JECRC™ UNIVERSITY

BUILD YOUR WORLD

School of Pure and Applied Sciences

Course Structure and Syllabi

M. Sc. (Physics)

Academic Programmes: 2021-2023

Credit Scheme (Category wise)						
Course(s)	Foundation	Core	Specialized	Interdisciplinary	General	Total Credits
Credits	22	28	44	-	-	94

Credit Scheme (Semester wise)					
Semester	First	Second	Third	Fourth	Total Credits
Credits	22	22	22	28	94

(Prof. Y. K. Vijay)

(Dr. Chandan Joshi)

(Dr. Nishant Gaur)
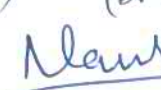
(Dr. Abhishek Sharma)

Course Structure: M. Sc. Physics

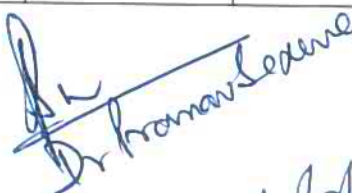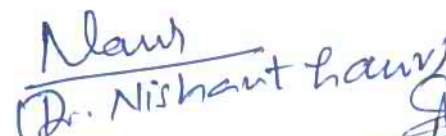| SEMESTER – I				Category
Code	Title of Course	Contact Hours	Credits	
MPH001B	Classical Mechanics	3L-1T	4	F
MPH002B	Quantum Mechanics-I	3L-1T	4	F
MPH003B	Classical Electrodynamics-I	3L-1T	4	F
MPH004B	Mathematical Physics	3L-1T	4	F
MPH005B	Classic Experiments in Physics (Ten Great Experiments)	18 Hours	6	F
	Total Credits		22	
SEMESTER – II				
MPH006B	Statistical Mechanics	3L-1T	4	C
MPH007B	Quantum Mechanics-II	3L-1T	4	C
MPH008B	Electrodynamics-II	3L-1T	4	C
MPH009B	Computational Physics	3L-1T	4	S
MPH010B	Advanced Physics Lab	18 Hours	6	S
	Total Credits		22	
SEMESTER – III				
MPH011B	Nuclear Physics	3L-1T	4	C
MPH012B	Quantum Mechanics-III (Relativistic Quantum Mechanics)	3L-1T	4	C
MPH013B	Advanced Solid State Physics	3L-1T	4	C
MPH014B	Solar Energy: Alternative Sources of Energy	3L-1T	4	S
MPH015B	Nuclear Physics Lab	18 Hours	6	S
	Total Credits		22	
SEMESTER – IV				
MPH016B	Quantum Field Theory	3L-1T	4	S
MPH017B	Instrumentation Techniques			
	Elective-1	3L-1T	4	S
	Elective-2	3L-1T	4	S
MPH031B	Project Work at any University/ Academic Inst./ Research Lab		12	S
MPH032B	Seminar (Presentation of Project Work)		4	C
	Total Credits		28	
	Total Credits of All Four Semesters		94	
A student has to opt one of the two papers *viz.*, MPH0160A or MPH0170A.				
Student has to opt a pair of elective papers from one of the groups in the prescribed list.				

(Prof. Y. K. Vijay)

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(Dr. Chandan Joshi)
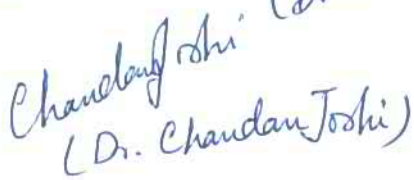
Naus
(Dr. Nishant Gaur)

(Dr Abhishek Sharma)

Dr Pranav Seni

LIST OF ELECTIVE COURSES OFFERED IN IV SEMESTER

Group	Course Code	Course/Paper
Group-1	MPH018B	General Theory of Relativity and Cosmology
	MPH019B	Astrophysics
Group-2	MPH020B	Ionospheric Physics
	MPH021B	Atmospheric Physics and Weather Science
Group-3	MPH022B	Particle Physics-I
	MPH023B	Particle Physics-II
Group-4	MPH024B	Condensed Matter Physics-I
	MPH025B	Condensed Matter Physics-II
Group-5	MPH026B	Digital Electronics
	MPH027B	Microwave Electronics

