Ramakrishna Mission Residential College (Autonomous)

Vivekananda Centre for Research

Ramakrishna Mission Ashrama

(A Branch Centre of Ramakrishna Mission, Belur Math, Howrah-711202)

Narendrapur, Kolkata - 700 103, West Bengal, India

A Scientific Industrial Research Organisation, Recognised by DST, Govt. of India

College with Potential for Excellence (CPE), Re-accredited by NAAC - 'A' (CGPA 3.56 out of 4)

NOTICE

Date: 07.08.2018

A meeting of the Board of Studies in Physics will be held on 25.08.2018, Saturday at 2 PM in the department.

You are requested to kindly attend the meeting.

Agenda

1. Confirmation of the proceedings of the last meeting held on 10.02.2018.

2. Preparation of the Panels of Paper Setters, Moderators, Examiners (Practical) and Reviewers related to UG & PG Examinations to be held during the months of November-December, 2018.

3. Finalization of new UG Syllabus (CBCS)

4. Miscellaneous.

Malay Purkait

Head, Dept. of Physics

Copy to:

1. Prof. Parongama Sen (C.U.)
2. Prof. Dipali Banerjee (IIEST, Shibpur)
3. Dr. Indranath Chaudhuri (St. Xavier's College)
4. Prof. Debnarayan Jana (C.U.)
5. Mr. Jyotirmay Bhowmik (DPSC Ltd., Kolkata)
6. Permanent Teaching Staff of the Dept. of Physics

PHONES : 24772201(3lines), 24772205 FAX : 033-24773597 EMAIL : rkmcnpur@vsnl.com

WEBSITE : www.rkmcnarendrapur.org

Proceedings of the Meeting of the Board of studies in Physics held on 25-08.2018 at 2PM in the Dept. of Physics.

The following members were present :-

Members present with signature :-

1. ~~Malay Purkait~~
2. Dipali Banerjee
3. Malay Purkait.
4.
5. Debnarayan Jana
6. Sourav Chattopadhyay
7. Koushik Sarkar
8. Debabrata Das
9. Swapan Bhunia
10. [signature]
11. Dhirajit Basak
12. Jagadish Ch. Mahato

HOD was on the chair. The following resolutions have been taken in the meetings.

1. The resolutions of the meeting held on 10.02.2018 were read and accepted by the members present.

2. Name of the Internal Examiners and ~~Paper~~ panel of the External paper-Setters, Panel of Moderators and external Examiners (for practicals) in connection with the B.Sc 1st, 3rd and 5th sem, M.Sc 1st and 3rd sem. Examination - 2018 were finalized after discussion, as given in the shell sheets attached.

3. The new ~~sty~~ syllabus for CBCS (Choice Based Credit System) to the UG students (from 2018) was finalized and the Changes in the syllabus with respect to old one are highlighted.

The Meeting ended with a vote of thanks to the chair.

Malay Purkait
25.08.18

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NOTICE

Date: 02.03.2019

A meeting of the Board of Studies in Physics will be held on 14.03.2019, Thursday at 3 PM in the department.

You are requested to kindly attend the meeting.

Agenda

1. Confirmation of the proceedings of the last meeting held on 25.08.2018.
2. Preparation of the Panels of Paper Setters, Moderators, Examiners (Practical) and Reviewers related to UG & PG Examinations to be held during the months of April - May, 2019.
3. Miscellaneous.

Malay Purkait
2.03.19
Head, Dept. of Physics

Copy to:

1. Prof. Parongama Sen (C.U.)
2. Prof. Dipali Banerjee (IIEST, Shibpur)
3. Dr. Indranath Chaudhuri (St. Xavier's College)
4. Prof. Debnarayan Jana (C.U.)
5. Mr. Jyotirmay Bhowmik (DPSC Ltd., Kolkata)
6. Permanent Teaching Staff of the Dept. of Physics

4/3/19
04/03/19
4/3/19
4/3/19

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NOTICE

Date: 02.08.2019

A meeting of the Board of Studies in Physics will be held on 17.08.2019, Saturday at 2 PM in the department.

You are requested to kindly attend the meeting.

Agenda

1. Confirmation of the proceedings of the last meeting held on 14.03.2019.
2. Preparation of the Panels of Paper Setters, Moderators, Examiners (Practical) and Reviewers related to UG & PG Examinations to be held during the months of November - December, 2019.
3. Introduction of CBCS syllabus of PG course w.e.f. 2019-20 session.
4. Miscellaneous.

Malay Purkait
Head, Dept. of Physics

Copy to:

1. Prof. Parongama Sen (C.U.)
2. Prof. Dipali Banerjee (IIEST, Shibpur)
3. Dr. Indranath Chaudhuri (St. Xavier's College)
4. Prof. Debnarayan Jana (C.U.)
5. Mr. Jyotirmay Bhowmik (DPSC Ltd., Kolkata)
6. Permanent Teaching Staff of the Dept. of Physics

17/03/19.

Proceedings of the Meeting of the Board of Studies in Physics held on 17.08.2019 at the Dept. of Physics at 2 PM.

Members present with signature :-

(1)	MALAY PURKAIT	Malay Purkait
2.	PROF. D. JANA.	Debnarayan Jana
3.	" P. SEN.	Absent.
4.	DR. I. CHAUDHURI	Indranath Chaudhuri
5.	PROF. D. BANERJEE.	Ab.
6.	Mr. J. BHOWMIK	Absent.
7.	DR. D. DAS.	Debabrata Das
8.	" K. SARKAR	K. Sarkar
9.	" J. MAHATO.	Jagadish Ch. Mahato
10.	" S. CHATTYAPADHYA.	Absent
11.	MR. S. BHUNIA.	Swapan Bhunia.
12.	" A. ROY.	Ab.
13.	" T. BISWAS.	Tanmay Biswas

HOD was on the chair. The following resolutions have been taken in the meeting.

1. The resolutions of the meeting held on 14.03.2019 were read and accepted by the members present.

2. Name of the Internal Examiners and panel of external paper-setters, moderators and the external Examiners for practical Examination in the connection with the UG 1st, 3rd and 5th Sem, and PG 1st and 3rd Sem. Examination 2019 has been finalized after discussion as given in the seperate sheets attached.

3. The CBCS for PG course (All Sem.) was finalized and the changes in the syllabus with respect to old one are highlighted.
The meeting ended with a vote of thanks to the chair

HOD
Malay Purkait.
17-08-2019

Ramakrishna Mission Residential College (Autonomous)
Narendrapur, Kolkata – 700103

Department of Physics

Syllabi for Courses offered by the Department at Postgraduate Level

Under **CBCS**

Name of the Programme: M.Sc.Physics

(Programme Code : MSXPHY)

2019-20

Course Structure: Semester-wise distribution of Courses

CBCS SYLLABUS *for* M.Sc. COURSE *in* PHYSICS

The course has been divided into 13 theoretical and 7 experimental modules, each of 50 marks.

Total marks: 1000 (Theory: 650, Experiment : 300, Project : 50)
Total number of lectures (including tutorials) for each theoretical paper (50 full marks) is 60.

