matter:** The Hohenberg-Kohn Theorems – Self-consistent total energies, forces, stresses, Kohn-Sham orbitals - Separable norm-conserving and ultrasoft pseudo-potentials, Projector Augmented Waves - exchange-correlation functionals from LDA to generalized-gradient corrections. **(6 HOURS)**

**Unit 3**

**Tutorial: Modeling of periodic solids:** Visualization of crystal types – Miller Indices – Crystal planes – Optimization of energy, lattice parameters, volume – Finding optimum k-point grid – Electronic band structure and density of states plotting –Finding band-gap and identifying origin of bands – Electronic charge density visualization – Bonding analysis. **(6 HOURS)**

**Unit 4**

**Tutorial: Modeling of Molecules:** Optimization of molecular structure - Effect of different exchange-correlation functionals – Bonding and conformation analysis – HOMO-LUMO gaps – Visualization of electrostatic potential surface – Excited-state properties – Identification of functional groups. **(6 HOURS)**

**Unit 5**

**Tutorial : Analysis of Band structure:** Semiconductor's band gap – direct, indirect. Metal, semi metal, semiconductor and insulator, Hole and electron carriers and effective mass, Physical interpretation of the effective mass Application to solar cells, transparent conductor and photocatalysts.

**(6 HOURS)**

# SKILL ENHANCEMENT COURSE

1. MACHINE SHOP
2. NANOSCIENCE AND NANOTECHNOLOGY
3. RENEWABLE ENERGY TECHNOLOGIES

**Course Code: PHYSE01**
**Course Title: Machine Shop (Practical)**
**Course Type: SEC**
**Credits: 02**

**List of Experiment:**
**Part A**
1. Lines and Lettering
2. Scales and paper sizes
3. Title blocks
4. Basic instruments used
   a) T-square
   b) Set-square
   c) Parallel rules
   d) Drafting Machine
5. Axonometric projections
   a) Dimetric projection
   b) Isometric projection
6. Orthographic projection
   a) First angle projection
   b) Third angle projection
7. Introduction to CAD

**Part B**
1. Introduction to machine tools
2. Safety aspects in machine shop
3. Milling
4. Turning
5. Shaping
6. Filing
7. Keyway/slot/groove making
8. Surface/slot milling

**References:**
1. R.K. Dhawan, “A text book of Engineering Drawing”, S. Chand Publishers, Delhi,2010. 2.G.S. Phull and H.S.Sandhu, “Engineering Graphics”, Wiley Publications, 2014.
3. K.Venugopal and V.Prabhu Raja, “Engineering Graphics”, New Age International Private Limited, 2008.
4. P.J.Shah, A Text Book of Engineering Graphics, S.Chand & Company Ltd.

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**Course Code: PHYSE02**
**Course Title: Renewable Energy Technologies**
**Course Type: SEC**
**Credits: 03**

**Unit - I**
**Fossil fuels and Alternate Sources of energy** **(9 hours)**
Introduction to Energy Sources - Energy consumption as a measure of Prosperity – World energy futures – Energy sources and their availability –Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources – Renewable energy sources – Materials limitation - Hydropower resources, hydropower technologies, environmental impact of hydro power sources.

**Unit-II**
**Solar Energy**
Solar radiation geometry – Solar radiation measurements – Principles of the conversion of solar radiation in to heat – Flat plate collectors – Energy balance equation and collector efficiency – Concentrating collector: Focusing type – Performance analysis of a parabolic collector – Solar energy storage systems – Solar pond – Principle of operation and extraction of thermal energy – Solar heating and solar cooling of buildings – Solar electric power generation: Solar photo-voltaic. **(9 hours)**

**Unit-III**
**Wind Energy and Energy from Biomass**
Basic principles of wind energy conversion – site selection considerations – Classification of wind energy conversion systems – types of wind machines – Performance analysis of wind machines – Schemes for electric generation – Applications of wind energy – Environmental aspects.- Biomass conversion technologies – Biomass as a source of energy – Methods for obtaining energy from biomass – Biogas generation – Biodegradation — Biogas from waste – Community biogas plants – Thermal gasification of biomass. **(18 hours)**