Dr Pranav Saxena

(Dr. Nishant Laur)

Chandan Joshi (Dr. Chandan Joshi)

(Dr Abhishek Sharma)

(Prof. Y. K. Vijay)

M. Sc. Physics

Objectives

Physics being one of the oldest academic disciplines is fundamental and foremost to all natural sciences. It has been influential through advances in its understanding that have translated into new technologies. The story of physics is also about people who thought out of the box. The progress of science, and Physics in particular is rooted in addressing fundamental questions about the Nature and to test the validity of a hypothesis or a physical theory, using a methodical approach to compare the implications of the theory in question with the associated conclusions drawn from experiments and observations conducted to test it.

The M.Sc. Physics course is aimed at imparting a rigorous study program at post graduate level covering both depth and breadth of all relevant areas. The course structure is designed with a due emphasis on wider conceptual base, including experiments and modern computational techniques. The three courses on Quantum Mechanics and one on Quantum Field Theory assure us of comprehensive and futuristic education that can pave way for Upcoming and Cutting Edge Technologies that mushroom from the laboratories of Physics and transform the society of tomorrow. The program aims to train future generations of physicists with specialization in one of the frontier areas of research, e.g. in Astrophysics and Cosmology/ Atomic and Nuclear Physics/ Atmospheric Physics and Weather Science/ Quantum Information Sciences/ Energy Studies etc.
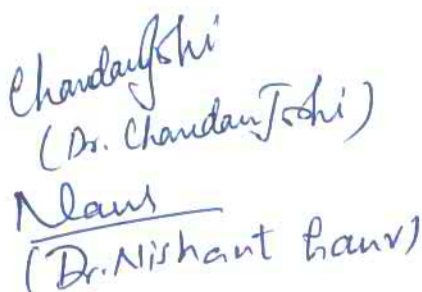
The M.Sc. Physics is a (post) graduate Four Semester Course spanning over two years duration.

- Semester Exchange and Project Work: Students of M.Sc. Physics Course will have **a choice of studying one semester (Fourth Semester) at University of Alabama Systems, USA** (which has three campuses namely: UA Birmingham, UA Huntsville, and UA Tusculussa). **It is pertinent to mention that JECRC University has an academic collaboration with the University of Alabama Systems, USA.**

** Alternatively, a student can visit University of Alabama for his/her Project Work as well.

(Prof. Y. K. Vijay)

Chandan Joshi
(Dr. Chandan Joshi)

(Dr. Nishant Chauri)

(Dr. Abhishek Sharma)

Dr. Kromav Saxena

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

I. Graduates will demonstrate proficiency in critical thinking and analysis as they relate to physics problems in core theoretical areas of mechanics, electromagnetism, quantum mechanics, and statistical mechanics.

II. Graduates will demonstrate familiarity with the major fields of modern physics research.

III. Graduates will demonstrate capability for conducting independent research.

PROGRAM OUTCOMES (PO's)

A postgraduate of the M.Sc. (Physics) Program will demonstrate:

I. **Critical Thinking:** Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives.

II. **Effective Communication:** Speak, read, write and listen clearly in person and through electronic media in English and in one Indian language, and make meaning of the world by connecting people, ideas, books, media and technology.

III. **Social Interaction:** Elicit views of others, mediate disagreements and help reach conclusions in group settings.

IV. **Effective Citizenship:** Demonstrate empathetic social concern and equity centred national development, and the ability to act with an informed awareness of issues and participate in civic life through volunteering.