Programme Name: M.Sc.Physics **Programme Code: MSXPHY**

Semester	Course Name	Paper Code	Credit point
1	Mathematical Methods	MPHY1CC01STH	4
	Classical and Relativistic Mechanics	MPHY1CC02STH	4
	Quantum Mechanics I	MPHY1CC03STH	4
	General Practical 1	MPHY1CC04SPR	4
	General Practical 2	MPHY1CC05SPR	4
II	Classical Electrodynamics	MPHY2CC06STH	4
	Quantum Mechanics II	MPHY2CC07STH	4
	Electronics and Instrumentation	MPHY2CC08STH	4
	General Practical 3	MPHY2CC09SPR	4
	Computer Practical	MPHY2CC10SPR	4
III	Atomic, Molecular and Laser Physics	MPHY3CC11STH	4
	Statistical mechanics	MPHY3CC12STH	4
	Nuclear and Particle Physics	MPHY3CC13STH	4
	Solid State Physics	MPHY3CC14STH	4
	Advanced Experiments I	MPHY3CC15SPR	4
IV	Advanced Paper I (Condensed Matter Physics I)	MPHY4CC16STH	4
	Advanced Paper II (Condensed Matter Physics II)	MPHY4CC17STH	4
	Elective Paper: Astrophysics Material Science	MPHY4CC18STHAP MPHY4CC18STHMS	4 4
	Advanced Experiments II	MPHY4CC19SPR	4
	Project	MPHY4CC20SPR	4

SEMESTER: I

PAPER CODE – MPHY1CC01STH, COURSE NAME: Mathematical Methods

COURSE OUTCOME:

- Will have a revision of important mathematical concepts taught at Undergraduate course: Complex number, Differential Equations etc.
- Will be able to use topics learnt here to mathematically understand rest of Post Graduate courses.
- Will be capable to use linear algebra and group theory concepts, that will help to understand quantum and particle physics in future.

1. Complex variables (12)
Recapitulation: Complex numbers, triangular inequalities, Schwarz inequality. Function of a complex variable | single and multiple-valued function, limit and continuity; Differentiation Cauchy-Riemann equations and their applications; Analytic and harmonic function; Complex integrals, Cauchy's theorem (elementary proof only), converse of Cauchy's theorem, Cauchy's Integral Formula and its corollaries; Series | Taylor and Laurent expansion; Classification of singularities; Branch point and branch cut; Residue theorem and evaluation of some typical real integrals using this theorem.

2. Theory of second order linear homogeneous differential equations (6)
Singular points, regular and irregular singular points; Frobenius method; Fuch's theorem; Linear independence of solutions. Wronskian, second solution. Sturm-Liouville theory; Hermitian operators; Completeness.

3. Inhomogeneous differential equations : Green's functions (3)

4. Special functions (3)
Basic properties (recurrence and orthogonality relations, series expansion) of Bessel, Legendre, Hermite and Laguerre functions.

5. Integral transforms (4)
Fourier and Laplace transforms and their inverse transforms, Bromwich integral [use of partial fractions in calculating inverse Laplace transforms]; Transform of derivative and integral of a function; Solution of differential equations using integral transforms.

6. Vector space and matrices (8)
Vector space: Axiomatic definition, linear independence, bases, dimensionality, inner product; Gram-Schmidt orthogonalisation.
Matrices: Representation of linear transformations and change of base; Eigenvalues and eigenvectors; Functions of a matrix; Cayley-Hamilton theorem; Commuting matrices with degenerate eigenvalues; orthonormality of eigenvectors.

7. Tensors (4)
Basic idea, Applications in various fields of physics.

8. Group theory (10)
Definitions; Multiplication table; Rearrangement theorem; Isomorphism and homomorphism;

Illustrations with point symmetry groups; Group representations: faithful and unfaithful representations, reducible and irreducible representations; Lie groups and Lie algebra, product representation of SU(2) and relation with angular momentum.

9. Tutorials (10)

"Highlighted portion has been revised vide the BOS meeting dated 17.08.2019"

PAPER CODE: MPHY1CC02STH, COURSE NAME: Classical and Relativistic Mechanics

COURSE OUTCOME

- Will learn advanced mechanism to deal with rigid and continuous systems: through Hamilton principle, Hamilton Jacobi theory.
- Will be able to treat symmetry and conserved quantities in an advanced framework: Canonical transformation
- Will learn special theory of relativity that will enable to treat other physical systems in a space-time equivalent framework.

1. An overview of the Lagrangian formalism (4)
Some specific applications of Lagarange's equation; small oscillations, normal modes and frequencies.

2. Rigid bodies (8)
Independent coordinates; orthogonal transformations and rotations (finite and infinitesimal); Euler's theorem, Euler angles; Inertia tensor and principal axis system; Euler's equations; Heavy symmetrical top with precession and nutation.

3. Hamilton's principle (6)
Calculus of variations; Hamilton's principle; Lagrange's equation from Hamilton's principle; Legendre transformation and Hamilton's canonical equations; Canonical equations from a variational principle; Principle of least action.

4. Canonical transformations (8)
Generating functions; examples of canonical transformations; group property; Integral variants of Poincare; Lagrange and Poisson brackets; Infinitesimal canonical transformations; Conservation theorem in Poisson bracket formalism; Jacobi's identity; Angular momentum Poisson bracket relations.

5. Hamilton-Jacobi theory (4)
The Hamilton Jacobi equation for Hamilton's principle function; The harmonic oscillator problem; Hamilton's characteristic function; Action angle variables.

6. Lagrangian formulation for continuous systems (6)
Lagrangian formulation of acoustic field in gases; the Hamiltonian formulation for continuous systems; Canonical equations from a variational principle, Poisson's brackets and canonical field variables.

7. Classical Chaos (4)
Periodic motions and perturbations; Attractors; Chaotic trajectories and Liapunov exponents; The logistic equation.

8. Special theory of relativity (10)
Lorentz transformations; 4-vectors, Tensors, Transformation properties, Metric tensor, Raising and lowering of indices, Contraction, Symmetric and antisymmetric tensors; 4-dimensional velocity and acceleration; 4-momentum and 4-force; Covariant equations of motion; Relativistic kinematics (decay and elastic scattering); Lagrangian and Hamiltonian of a relativistic particle.

9. Tutorials (10)

PAPER CODE: MPHY1CC03STH, COURSE NAME: Quantum Mechanics I

COURSE OUTCOME:

- Will get a summarized view of all basic concepts of Quantum mechanics which may or may not been covered in Under Graduate.
- Will be able to use angular momentum operators and their algebra to deal with rotationally invariant quantum systems.
- Will learn to treat quantum systems with perturbed Hamiltonian using the methods taught here: Variational Method etc., important to study solid state physics systems.

1. Recapitulation of Basic Concepts (10)
Wave packet: Gaussian wave packet; Fourier transform; Spreading of a wave packet; Fourier Transforms of delta and sine functions. Coordinate and Momentum space: Coordinate and Momentum representations; x and p in these representations; Parserval's theorem. Eigenvalues and eigenfunctions: Momentum and parity operators; Commutativity and simultaneous eigenfunctions; Complete set of eigenfunctions; expansion of wave function in terms of a complete set. One-dimensional problems: Square well problem (E > 0); Delta-function potential; Double-delta potential; Application to molecular inversion; Multiple well potential, Kronig- Penney model.

2. Operator method in Quantum Mechanics (8)
Formulation of Quantum Mechanics in vector space language; Uncertainty principle for two arbitrary operators; One dimensional harmonic oscillator by operator method.

3. Quantum theory of measurement and time evolution (4)
Double Stern-Gerlach experiment for spin-1/2 system; Schrodinger, Heisenberg and interaction pictures.

4. Three-dimensional problems (6)
Three dimensional problems in Cartesian and spherical polar coordinates, 3-d well and Fermi energy; Radial equation of free particle and 3-d harmonic oscillator; Eigenvalue of a 3-d harmonic oscillator by series solution.

5. Angular momentum (6)
Angular momentum algebra; Raising and lowering operators; Matrix representation for j = 1/2 and j = 1; Spin; Addition of two angular momenta, Clebsch-Gordan coefficients, examples.