**Unit-IV**
**Geothermal Energy and Energy from the Oceans**
Nature of geothermal fields - Geothermal resources – Hot dry rock resources – Magma resources – Geothermal exploration – Advantages and disadvantages of geothermal energy – Applications of geothermal energy – Operational and environmental problems. Ocean thermal electric conversion (OTEC) – Introduction – Open cycle OTEC system - – Closed cycle OTEC system – Energy from Tides – Basic principle of tidal power – Operation methods of utilization
of tidal energy – Single cycle and double cycle systems – Advantages and limitations of tidal power generation - Ocean waves – Energy and power from the waves – Wave energy conversion devices - Advantages and limitations of wave energy. **(9 hours)**

**Unit V**
**Energy storage**
Hydrogen economy, Hydrogen energy – Hydrogen production (Electrolysis, thermochemical and photoelectrochemical methods) – hydrogen storage methods - hydrogen as an alternative fuel for motor vehicles. Fuel cells – Design and principle of operation of a fuel cell – Classification of fuel

cells - Conversion efficiency of fuel cells – Applications of fuel cells – Rechargeable batteries.

**(9 hours)**

References


1. Non – Conventional Energy Sources: G D Rai (Khanna Publishers), New Delhi
2. Renewable Energy Technologies : Solanki C S (Prentice-hall Of India Pvt Ltd)
3. Renewable Energy Sources & Their Environmetal Impact : Abbasi (Prentice-hall of India Pvt Ltd)
4. Renewable Energy Sources for Sustainable Development N.S.Rathore N.L.Panwar (New India Publishing Agency)
5. Renewable Energy : Ulrich Laumanns And Dieter Uh Dirk Abmann (James & James Science Publishers)
6. Understanding Renewable Energy Systems : Volker Quaschning (James & James Science Publishers)
7. Renewable Energy: Global Perspectives : Azmal Hussain (Icfai University Press)
8. New And Renewable Energy Technologies For Sustainable Development : Naim Hamdia Afgan, Da Graca Carvalho Maria, Maria Da Graca Carvalho (Taylor & Francis Group)
9. Renewable Energy from the Ocean : Avery, William H.; Wu, Chih; Craven, John P. (Oxford University Press)
10. Fundamentals of Renewable Energy Systems : Mukherjee D (New Age International (p) Limited)
11. Renewable Energy Sources & Emerging Tech., : Kothari D P (Prentice-hall Of India Pvt Ltd)
12. Energy From Biomass : Willeke Palz, D. Pirrwitz (Springer)
13. Understanding Renewable Energy Systems : Volker Quaschning (James & James)
14. Solar energy - M P Agarwal - S Chand and Co. Ltd.
15. Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.
16. Godfrey Boyle, "Renewable Energy, Power for a sustainable future", 2004,
17. Oxford University Press, in association with The Open University.
18. Dr. P Jayakumar, Solar Energy: Resource Assesment Handbook, 2009
19. J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).
20. http://en.wikipedia.org/wiki/Renewable_energy


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**Course Code: PHYSE03**
**Course Title: Nanoscience and Nanotechnology**
**Course Type: SEC**
**Credits: 03**

**Unit-I**

**Basic Physical Properties of Nanostructures** : Definition of nanoscience and nanotechnology – History of Nanotechnology- Nanostructures Nanoparticles – Metal nanoclusters –Surface to volume ratio – Quantum confinement – Qualitative and Quantitative description – Size Dependence of Properties - Metal Nanoclusters –plasmonic effect - Magic Numbers -Electronic Structure - Reactivity -Fluctuations -Magnetic Clusters -Bulk to Nanotransition- Density of states of nanostructures – DOS of 3D Bulk solid- DOS of quantum wells - DOS of quantum wires - Excitons in Nano semiconductors - Natural Nanocrystals..