V. **Ethics:** Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them.

VI. **Environment and Sustainability:** Understand the issues of environmental contexts and sustainable development.

VII. **Self-directed and Life-long Learning:** Acquire the ability to engage in independent and life-long learning in the broadest context sociotechnological changes.
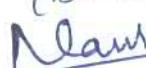
PROGRAM SPECIFIC OUTCOMES (PSOs):

PSO-1: The course structure is designed with a due emphasis on wider conceptual base, including experiments and modern computational techniques.

PSO-2. With the importance of "Energy Crisis" in the world, a course on "Energy Studies and Non-Conventional Energy Sources" has been prescribed in the syllabus of M.Sc. III Semester to update the students with problems, challenges and the possible solutions of the energy crisis.

PSO-3. The program aims to train future generations of physicists with specialization in one of the frontier areas of research, e.g. in Astrophysics and Cosmology/ Atomic and Nuclear Physics/ Atmospheric Physics and Weather Science/ Quantum Information Sciences/ Energy Studies etc.

(Prof. Y.K.Vijay)

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(Dr. Chandan Joshi)

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(Dr. Nishant Gaur)

(Dr. Abhishek Sharma

Dr. Pawan Sedwa

CLASSICAL MECHANICS

Code:MPH001B   **Credit(s):4**

Unit-I

Lagrangiaan and Hamiltonian Dynamics: Constraints, holonomic and non-holonomic constraints, D'Alembert's Principle and Lagrange's Equation, velocity dependent potentials, simple applications of Lagrangian formulation. Hamilton Principle, Calculus of Variations, Derivation of Lagrange's equation from Hamilton's principle. Extension of Hamilton's Principle for nonconservative and nonholonomic systems, Method of Lagrange's multipliers, Conservation theorems and Symmetry Properties, Noether's theorem. Conservation of energy, linear momentum and angular momentum as a consequence of homogeneity of time and space and isotropy of space.

Unit-II

Generalized momentum, Legendre transformation and the Hamilton's Equations of Motion, simple applications of Hamiltonian formulation, cyclic coordinates, Routh's procedure, Hamiltonian Formulation of Relativistic Mechanics, Derivation of Hamilton's canonical Equation from Hamilton's variational principle. The principle of least action.

Unit-III

Inertia Tensor: Inertial tensor. Moment and Product of Inertia. Rotational Dynamics. Pseudo forces. Coriolis forces. Similarity transformations.

Unit-IV

Canonical transformation, integral invariant of Poincare: Lagrange's and Poisson brackets as canonical invariants, equation of motion in Poisson bracket formulation. Infinitesimal contact transformation and generators of symmetry, Liouvilee's theorem, Hamilton-Jacobi equation and its application.

Unit-V

Action angle variable adiabatic invariance of action variable: The Kepler problem in action angle variables, theory of small oscillation in Lagrangian formulation, normal coordinates and its applications. Orthogonal transformation, Euler's theorem, Eigenvalues of the inertia tensor, Euler equations, force free motion of a rigid body.
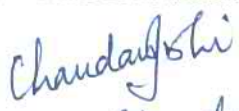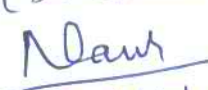
Suggested Books

1. Herbert Goldstein, C. Poole, John Safko: Classical Mechanics, Pearson.
2. L. D. Landau and E.M. Lifshitz: Mechanics, Butterworth-Heinemann.
3. A. Raychoudhary: Classical Mechanics, Oxford University Press
4. N. C. Rana and P. S. Joag: Classical Mechanics, Tata McGraw Hill.
5. Ronald L. Greene: Classical Mechanics with Maple, Springer

Course Outcomes: After completion this course, students shall -

CO-1 be able to apply Newton's laws using various mathematical formulations to describe the motion of microscopic objects

CO-2 Be able to solve the Newton equations using generalized coordinates.

CO-3 Be enable to understand the dynamics of rotational objects, inertial tensors and coroilis forces of objects.

CO-4 be able understand the different formalism and theorem to describe the motion of microscopic objects.