6. Approximation Methods (16)
Time independent perturbation theory: First and second order corrections to the energy eigenvalues; First order correction to the eigenvector; Degenerate perturbation theory; Application to one-electron system - Relativistic mass correction, Spin-orbit coupling (L-S and j- j), Zeeman effect and Stark effect. Variational method: He atom as example; First order perturbation; Exchange degeneracy; Ritz principle for excited states for Helium atom.

7. Tutorials (10)

PAPER CODE: MPHY1CC04SPR, COURSE NAME: Practical (General Experiments – I)

COURSE OUTCOME:

- Will learn to measure electric conducting nature of conductor and semi-conductor systems to design experiments to determine conductivity of other set up.

- Will able to learn how simple electromagnetic set up can be utilized to check basic properties of quantum physics.
- Will figure out different basic concepts of atomic and molecular physics form measurements of atomic spectrum.

Name of the experiments:

1. **Study of Hall Effect**
2. **Determination of Band-Gap of a Semiconductor**
3. **Study of Iodine Spectra**
4. **Determination of e/m of an electron**
5. **Determination of Planck's Constant**

"This is an entirely new course added vide the BOS meeting dated 17.08.2019".

PAPER CODE: MPHY1CC05SPR, COURSE NAME: Practical (General Experiments – II)

COURSE OUTCOME:

- Will understand basic concepts of electronics through different experiments.
- Will get a first-hand insight on how computer does its work, from microprocessor experiments.
- Will get an idea on most advanced communication and connectivity concepts through optical fibre experiments.

Name of the experiments:

1. **Study of Amplitude Modulation**
2. **Study of Filter Circuits**
3. **Microprocessor – I (Basic Experiments)**
4. **Study of Optical Fiber and determination of Numerical Aperture**

"This is an entirely new course added vide the BOS meeting dated 17.08.2019".

SEMESTER II

PAPER CODE: MPHY2CC06STH, COURSE NAME: Classical Electrodynamics

COURSE OUTCOME:

- Will be familiar to work with tensor notations in relativistic formulation.
- Will be able to solve problems with arbitrary charge and field configurations.
- Will be able to find radiation patter for different time dependent charge and current densities.

1. Electrostatics and Magnetostatics (6)
Scalar and vector potentials; Gauge transformations; Multipole expansion of (i) scalar potential and energy due to a static charge distribution (ii) vector potential due to a stationary current distribution. Electrostatic and magnetostatic energy. Poynting's theorem. Maxwell's stress tensor.

2. Radiation from time-dependent sources of charges and currents (6)
Inhomogeneous wave equations and their solutions; Radiation from localised sources and multipole expansion in the radiation zone.

3. Relativistic electrodynamics (15)
Equation of motion in an electromagnetic field; Electromagnetic field tensor, covariance of Maxwell’s equations; Maxwell's equations as equations of motion; Lorentz transformation law for the electromagnetic fields and the fields due to a point charge in uniform motion; Field invariants; Covariance of Lorentz force equation and the equation of motion of a charged particle in an electromagnetic field; The generalised momentum; Energy-momentum tensor and the conservation laws for the electromagnetic field; Relativistic Lagrangian and Hamiltonian of a charged particle in an electromagnetic field.

4. Radiation from moving point charges (12)
Lienard-Wiechert potentials; Fields due to a charge moving with uniform velocity; Fields due to an accelerated charge; Radiation at low velocity; Larmor's formula and its relativistic generalisation; Radiation when velocity (relativistic) and acceleration are parallel, Bremsstrahlung; Radiation when velocity and acceleration are perpendicular, Synchrotron radiation; Cherenkov radiation (qualitative treatment only). Thomson and Compton scattering.

5. Radiation reaction (3)
Radiation reaction from energy conservation; Problem with Abraham-Lorentz formula; Limitations of CED.

6. Plasma physics (8)
Definition of plasma; Its occurrence in nature; Dilute and dense plasma; Uniform but time-dependent magnetic field: Magnetic pumping; Static non-uniform magnetic field: Magnetic bottle and loss cone; MHD equations, Magnetic Reynold's number; Pinched plasma; Bennett's relation; Qualitative discussion on sausage and kink instability.

7. Tutorials (10)

PAPER CODE: MPHY2CC07STH, COURSE NAME: Quantum Mechanics II

COURSE OUTCOME:

- Will use the quantum mechanics scattering concepts to deal with scattering processes in quantum field theory and particle physics, later.
- Will be able to connect group theory with quantum mechanics, that help to understand particle physics better.
- Will be able to understand the intricacies of quantum mechanics in the relativistic regime, eventually leading to quantum field theory in future.

1. WKB Approximation (4)
Quantisation rule, tunnelling through a barrier, qualitative discussion of α-decay.

2. Time-dependent Perturbation Theory (6)
Time dependent perturbation theory, interaction picture; Constant and harmonic perturbations Fermi's Golden rule; Sudden and adiabatic approximations.

3. Scattering theory (12)
Laboratory and centre of mass frames, differential and total scattering cross-sections, scattering amplitude; Scattering by spherically symmetric potentials; Partial wave analysis and phase shifts; Ramsauer-Townsend effect; Relation between sign of phase shift and attractive or repulsive nature of the potential; Scattering by a rigid sphere and square well; Coulomb scattering; Formal theory of scattering Green's function in scattering theory; Lippman-Schwinger equation; Born approximation.

4. Symmetries in quantum mechanics (12)
Conservation laws and degeneracy associated with symmetries; Continuous symmetries | space and time translations, rotations; Rotation group, homomorphism between SO(3) and SU(2); Explicit matrix representation of generators for j = 1/2 and j = 1; Rotation matrices; Irreducible spherical tensor operators, Wigner-Eckart theorem; Discrete symmetries | parity and time reversal.

5. Identical Particles (4)
Meaning of identity and consequences; Symmetric and antisymmetric wavefunctions; Slater determinant; Symmetric and antisymmetric spin wavefunctions of two identical particles; Collisions of identical particles.

6. Relativistic Quantum Mechanics (12)
Klein-Gordon equation, Feynman-Stueckelberg interpretation of negative energy states and concept of antiparticles; Dirac equation, covariant form, adjoint equation; Plane wave solution and momentum space spinors; Spin and magnetic moment of the electron; Non-relativistic reduction; Helicity and chirality; Properties of matrices; Charge conjugation; Normalisation and completeness of spinors; Lorentz covariance of Dirac equation; Bilinear covariants and their transformation under parity and infinitesimal Lorentz transformation; Weyl representation and chirality projection operators.

7. Tutorials (10)

"This is an entirely new course added vide the BOS meeting dated 17.08.2019".

PAPER CODE: MPHY2CC08STH, COURSE NAME: Electronics and Instrumentation

COURSE OUTCOME:

- Will be able to design different digital and analog circuits using semiconductor devices and explain their functions.
- Will be able to understand the role of diodes and transistors to design advanced circuits for latest electronic devices.
- Will help the students to study design of detectors and related instruments to enable them to work in domain of experimental physics.

1. Analog circuits (4)
Comparators, Multivibrators, Waveform generators: Square wave, triangle wave and pulse generators.

2. Digital MOS circuits (8)
NMOS and CMOS gates (AND, NAND and NOT), Dynamic MOS circuits, ratio-inverter, two phase inverter; dynamic MOS shift register, static MOS shift registers, four phase shift registers. Memory Devices; Static and dynamic random access memories (SRAM and DRAM).