**(9 hrs)**

**Unit-II**

**Quantum nanoparticles and Carbon Nanostructures :** Semiconducting Nanoparticles - Size and Dimensionality Effects –Size Effects -Potential Wells-Partial Confinement -Conduction Electrons and Dimensionality - Nanoparticles in Colloidal Suspensions -Photonic Crystals – Excitons. Carbon in nanotechnology – Graphite – Graphene –Fullerenes- Carbon nanotubes. Nanostructured Multilayers - Basics of Ferromagnetism - Dynamics of Nanomagnets -Nanopore Containment of Magnetic Particles - -Ferrofluids -Effect of Nanostructuring on Magnetic Properties - Giant and Colossal Magnetoresistance.

**(9 hrs)**

**Unit-III**

**Synthesis of Nanostructures :** Top-down and bottom up approaches - Methods of Synthesis - Synthesis of ultrafine/nano powders. RF Plasma - Chemical Methods -Thermolysis -Pulsed Laser Methods. Solid-State Reaction - Sol-Gel Technique - Hydrothermal growth - Ball Milling –Plasma arc discharge-sputtering-chemical vapour deposition-pulsed laser depositionmolecularbeam epitaxy- Electrochemical deposition - SILAR method. Combustion synthesis – Sonochemical method - Microwave synthesis – Coprecipitation.

**(9 hrs)**

**Unit-IV**

**Characterization of Nanoparticles:** Surface to volume ratio –Properties of Nanomaterials – wet chemical methods and its functionalizationTheoretical Modeling of Nanoparticles Particle Size Determination- Surface Structure-Microscopy-Transmission Electron Microscopy- Field Ion Microscopy- Scanning Electron Microscopy. Working principles and instrumentation – XRD – XPS – AES - SIMS - RBS – LEED - AFM – SEM – TEM – EDAX –STM. **(9 hrs)**

**Unit-V**

**Nanomachines and Nanodevices :** Limitation of Moor's Law, understanding quantum transport in nanoscale transistors/Devices Microelectromechanical Systems (MEMSs) -Nanoelectromechanical Systems (NEMSs) -Fabrication Nanodevices and Nanomachines -Molecular and Supramolecular Switches. --Single-Electron Tunneling -Applications -Infrared Detectors - Quantum Dot Lasers. Carbon Molecules - Applications of Carbon Nanotubes -Computers -Fuel Cells -Chemical Sensors-Catalysis –Mechanical Reinforcement -Field Emission and Shielding.

**(9 hrs)**

References:


1. Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J. Owens, Wiley, 2003 & Study materials from the course.
2. MEMS/NEMS ; micro electro mechanical systems/nano electro mechanical systems Volume 1, Design Methods,, Cornelius T. Leondes, Springer, 2006.
3. Nano: the essentials, T. PRADEEP,TMH ,2007.
4. Nanoscale Materials ,Luis M. Liz-Marzan and Prashant V. Kamat, Kluwer Academic Publishers, 2003
5. Nanoscience,Nanotechnologies and Nanophysics, C. Dupas, P. Houdy and M.

Lahmani,Springer-Verlag , 2007.
6. Nanotechnology 101, John Mongillo, Greenwood Press, 2007.
7. Semiconductor Nanostructures for Optoelectronic Applications, Todd Steiner, Artech House, 2004.
8. What is What in the Nanoworld,A Handbook on Nanoscience and Nanotechnology, Victor E. Borisenko and Stefano Ossicini , WILEY-VCH Verlag, 2008.
9. Nanotechnology and Nano-Interface Controlled Electronic Devices, M. Iwamoto,K.
10. Kaneto,S. Mashiko Elsevier Science, Elsevier Science, 2003.
Semiconductors for Micro and Nanotechnology—An Introduction for Engineers
11. Jan G. Korvink and Andreas Greiner, WILEY-VCH Verlag ,2002.