CO-5 Understand the foundations of force free motion of rigid body

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1		H			L			L		
CO2				L			M			H
CO3	M								M	
CO4					H				H	
CO5		L	M			H		M		

H = Highly Related; M = Medium L = Low

QUANTUM MECHANICS- I

Code: MPH002B   **Credit(s):4**

Unit-I

Linear spaces and Operators: Vector spaces, Linear independence, Bases, dimensionality and Isomorphisms. Linear transformations, inverses, matrices, similarity transformations, Eigenvalues and Eigenvectors. Inner product, orthogonality and completeness, complete orthogonal set, Gramm-Schmidt orthogonalization procedure, Eigenvalues and Eigenvectors of Hermitian and Unitary transformations, diagonalization. Function space and Hilbert space. Complete orthonormal sets of functions.

Unit-II

Structure of Quantum mechanics: Postulates of QM, Hilbert space; Hermitian and unitary operators; Orthonormality, completeness andclosure. Dirac's bra and ket notations. Matrix Representation and change of basis. Operators and observables, significance of eigenvector and eigenvalues, Commutation relation; Uncertianity principle for arbitrary Operators.

Unit-III

Quantum Linear Harmonic Oscillator: Creation and annihilation operators. Occupation number. Quantization of creation and annilation operators. Number operator. Coherent states and time-evolution of coherent states.

Unit-IV

Angular Momentum-I: Orbital angular momentum and Quantum Mechanics of rotations. Orbital angular momentum operators and their properties. Theory of Hydrogen-like atoms. Quantum Mechanics of rotations. Infinitesimal rotations. Euler angles. Three-dimensional oscillators. Rotation-vibration spectra of diatomic molecules.

Unit-V

Angular Momentum-II: Total angular momentum. Angular momentum operators: $\hat{J}_x, \hat{J}_y, \hat{J}_z, \hat{J}, \hat{J}^2$ and $\hat{J}_+$, and $\hat{J}_-$. Angular momentum eigen-values. Angular momentum matrices corresponding to spin half particles: Pauli's spinors and their properties. Spin angular momentum. Stern-Gerlack experiment. Larmour's precession.

(Prof. Y.K. Vijay)   (Dr. Chandan Joshi)   (Dr. Abhishek Sharma)

(Dr. Nishant Gaur)

Total angular momentum ans spin-orbit ($L-S$) coupling. Addition of angular momentum. Clebsch-Gordon coefficients. Selection rules.

Suggested Books
1. Ashok Das and A.C. Melissions: Quantum Mechanics- A Modern Approach, Gordon and Breach Science Publishers.
2. Albert Messiah: Quantum Mechanics, Dover Publications
3. L. I. Schiff: Quantum Mechanics, Mc-Graw Hill.
4. Claude Cohen-Tannoudji, Bernard Diu, Frank Laloe: Quantum Mechanics, Wiley.
5. J. J. Sakurai: Modern Quantum Mechanics, Pearson Education.
6. E. Merzbecher: Quantum Mechanics, John Wiley.

CO-1: Understand the fundamentals of Quantum Mechanics specifically the 'Operator Mechanism in Quantum Mechanics'.
CO-2: Understand the 'Premise and Postulates of Quantum Mechanics'and make them understand Dirac's 'Bra and Ket representation'.
CO-3: Understand the theory of 'Quantum Linear Harmonic Oscillator' and 'The Idea of Creation and Annihilation Operators'.
CO-4: Understand- 'Theory of Angular Momentum in Quantum Mechanics' and apply it to 'Hydrogen-like Atom' and 'Spectroscopic Techniques'.
CO-5: Understand and apply the mathematical techniques of 'Total Angular Momentum' including 'selection rules' and 'Chlebsch-Gordon Coefficients'.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1			H			L			L	
CO2		L			L			M		
CO3	M									M
CO4					H					H
CO5			L	M			H		M	