3. Transmission line (8)
Transmission line equation and solution; Reflection and transmission coefficient; Standing wave and standing wave ratio; Line impedance and admittance; Smith chart.

4. Physics of Semiconductor devices – I (8)
Carrier concentrations in semiconductors; Band structure of p-n junction; Basic semiconductor equations; p-n diode current voltage characteristics; Dynamic diffusion capacitances; Ebers-Moll equation.

5. Physics of Semiconductor devices – II (10)
Metal semiconductor junctions: Schottky barriers; Rectifying contacts; Ohmic contacts; Typical Schottky barriers. Miscellaneous semiconductor devices: Tunnel diode; Photodiode; Solar cell; LED; LDR; p-n-p-n switch, SCR; Unijunction transistor (UJT); Programmable Unijunction transistor (PUT).

6. Experimental design (8)
Scintillation detectors; Solid state detectors (Si and HPGe).
Measurement of energy and time using electronic signals from the detectors and associated instrumentation, Signal processing; Multi channel analyzer; Time of flight technique; Coincidence measurements true-to-chance ratio.

7. Error analysis and hypothesis testing (4)
Propagation of errors; Plotting of graphs, Distribution, Least square fit, Criteria for goodness of fit ($\chi 2$-testing).

8. Tutorials (10)

PAPER CODE: MPHY2CC09SPR, COURSE NAME: Practical (General Experiments – III)

COURSE OUTCOME:

- Will be able to understand and design circuits to study electrical conductivity in advanced electronic and non-electronic systems.
- Will be able to use wave propagation techniques to understand wave and optics fundamentals.
- Will enable for future set up of circuits with advanced computation mechanism using the microprocessors.

Name of the experiments:

1. **Determination of Velocity of Ultrasonic Wave**
2. **Study of S.C.R.**
3. **Microprocessor – II (Advanced Experiments)**
4. **Study of Magneto-resistance**

"This is an entirely new course added vide the BOS meeting dated 17.08.2019".

PAPER CODE: MPHY2CC10SPR, COURSE NAME: Computer Practical (Python)

COURSE OUTCOME:

- Will help students to be familiar with more prevalent coding languages: familiarity with python along with fortran.
- Will be able to use a number of recent physics computation packages written in python.
- Will be able to solve a number of differential equations that are core to future research in cosmology and solid state physics etc.

1. FORTRAN Language (12)
Constants and variables. Assignment and arithmetic expressions. Logical expressions and control statements, DO loop, array, input and output statements, function subprogram, subroutine.

2. Numerical analysis (12)
Computer arithmetic and errors in floating point representation of numbers, different numerical methods for (i) finding zeroes of a given function, (ii) solution of linear simultaneous equations,
(iii) numerical differentiation and integration, (iv) solution of first-order differential equations, (v) interpolation and extrapolation, (vi) least square fitting. Random number generation, sorting.

"This is an entirely new course added vide the BOS meeting dated 17.08.2019".

SEMESTER III

PAPER CODE: MPHY3CC11STH, COURSE NAME: Atomic, Molecular, and Laser Physics

COURSE OUTCOME:

- Students will learn the details of atomic and diatomic molecular structures along with fine and Hyperfine structure in terms of quantum mechanical treatment in details and beyond the basic models.
- It will give the descriptions of rotational, vibrational and electronic energies of molecules manifesting in their respective spectroscopies which would serve as the fundamentals for various concerned experimental results.
- Students will also learn the basic principles of light coherence as laser with threshold condition, types and variants will also be covered exposing the students to the important modern spectroscopic tool.
- The basics of the laser and some spectroscopic techniques using laser taught in this course will be an added asset. This specialization would provide a larger scope for research in the various field and interdisciplinary areas.

1. One Electron Atom (2)
Introduction: Quantum States; Atomic orbital; Parity of the wave function; Angular and radial distribution functions.

2. Interaction of radiation with matter (6)
Time dependent perturbation: Sinusoidal or constant perturbation; Application of the general equations; Sinusoidal perturbation which couples two discrete states - the resonance phenomenon. Interaction of an atom with electromagnetic wave: The interaction Hamiltonian - Selection rules; Non-resonant excitation, Comparison with the elastically bound electron model; Resonant excitation, Induced absorption and emission.

3. Fine and Hyperfine structure (10)
Solution of Dirac equation in a central field; Relativistic correction to the energy of one electron atom. Fine structure of spectral lines; Selection rules; Lamb shift. Effect of external magnetic field - Strong, moderate and weak field. Hyperfine interaction and isotope shift; Hyperfine splitting of spectral lines; selection rules.

4. Many electron atom (6)
Independent particle model; He atom as an example of central field approximation; Central field approximation for many electron atom; Slater determinant; L-S and j-j coupling; Equivalent and nonequivalent electrons; Energy levels and spectra; Spectroscopic terms; Hund's rule; Lande interval rule; Alkali spectra.

5. Molecular Electronic States (5)
Concept of molecular potential, Separation of electronic and nuclear wavefunctions, Born-Oppenheimer approximation, Electronic states of diatomic molecules, Electronic angular momenta, Approximation methods for the calculation of electronic Wave function, The LCAO approach, States for hydrogen molecular ion, Coulomb, Exchange and Overlap integral, Symmetries of electronic wavefunctions; Shapes of molecular orbital; π and σ - bond; Term symbol for simple molecules.

6. Rotation and Vibration of Molecules (3)
Solution of nuclear equation; Molecular rotation: Non-rigid rotator, Centrifugal distortion, Symmetric top molecules, Molecular vibrations: Harmonic oscillator and the anharmonic oscillator approximation, Morse potential.

7. Spectra of Diatomic Molecules (4)
Transition matrix elements, Vibration-rotation spectra: Pure vibrational transitions, Pure rotational transitions, Vibration-rotation transitions, Electronic transitions: Structure, Franck-Condon principle, Rotational structure of electronic transitions, Fortrat diagram, Dissociation energy of molecules, Continuous spectra, Raman transitions and Raman spectra.

8. Vibration of Polyatomic Molecules: Application of Group Theory (4)
Molecular symmetry; Matrix representation of the symmetry elements of a point group; Reducible and irreducible representations; Character tables for C_{2v} and C_{3v} point groups; Normal coordinates and normal modes; Application of group theory to molecular vibration.

9. Laser Physics (10)
Basic elements of a laser; Threshold condition; Four-level laser system, CW operation of laser; Critical pumping rate; Population inversion and photon number in the cavity around threshold; Output coupling of laser power. Optical resonators; Cavity modes; Mode selection; Pulsed operation of laser: Q-switching and Mode locking; Experimental technique of Q-switching and mode locking Different laser systems: Ruby, CO_2, Dye and Semiconductor diode laser.

10. Tutorials (10)

PAPER CODE: MPHY3CC12STH, COURSE NAME: Statistical Mechanics

COURSE OUTCOME:

- In this course, students will understand how a probabilistic description of a system at the microscopic level gives rise to deterministic laws at the macroscopic world.
- The concepts would relate thermodynamically defined parameters in statistical mechanics to their familiar versions which will be helpful to solve for the thermal properties of classical and quantum gases and other condensed systems from the knowledge of their microscopic Hamiltonians.
- Understanding of various phase matter in nature through the interactions between particles, as well as the characterization of phase transitions.

1. Introduction (8)
Objective of statistical mechanics. 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.

2. Canonical Ensemble (4)
System in contact with a heat reservoir, expression of entropy, canonical partition function, Helmholtz free energy, fluctuation of internal energy.

3. Grand Canonical Ensemble (4)
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.

4. Classical non-ideal gas (4)
Mean field theory and Van der Wall's equation of state; Cluster integrals and Mayer-Ursell expansion.