H = Highly Related; M = Medium L = Low

CLASSICAL ELECTRODYNAMICS – I

Code:MPH003B   **Credit(s):4**

Unit-I
Electromotive force: Ohm's law. Electromotive force. Motional EMF
Faraday's law: Electromagnetic induction. Inductance. Energy in Magnetic fields
Unit-II
Maxwell's equations: Maxwell equations for Electromagnetic fields in matter and vacuum (by conventional methods). Electro-magnetic waves. Boundary conditions

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(Dr. Chandan Joshi)
Naur
(Dr. Nishant Gaur)   Dr.Praman Singh   Dr.Abhishek Sharma

Potential formulation: Four potentials: Divergence-less and curl-less quantities. Gauge transformations. Coulomb's gauge and Lorentz' force. Lorentz' force in potential forms

Unit-III

Electromagnetism (Without Matter and Medium)

Relativistic electrodynamics using potential formulation: Field tensor and Electrodynamics in tensor notations. *Maxwell's equations in potential formulation*. Relativistic transformations of electro-magnetic fields

Unit-IV

Dipole radiations: Retarded potentials. Electric dipole radiations. Magnetic dipole radiations. Radiation from an arbitrary distribution of charges

Radiation from a point charge: Lienard-Wiechert potentials. The fields of a point charge in motion. Power radiated by a point charge

Unit-V

Radiation reaction: The Abraham-Lorentz' formula. The physical origin of the radiation reaction.

Special radiative processes: Bremstrahlung. Synchrotron radiations. Cerenkov radiations.

Suggested Books
1. L. D. Landau & Lifshitz: Classical Theory of Electrodynamics; Pergamon Press.
2. L. D. Landau & Lifshitz: Electrodynamics of continuous media; Pergamon Press.
3. J. D. Jacksson: Classical Electro-dynamics; John Wiley.
4. David J. Griffiths: Introduction to Electro-dynamics; Prentice Hall.
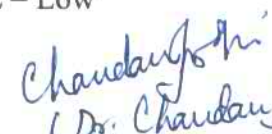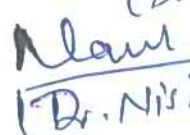5. Panofsky & Phillip: Classical electrodynamics and magnetism

Course Outcomes:

CO1: Explain classical electrodynamics based on Maxwell's equations including its formulation in covariant form.

CO2: Solve the electromagnetic problems with the help of electrodynamic potentials and superpotentials, and make a detailed account for gauge transformations and their use

CO3: Formulate and solve electrodynamic problems in relativistically covariant form in four-dimensional spacetime.

CO4: Calculate the electromagnetic radiation from localised charges which move arbitrarily in time and space, taking into account retardation effects.

CO5: Calculate the electromagnetic radiation from radiating systems, like oscillating electric and magnetic dipoles (aerials, localised charge and current distributions)

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	H				M		L	H		
CO2		H	H			M			L	
CO3		M		L	H			M		
CO4		H	M		L				M	
CO5		H	L			M			M	

H = Highly Related; M = Medium L = Low

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Chandanjoshi
(Dr. Chandan Joshi)

(Dr. Nishant Kaur)

(Dr. Abhishek Shyr.

Dr. Pramon Sidane

MATHEMATICAL PHYSICS

Code: MPH004B   Credit(s):4

Unit-I

Special Mathematical Techniques: Dirac Delta Function. Green's Function. Gamma and Beta function. Sterling's formula.

Unit-II

Complex Variables: Functions of complex variable, Limits and continuity, differentiation, Analytical functions, Cauchy- Riemannn conditions, Cauchy Integral theorem, Cauchy integral formula, Derivatives of analytical functions, Liouville's theorem. Power series Taylor's theorem, Laurent's theorem. Calculus of residues –poles, essential singularities and branch points, residue theorem, Jordan's lemma, singularities on contours of integration, evaluation of definite integrals. Analytic continuation. Saddle Point Function.