5. Quantum statistical mechanics (6)
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.

6. Ideal Bose and Fermi gas (6)
Equation of state; Bose condensation; Equation of state of ideal Fermi gas; Fermi gas at finite T.

7. Special topics (10)
Ising model: partition function for one dimensional case; Chemical equilibrium and Saha ionization formula. 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.
8. Irreversible Thermodynamics (8)
Flux and afinity. Correlation function of fluctuations. Onsager reciprocity theorem (including proof). Thermoelectric effect.
9. Tutorials (10)

"This is an entirely new course added vide the BOS meeting dated 17.08.2019".

PAPER CODE: MPHY3CC13STH, COURSE NAME: Nuclear and Particle Physics

COURSE OUTCOME:

- Students will extend the knowledge of nuclear structure, basic properties of nuclei and understanding of fundamental forces by studying nuclear and weak forces. The scattering and reaction dynamics will provide knowledge of nuclear-nucleon interaction.
- The knowledge of nuclear detectors, accelerators and the interaction of radiation with matter would provide a larger scope for research in this field and interdisciplinary areas.
- Students will also extend their understanding in particle physics through this course. The role of symmetries and conservation laws in understanding particle interactions and their classification. SU(2), SU(3) and quark model. Drawing up the theory of particle interactions, ideas of electroweak interactions and standard model.

1. Nuclear Properties (4)
Basic nuclear properties: nuclear size, Rutherford scattering, nuclear radius and charge distribution, nuclear form factor, mass and binding energy, Angular momentum, parity and symmetry, Magnetic dipole moment and electric quadrupole moment, experimental determination, Rabi's method.

2. Two-body bound state (4)
Properties of deuteron, Schrodinger equation and its solution for ground state of deuteron, rms radius, spin dependence of nuclear forces, electromagnetic moment and magnetic dipole moment of deuteron and the necessity of tensor forces.

3. Two-body scattering (8)
Experimental n-p scattering data, Partial wave analysis and phase shifts, scattering length, magnitude of scattering length and strength of scattering, Significance of the sign of scattering length; Scattering from molecular hydrogen and determination of singlet and triplet scattering lengths, effective range theory, low energy p-p scattering, Nature of nuclear forces: charge independence, charge symmetry and iso-spin invariance of nuclear forces.

4. β-decay (4)
β-emission and electron capture, Fermi's theory of allowed β-decay, Selection rules for Fermi and Gamow-Teller transitions, Parity non-conservation and Wu's experiment.

5. Nuclear Structure (6)
Liquid drop model, Bethe-Weizsacker binding energy/mass formula, Fermi model, Shell model and Collective model.
6. Nuclear Reactions and Fission (10)
Different types of reactions, Quantum mechanical theory, Resonance scattering and reactions-Breit-Wigner dispersion relation; Compound nucleus formation and break-up, Statistical theory of nuclear reactions and evaporation probability, Optical model; Principle of detailed balance, Transfer reactions, Nuclear fission: Experimental features, spontaneous fission, liquid drop model, barrier penetration, statistical model, Super-heavy nuclei.
7. Nuclear Physics in other areas (Qualitative ideas only) (4)
Nuclear Astrophysics: nucleo-synthesis and abundance of elements, neutron star.
Nuclear medicine: diagnostic and therapeutic.
8. Particle Physics (10)
Symmetries and conservation laws, Hadron classification by isospin and hypercharge, SU(2) and SU(3): Groups, algebras and generators; Young tableaux rules for SU(2) and SU(3); Quarks; Colour; Elementary ideas of electroweak interactions and standard model.

9. Tutorials (10)

PAPER CODE: MPHY3CC14STH, COURSE NAME: Solid State Physics

COURSE NAME:

- In this course students will be able develop the skill to explained the important features of solid state physics using the knowledge of crystal lattices and its dynamics, binding, band theory of solids and semiconductors and understand the theory of Mossbauer Effect.
- The students will understand the quantum theory of lattice dynamics and neutron scattering extensively.
- The electric and magnetic properties with resonance condition will also be covered exposing the students to the important structure and field.

1. Crystal structure (8)
Bravais lattice - primitive vectors, primitive unit cell, conventional unit cell, Wigner-Seitz cell; Symmetry operations and classification of 2- and 3-dimensional Bravais lattices; Crystal structures: basis, crystal class, point group and space group (information only); Common crystal structures: NaCl and CsCl structure, crystals of alkali and noble metals, close-packed structure, cubic ZnS structure; Reciprocal lattice and Brillouin zone; Bragg-Laue formulation of X-ray diffraction by a crystal; Atomic and crystal structure factors; Ewald construction; Explanation of experimental methods on the basis of Ewald construction; Electron and neutron diffraction by crystals (qualitative discussion); Intensity of diffraction maxima; Extinctions due to lattice centering; Surface crystallography.
2. Band theory of solids (8)
Limitations of free electron theory; Periodic potential and Bloch's theorem; Nearly free electron bands; Band gap; Number of states in a band; Tight binding method; Effective mass of an electron in a band: concept of holes; Energy band in one dimension | reduced zone scheme; E-k diagram in three dimensions - band structures and energy gap; Other methods for calculating band structures. Band structures in Cu, GaAs and Si; Classification of metal, semiconductor and insulator; Topology of Fermi surface - cyclotron resonance; de Haas-van Alphen effect; Boltzmann transport equation relaxation time approximation, electrical conductivity; limitations of Band Theory | metal-insulator transitions.
3. Lattice dynamics and Specific heat (8)
Classical theory of lattice vibration under harmonic approximation; Vibrations of linear monatomic and diatomic lattices, accoustical and optical modes, long wavelength limits; Optical properties of ionic crystal in the infrared region; Adiabatic approximation (qualitative discussion); Normal modes and phonons; Inelastic scattering of neutron by phonon; Lattice heat capacity, models of Debye and Einstein, comparison with electronic heat capacity; Anharmonic effects in crystals - thermal expansion and thermal conductivity; Mossbauer effect; optical properties of lattice in the infra-red region.
4. Dielectric properties of solids (4)
Complex dielectric constant and dielectric losses, relaxation time and Debye equation for orientational polarizability; Classical theory of electronic and ionic polarization, optical absorption; Ferroelectricity| dipole theory, classifications of ferroelectric material.
5. Magnetic properties of solids (8)
Origin of magnetism; Diamagnetism: quantum theory of atomic diamagnetism; Landau diamagnetism (qualitative discussion); Paramagnetism: quantum theory of paramagnetism; quenching of orbital angular momentum; Van-Vleck paramagnetism and Pauli paramagnetism; Ferromagnetism: Curie-Weiss law, temperature dependence of saturated magnetisation, Heisenberg's exchange interaction, ferromagnetic domains; Ferrimagnetism and antiferromagnetism; Neutron scattering and magnetic structures.
6. Magnetic resonances (3)
Nuclear magnetic resonances, paramagnetic resonance, Bloch equation, longitudinal and transverse relaxation time; Hyperfine field; Electron-spin resonance.
7. Imperfections in solids and optical properties (5)

Frenkel and Schottky defects, defects in growth of crystals; role of dislocations in plastic deformation and crystal growth; Colour centers and photoconductivity; Luminescence and phosphors; Alloys - order-disorder phenomena, Bragg-Williams theory; Extra specific heat in alloys.

8. Superconductivity (6)

Phenomenological description of superconductivity | occurrence of superconductivity, destruction of superconductivity by magnetic field, Meissner effect; Type-I and type-II superconductors; Heat capacity, energy gap and isotope effect; Outlines of the BCS theory; Giaver tunnelling; Flux quantization and Josephson effect.