Unit-III

Second Order Differential Equations and Special functions: Separation of variables-ordinary differential equations, singular points, series solutions leading to Legendre, Bessel, Hermite, Laguerre as solutions. Orthogonal properties and recurrence relations of these functions. Spherical harmonics and associated Legendre polynomials. Hermite polynomials. Sturm-Liouville systems and orthogonal polynomials. Wronskian-linear independence and linear dependence.

Unit-IV

Integral Transforms: Fourier Transforms: Development of the Fourier integral from the Fourier Series, Fourier and inverse Fourier transform: Simple Applications: Finite wave train, Wave train with Gaussian amplitude, Fourier transform of derivatives, solution of wave equation as an application. Convolution theorem. Intensity in terms of spectral density for quasi monochromic EM Waves, Momentum representation.
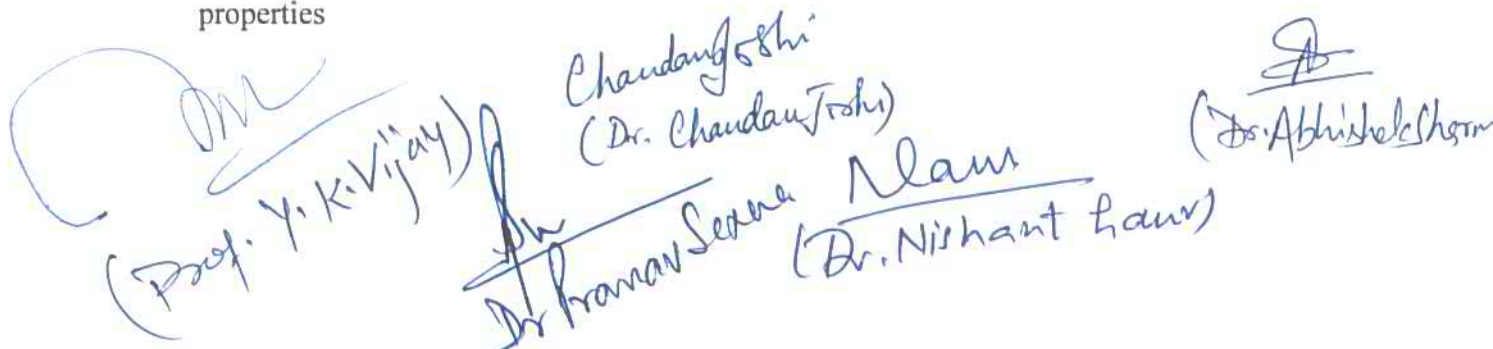
Unit-V

Applcations of integral transforms: Application of Fourier transform to diffraction theory: diffraction pattern of one and two slits. Laplace transforms and their properties, Laplace transform of derivatives and integrals, derivatives and integral of Laplace transform. Convolution theorem. Impulsive function, Application of Laplace transform in solving linear, differential equations with constant coefficient with variable coefficient and linear partial differential equation.

Suggested Readings

1. George Arfken: Mathematical Methods for Physicists, Academic Press.
2. L. A. Pipes: Applied Mathematics for Engineers & Physicists, McGraw Hill.
3. Merle C. Potter and Jack Goldberg: Mathematical Methods, PHI.
4. Fredrick W. Byron and Robert W. Fuller: Mathematics of Classical and Quantum Physics, Dover Publications.
5. Tulsi Dass and S.K. Sharma: Mathematical Methods in Classical and Quantum Physics, Orient Longman.

Course Outcomes:

CO-1: apply special mathematical function appropriately in solving problems in physics, understand the Dirac Delta and other distributions and be able to derive their various properties

CO-2: use Fourier transform to obtain the Fourier series of periodic functions in physics; and apply transform methods to solve elementary differential equations of interest in physics and engineering.