9. Tutorials (10)

PAPER CODE: MPHY3CC15SPR, COURSE NAME: Practical (Advanced Experiments – I)

COURSE OUTCOME:

- At the end of this laboratory course, each and every student is expected to understand the basic concepts of physics through experiments, which would immensely help them in acquiring knowledge to tackle various competitive exam questions.
- Experience of the measurement of the Lande's g-factor in a free radical using an electron spin resonance spectrometer.
- The study of lattice dynamics is the study of vibrations in crystal. When one considers harmonic vibrations (that is when the expansion of the crystal potential is truncated at the second order term) one can explain and understand many physical properties, such as phonon modes, specific heat. This experiment is an essential part of understanding the electromagnetic waves and crystalline solids. The lattice *dynamics* experiment provides an experience in the *study* of *dynamics* of mono and di-atomic *lattices.*
- In this experiment, students will have hands on experience of calibrating a condenser.
- Hands on experience of Michelson Interferometer which is a common configuration for optical interferometry. Study of the superposition principle using the splitter light beam amplitudes.

Name of the experiments:

1. **Determination of Lande g - factor**
2. **Study of Lattice Dynamics**
3. **Calibration of Condenser**
4. **Michelson Interferometer**

"This is an entirely new course added vide the BOS meeting dated 17.08.2019".

SEMESTER IV

PAPER CODE: MPHY4CC16STH, COURSE NAME: Advanced – I (Condensed Matter Physics – I)

COURSE OUTCOME:

- A student of this course is expected to understand thoroughly the concepts of lattice dynamics for many-electron and free electron gas systems.
- In addition, the students would be able to perform various analytical as well as numerical calculations needed for understanding the quantum theory of solids.
- A student of this course is expected to learn the advanced theoretical treatments involved in magnetism and superconductivity.

1. Fundamentals of many-electron system: Hartree-Fock theory (8)
The basic Hamiltonian in a solid: electronic and ionic parts, the adiabatic approximation; Single particle approximation of the many-electron system - single product and determinantal wave functions, matrix elements of one and two-particle operators; The Hartree-Fock (H-F) theory: the H-F equation, exchange interaction and exchange hole, Koopmans theorem; The occupation number representation: the many electron Hamiltonian in occupation number representation; the H-F ground state energy.

2. The interacting free-electron gas: Quasi electrons and Plasmon (12)
The H-F approximation of the free electron gas: exchange hole, single-particle energy levels, the ground state energy; Perturbation: theoretical calculation of the ground state energy; Correlation energy - difficulty with the second-order perturbation theoretic calculation, Wigner's result at high density, low density limit and Wigner interpolation formula; Cohesive energy in metals; Screening and Plasmons; Experimental observation of plasmons; The dielectric function of the electron gas; Friedel oscillation; Quasi-electrons; Landau's quasi-particle theory of Fermi liquid; Strongly correlated electron gas; Mott transition.

3. Spin-spin interaction: Magnons (9)
Absence of magnetism in classical statistics; Origin of the exchange interaction; Direct exchange, superexchange, indirect exchange and itinerant exchange; Spin-waves in ferromagnets - magnons, spontaneous magnetisation, thermodynamics of magnons; Spin-waves in lattices with a basis – ferri and antiferromagnetism; Measurement of magnon spectrum; Ordered magnetism of valence and conduction electrons, the Hubbard Model; Stoners criterion for metalic ferromagnet; Kondo effect.

4. Superconductivity (8)
Electron-electron interaction via lattice: Cooper pairs; BCS theory; Bogoliubov transformation - notion of quasiparticles; Ginzburg-Landau theory and London equation; Meissner effect; Type II superconductors-characteristic length; Josephson effect; “Novel High Temperature" superconductors.

5. Superuidity (5)
Basic phenomenology; λ-Transition and Bose-Einstein condensation; Two fluid model; Roton spectrum and specific heat calculation, Critical velocity.

6. Disordered systems (8)
Disorder in condensed matter - substitutional, positional and topographical disorder; Short - and long range order; Atomic correlation function and structural descriptions of glasses and liquids; Anderson model for random systems and electron localization; mobility edge; Qualitative application of the idea to amorphous semiconductors and hopping conduction.

PAPER CODE: MPHY4CC17STH, COURSE NAME: Advanced –II (Condensed Matter Physics – II)

COURSE OUTCOME:

- This course provides knowledge of advance condensed matter physics. This course also provides an intensive introduction to the theoretical and experimental aspects of electronic and optical properties of solid in different conditions.
- In addition, the students will impart the quantum theory of some of the advanced topics such as the quantum hall effect.
- In this course the students should able to elucidate the important features of advanced topics in experimental condensed matter physics. Further, the students are encouraged to widen their research interests in these topics.

1. Symmetry in crystals (7)

Concepts of point group; Point groups and Bravais lattices; Crystal symmetry - space groups; Symmetry and degeneracy - crystal field splitting; Kramer's degeneracy; Quasicrystals: general idea, approximate translational and rotational symmetry of two-dimensional Penrose tiling, Frank-Casper phase in metallic glass.

2. Lattice dynamics (12)

Classical theory of lattice vibrations in 3-dimensions under harmonic approximation; Dispersion relation: accoustical and optical, transverse and longitudinal modes; Lattice vibrations in a monatomic simple cubic lattice; Frequency distribution function; Normal coordinates and phonons; Occupation number representation of the lattice Hamiltonian; Thermodynamics of phonons; The long wavelength limits of the acoustical and optical branches; Neutron diffraction by lattice vibrations; Debye-Waller factor; Atomic displacement and melting point; Phonon- phonon interaction - interaction Hamiltonian in occupation number representation; Thermal conductivity in insulators.

3. Density Functional Theory (8)

Basics of DFT, Comparison with conventional wave function approach, Hohenberg-Kohn Theorem; Kohn-Sham Equation; Thomas-Fermi approximation and beyond; Practical DFT in a many body calculation and its reliability.

4. Electronic properties - I (8)

The Boltzmann transport equation and relaxation time; Electrical conductivity of metals- impurity scattering, ideal resistance at high and low temperatures, U-processes; Thermo-electric effects; Thermal conductivity; The Wiedemann-Franz law.

5. Electronic properties-II (8)

Electronic properties in a magnetic field; Classical theory of magneto-resistance; Hall effect and magneto-resistance in two-band model; K-space analysis of electron motion in a uniform magnetic field; Idea of closed, open and extended orbits, cyclotron resonance; Azbel-Kaner resonance; Energy levels and density of states in a magnetic field; Landau diamagnetism; de Haas-van Alphen effect; Quantum Hall effect.

6. Optical properties of solids (7)

The dielectric function: the dielectric function for a harmonic oscillator, dielctric losses of electrons, Kramers-Kronig relations; Interaction of phonons and electrons with photons; Interband transition - direct and indirect transition; Absorption in insulators; Polaritons; One-phonon absorption; Optical properties of metals, skin effect and anomalous skin effect.

PAPER CODE: MPHY4CC18STHAP, COURSE NAME: Elective Paper (Astrophysics)

COURSE OUTCOME:

- In this course, **s**tudents will demonstrate a basic understanding of various aspects of observational astronomy through historical perspective of the development of Astronomy and conceptual understanding of basic principles involved.
- Understanding of handling astronomical instruments, collecting data and interpreted to obtain physical properties of a variety of astronomical objects using different methods.
- Understanding of evolution of stars and its spectral classification. A flavour of current developments in this field and India's role in them.
- **GTR: In this course, s**tudents will also extend their understanding in GTR. Learning of physical and mathematical basis of Einstein's relativistic theory of gravitation. The training in tensor analysis and tensor calculus will help to understand the formalism of general relativity (GR) and develop the ability to obtain an exact Scwarzschild solution. Application of general relativity to relativistic stars, cosmology and gravitational waves.

1. Basic Background and Instrumentation (6)
Elementary radiative transfer equations, absorption and emission, atomic processes, continuum and line emission; Optical and radio telescopes, Fourier transform methods, detectors and image processing; Distance measurements in astronomy, Hubbles law; Modern observational techniques (qualitative discussion only).

2. Spectral Classification of Stars (3)
Saha's equation; Harvard system, luminosity effect; Absolute and apparent luminosity; Mass luminosity relation, spectroscopic parallax.

3. Evolution of Stars (14)
Observational basis, protostars, disks, bipolar outflows, hydrostatic equilibrium; Sources of stellar energy: gravitational collapse, fusion reactions (p-p chain, CNO cycle, triple α reactions); formation of heavy elements; Hertzsprung-Russell diagram, evolution of low-mass and high-mass stars; Chandrasekhar limit; Pulsars, neutron stars, and black holes.

4. Elements of General Relativity (12)
Curved space-time; Eotvos experiment and the equivalence principle; Equation of geodesic; Christoffel symbols; Schwarzschild geometry and black holes; FRW geometry and the expanding universe; Riemann curvature; Einstein equations.

5. Binary Stars (3)
Different types of binary stars; Importance of binary systems; Accretion; Gravitational radiation.

6. Cosmic Astrophysics (12)
Important models of the universe; Red shift and expansion; Big bang theory; Early universe and decoupling; Neutrino temperature, nucleo-synthesis, relative abundances of hydrogen, helium, deuterium; Radiation and matter-dominated phases; Cosmic microwave background radiation, its isotropy and anisotropy properties; COBE and WMAP experiments; CMBR anisotropy as a hint to large scale structure formation.

PAPER CODE: MPHY4CC18STHMS, COURSE NAME: Elective Paper (Material Science)

COURSE OUTCOME:

- Identify the properties of metals with respect to crystal structure and grain size.
- Understand the conducting, semiconducting, superconducting, dielectric, ferro-eleletric and piezoelectric behavior of materials.
- Synthesis and processing of semi-conducting materials and different characterization technique for engineering applications.
- The different electrical, optical, mechanical, diaelectric and ferroelecric properties and their application towards devices like LED, Solar cell, sensors etc.
- The background on Nanoscience and broad outline of Nanomaterial for Nanoscience and Nanotechnology applications.
- Apply their learned knowledge to develop small scale devices .

1. Overview of materials (5)
Introduction:
Introduction to crystalline and amorphous materials, Density of state of different low dimensional structures, Defects in crystal
Crystalline materials:
Optoelectronics materials, Solar energy materials, ceramics, classification according to bonding — Pauling and Philips theories.
Amorphous materials:
Glass, polymer, liquid crystals,

2. Synthesis and preparation of materials (7)
Bulk crystal growth:
Single crystal growth, zone refining, doping techniques of elemental and compound semiconductors,
Thin film and nanostructure growth:
Fabrication and control of thin films, PLD, CVD, MBE, LPE processes, mechanical and chemical methods.

3. Characterization of materials (15)
Defects and microstructures:
X-ray diffraction — structure determination from XRD data; Neutron diffraction and analysis;
Thermal methods:
DTA, TGA, DSC and analysis
Electron Microscopy:
TEM, SEM;
Optical spectroscopy:
UV-Vis and IR spectroscopy, Raman spectroscopy; Photoluminescence and electroluminescence
Nuclear techniques:
NMR, ESR, Mössbauer and Positron annihilation. Radiation damage.

4. Properties of materials (23)
Electrical Properties (4)
Conception of superconductors and novel materials (graphene and CNT), Effects of low dimension in electric properties, Type of heterostructures and quantum confinement, Quantum electronic devices – Tunnel diode, SET etc.

Magnetic Properties (4)
Magnetocaloric materials and spin glasses. Magnetic properties of nanostructures and thin film.; GMR, TMR and CMR and magnetic memory devices
Dielectric and ferroelectric properties (5)
Structural phase transitions, Ferroelectric crystals, Classification of ferroelectric materials: piezo-pyro and anti-ferroelectric materials, multiferroic materials, relaxor materials. Multiferroic materials and composites, effects of nanostructures
Optical Properties (5)
Interaction of light with electrons in solids; absorption, colour, refraction, polarization, optical process, semiconducting devices like photodiode, solar cell, LED and semiconductor Lasers. Nano-photonic devices.
Mechanical properties (5)
Introduction, elastic, anelastic and viscoelastic behaviour, stress-strain relationship, plastic deformation, Creep, fatigue, elasticity, plasticity, superplasticity, viscoelasticity and creep of metals, Effect of nanostructures in mechanical properties, MEMS applications.

"This is an entirely new course added vide the BOS meeting dated 17.08.2019".

PAPER CODE: MPHY4CC19SPR, COURSE NAME: Practical (Advanced Experiments – II)

COURSE OUTCOME:

- Towards the end of these laboratory courses, every student is expected to understand the basic concepts of physics through experiments, which would immensely help them to be prepared for various competitive exam questions.
- Hands on experience of Hall Effect at elevated temperature which is an important diagnostic tool for the characterization of materials – particularly semi-conductors. It provides a direct determination of both the sign of the charge carriers, *e.g.* electron or holes, and their density in a given sample.
- Hands on experience to find out the dielectric constant of a dielectric material which can be defined as the ratio of the capacitance using that material as the dielectric in a capacitor to the capacitance using a vacuum as the dielectric. Also, the experience of finding out the Transition or Curie Temperature (T_c) for a ferroelectric material. For temperature $T > T_C$ the crystal does not exhibit ferroelectricity, while for $T < T_C$ it is ferroelectric. Decreasing the temperature through T_c, a ferroelectric crystal has a phase transition from a non-ferroelectric (paraelectric) phase to a ferroelectric phase.
- In this experiment students will experience and study the characteristics of a P-N junction diode at elevated temperatures. The conventional characterization of a diode involves varying the voltage across it and measuring the current flowing through it under the generally incorrect assumption that the temperature remains constant throughout. This experiment is important if the diode is to be used in an accurate temperature sensing application.
- In this experiment, the students will analysed and determine the lattice constant for the diffracting crystal from the diffraction patterns of x-rays of known wavelengths will be analysed to determine.

Name of the experiments:

1. **Study of Hall Effect at elevated temperatures**
2. **Study of Dielectric constant and determination of Curie temperature**
3. **Study of P-N junction at elevated temperatures**

4. **X-ray diffraction :** Debye-Scherrer and Laue photographs.

"Highlighted portion has been revised vide the BOS meeting dated 17.08.2019".

PAPER CODE: MPHY4CC20SPR, COURSE NAME: Project

COURSE OUTCOME:

- This is an excellent opportunity for the students to enter in the world of research. They will have experience working with different institute and laboratories.
- A flavor of current developments in the respective fields and countries role in them. This experience would provide a base for researcher in various field and future direction of research.
- Also, this would open up several opportunities in industries for the students.