CO-3: be fluent in the use of Fourier and Laplace transformations to solve differential equations, apply techniques of complex variables, to the study of special functions of mathematical physics

CO-4: solve partial differential equations with appropriate initial or boundary conditions; and understand Group theory, special unitary groups

CO-5: have confidence in solving mathematical problems arising in physics by a variety of mathematical techniques

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1			H	H		L		H		
CO2			L			M		H		
CO3		H					H		L	
CO4					M					M
CO5		L			M		L		M	

H = Highly Related; M = Medium; L = Low

CLASSIC EXPERIMENTS IN PHYSICS

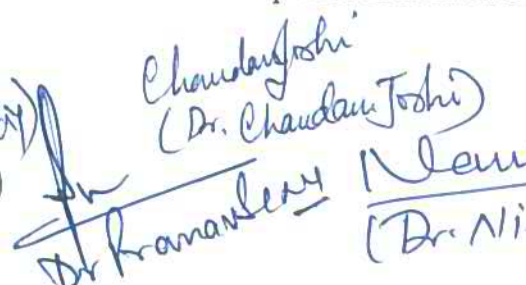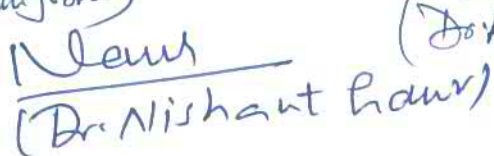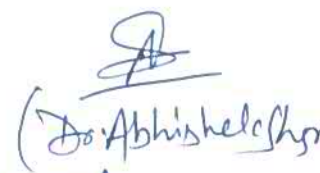Code:MPH005B   Credit(s): 6

(Ten Great Experiments in Physics)

Students have to perform any ten experiments
1. *Frank-Hertz'* experiment to determine Planck's constant.
2. *Millican's Oil Drop experiment* to determine e/m of electron.
3. *Thomson's experiment* to determine e/m of electron.
4. *Bragg's experiment* of diffraction of X-Ray.
5. *Compton Effect*: Study of Compton scattering of γ - rays.
6. *Faraday's experiment*: Electromagnetic Induction and Laws of Electrolysis.
7. *Joule's experiment*: Determination of mechanical equivalent of heat.
8. *Davisson Germer's* experiment:
9. *Stern-Gerlach experiment*: Study of spin of particles.
10. Michelson's Interferometer: Experiment of interference with Michelson's Interferometer.
11. *Hall effect*: To study *Hall effect* and determine *Hall coefficient*.
12. *Focualt's Pendulum*: Determination of time period of rotation of the Earth.
Suggested Readings

Morris H. Shamos: Great Experiments in Physics, Dover Publications Inc. (New York 1959).
Course Outcomes:
CO-1. How to determine the crystal structure, lattice parameter and crystallite size?
CO-2. Measurement and analysis of various laws of physics.
CO-3. Determination of time period of rotation of the Earth.
CO-4. Determine *Hall effect* and *Hall coefficient*.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1			L			M		H		
CO2		H					H		L	
CO3					M					M
CO4		L			M		L		M	