Text & Reference Books:

Mathematical Methods

1. G. Arfken: Mathematical Methods for Physicists
2. J. Mathews and R.L. Walker : Mathematical Methods of Physics
3. P.K. Chattopadhyay: Mathematical Physics
4. R.V. Churchill and J.W. Brown: Complex variables and Applications
5. M.R. Spiegel: Theory and Problems of Complex Variables
6. W.W. Bell: Special Functions for Scientists and Engineers
7. A.W. Joshi: Matrices and Tensors in Physics
8. A.W. Joshi: Elements of Group Theory for Physicists
9. M. Tinkham: Group Theory and Quantum Mechanics

Classical and Relativistic Mechanics

1. H. Goldstein: Classical Mechanics
2. K.C. Gupta: Classical Mechanics of Particles and Rigid Bodies
3. S.N. Biswas: Classical Mechanics
4. N.C. Rana and P.S. Joag: Classical Mechanics
5. A.P. French: Special Relativity

Quantum Mechanics I

1. S. Gasiorowicz : Quantum Physics
2. P.M. Mathews and K. Venkatesan: A Text Book of Quantum Mechanics
3. E. Merzbacher: Quantum Mechanics
4. J.J. Sakurai : Modern Quantum Mechanics

Classical Electrodynamics

1. J.D. Jackson: Classical Electrodynamics
2. W.K.H. Panofsky and M. Phillips: Classical Electricity and Magnetism
3. J.R.Reitz, F.J. Milford and R.W. Christy: Foundations of Electromagnetic theory
4. D.J. Griffiths: Introduction to Electrodynamics
5. L.D. Landau and E.M. Lifshitz: (i) Electrodynamics of Continuous Media (ii) Classical theory
6. C.A. Brau, Modern Problems in Classical Electrodynamics
7. J.A. Bittencourt, Fundamentals of Plasma Physics

Quantum Mechanics II

1. L.I. Schiff: Quantum Mechanics
2. J.J. Sakurai: Modern Quantum Mechanics
3. P.M. Mathews and K. Venkatesan: A Text Book of Quantum Mechanics
4. E. Merzbacher: Quantum Mechanics
5. Messiah: Quantum Mechanics, Vol. II
7. F. Halzen and A.D. Martin: Quarks and Leptons
8. W. Greiner: Relativistic Quantum Mechanics
9. A. Lahiri and P.B. Pal: A First Book of Quantum Field Theory

Electronics and Instrumentation

1. J.D. Ryder: Network, Lines and Fields
2. J. Millman and C. Halkias: Integrated Electronics
3. J.D. Ryder: Electronic Fundamental and Applications
4. J. Kennedy: Electronic Communication Systems
5. J. Millman and A. Grabel: Microelectronics
6. B.G. Streetman, S. Banerjee: Solid State Electronic Devices
7. G.F. Knoll: Radiation, Detection and Measurement
8. Sedra and Smith: Microelectronic Devices
9. Taub and Schilling: Digital Integrated Electronics
10. S.Y. Liao: Microwave Devices and Circuits
11. P. Bhattacharyya: Semiconductor Optoelectronic Devices
12. S.M. Sze: Physics of Semiconductor Devices
13. Boylestad and Nashelski: Electronic Devices and Circuit Theory

Computer Practical

1. V. Rajaraman: Computer Programming in Fortran IV
2. V. Rajaraman: Computer Oriented Numerical Methods
3. J.M. McCulloch and M.G. Salvadori: Numerical Methods in Fortran

Atomic, Molecular and Laser Physics

1. B.H. Bransden and C.J. Joachain: Physics of Atoms and Molecules
2. C. Cohen-Tannoudji, B. Dier, and F. Laloe: Quantum Mechanics vol. 1 and 2
3. R. Shankar: Principles of Quantum Mechanics
4. C.B. Banwell: Fundamentals of Molecular Spectroscopy
5. G.M. Barrow: Molecular Spectroscopy
6. K. Thyagarajan and A.K. Ghatak: Lasers, Theory and Applications
7. O. Svelto: Principles of Lasers
8. B.H. Eyring, J. Walter and G.E. Kimball: Quantum Chemistry
9. W. Demtroder: Molecular Physics
10. H. Herzberg: Spectra of Diatomic Molecules
11. J.D. Graybeal: Molecular Spectroscopy
12. M.C. Gupta: Atomic and Molecular Spectroscopy
13. B.B. Laud: Lasers and Non-linear Optics
14. A. Thorne, U. Litzen and J. Johnson: Spectrophysics

Statistical Mechanics

1. F. Reif: Fundamentals of Statistical and Thermal Physics
2. R.K. Pathria: Statistical Mechanics
3. K. Huang: Statistical Mechanics
4. F. Mandl: Statistical Physics
5. H.B. Callen: Thermodynamics and an Introduction to Thermostatics

Nuclear and Particle Physics

1. M.A. Preston: Physics of the Nucleus
2. M.K. Pal: Theory of Nuclear Structure
3. R.R. Roy and B.P. Nigam: Nuclear Physics
4. S.N. Ghoshal: Atomic and Nuclear Physics (Vol. 2)
5. D.H. Perkins: Introduction to High Energy Physics
6. D.J. Griffiths: Introduction to Elementary Particles

Condensed Matter Physics

1. N.W. Ashcroft and N.D. Mermin: Solid State Physics
2. J.R. Christman: Fundamentals of Solid State Physics
3. A.J. Dekker: Solid State Physics
4. C. Kittel: Introduction to Solid State Physics
5. H. Ibach and H. Luth: Solid State Physics: An Introduction to Theory and Experiment
6. J.P. Srivastava: Elements of Solid State Physics
7. J.P. McKelvey: Solid State and Semiconductor Physics

Advanced Condensed Matter Physics I

1. D. Pines: Elementary Excitations in Solids
2. S. Raimes: Many Electron Theory
3. O. Madelung: Introduction to Solid State Theory
4. N.H. March and M. Parrinello: Collective Effects in Solids and Liquids
5. H. Ibach and H. Luth: Solid State Physics: An Introduction to Theory and Experiments
6. J.M. Ziman: Principles of the Theory of Solids
7. C. Kittel: Quantum Theory of Solids

Advanced Condensed Matter Physics II

1. M. Tinkham: Group Theory and Quantum Mechanics
2. M. Sachs: Solid State Theory
3. A.O.E. Animalu: Intermediate Quantum Theory of Crystalline Solids
4. N.W. Ashcroft and N.D. Mermin: Solid State Physics
5. J.M. Ziman: Principles of the Theory of Solids
6. C. Kittel: Introduction to Solid State Physics

Astrophysics (Elective Paper)

1. T. Padmanabhan: Theoretical Astrophysics, vols. 1-3
2. S. Weinberg: Gravitation and Cosmology
3. M. Rowan-Robinson: Cosmology
4. E.W. Kolb and M.S. Turner: The Early Universe
5. J.V. Narlikar: Introduction to Cosmology
6. T.T. Arny: Explorations, An Introduction to Astronomy
7. M. Zeilik and E.V.P. Smith: Introductory Astronomy and Astrophysics
8. D. Clayton: Introduction to Stellar Evolution and Nucleo-synthesis

Material Science (Elective Paper)

1. Raghavan V, Materials Science and Engineering, 4th Edition, Prentice Hall of India, 1998.
2. Pradeep fuley, Electrical, magnetic, and Optical Materials, 1st edition, CRC press, 2010
3. Kittel C, Introduction to Solid State Physics, 6th Edition, Wiley Eastern, New International Publishers, 1997.
4. Dekker A.J, Solid State Physics, MacMillan India, 1995
5. Pollok Deniel D, Physical Properties of Materials For Engineers, CRC Press Volume 3
6. William D. Callister, Jr., David G. Rethwisch, Fundamentals of Materials Science and Engineering: An Integrated Approach, John Wiley & Sons,2012