H = Highly Related; M = Medium; L = Low

SEMESTER-II
STATISTICAL MECHANICS

Code: MPH006B **Credit(s): 4**

Unit-I
Elementary Probability Theory: Preliminary concepts, Random walk problem, Binomial distribution, mean values, standard deviation, various moments, Gaussian distribution, Poisson distribution, mean values. Probability density, probability for continuous variables.
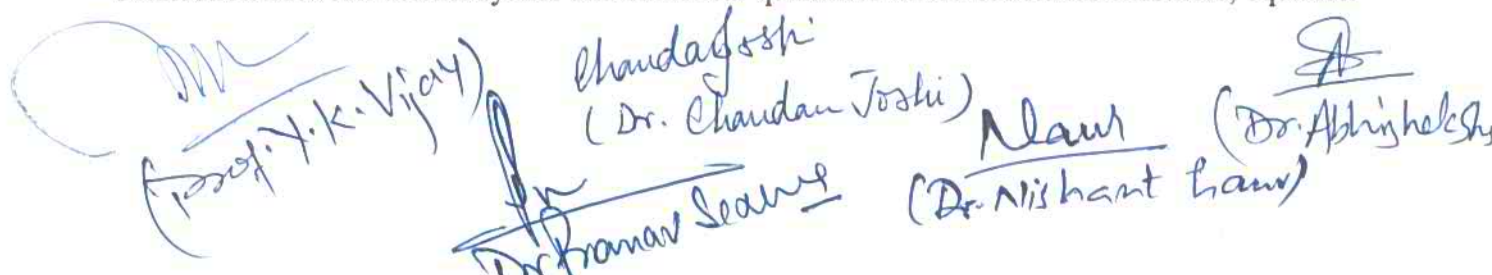**Extensive and Intensive Variables**: laws of thermodynamics, Legendre transformations and thermodynamic potentials, Maxwell relations, applications of thermodynamics to (a) ideal gas, (b) magnetic material, and (c) dielectric material. The laws of thermodynamics and their consequences.

Unit-II
Statistical Description of System of Particles: State of a system, microstates, ensemble, basic postulates, behavior of density of states, density of state for ideal gas in classical limit, thermal and mechanical interactions, quasi-static process. Statistical thermodynamics: Irreversibility and attainment of equilibrium, Reversible and irreversible processes. Thermal interaction between macroscopic systems, approach to thermal equilibrium, dependence of density of states on external parameters, Statistical calculation of thermodynamic variables.

Unit-III
Canonical and Grand Canonical Ensembles: Concept of statistical distribution, phase space, density of states, Liouville's theorem, systems and ensemble, entropy in statistical mechanics Connection between thermodyanic and statistical quantities micro canonical ensemble, equation

of state, specific heat and entropy of a perfect gas, using micro canonical ensemble. Canonical ensemble, thermodynamic functions for the canonical ensemble, calculation of mean values, energy fluctuation in a gas, grand Canonical ensemble, thermodynamic functions for the grand canonical ensemble, density fluctuations.

Unit-IV

Partition Functions and Statistics: Partition functions, Properties, partition function for an ideal gas & calculation of thermodynamic quantities, Gibbs Paradox, validity of classical approximation, translational, rotational & vibrational contributions to the partition function of an ideal diatomic gas. Specific heat of a diatomic gas, ortho & para Hydrogen. **Maxwell-Boltzmann Gas Velocity and Speed Distribution**: Chemical potential, Free energy and connection with thermodynamic variables, First and Second order phase transition; phase equilibrium.

Unit-V

Formulation of Quantum Statistics: Density Matrix, ensembles in quantum statistical mechanics, simple applications of density matrix. Theory of simple gases: Maxwell-Boltzmann, Bose-Einstein, Fermi-Dirac gases. Statistics of occupation numbers, Evaluation of partition functions, Ideal gases in the classical limit. **Ideal Bose System**: Thermodynamic behavior of an Ideal Bose gas, **Bose-Einstein condensation**. Thermodynamics of Black body radiation, Stefan-Boltzmann law, Wien's displacement law. Specific heat of solids (Einstein and Debye models).

Ideal Fermi System: Thermodynamic behavior of an ideal Fermi gas, degenerate Fermi gas, Fermi energy and mean energy, Fermi temperature, Fermi velocity of a particle of a degenerate gas. **Black Holes, White Dwarfs and Chandrashekhar Limit.**
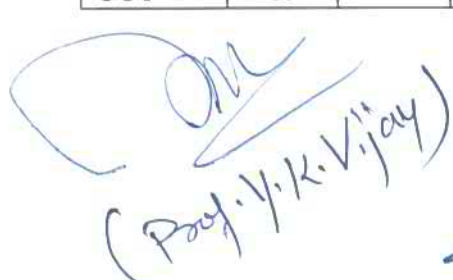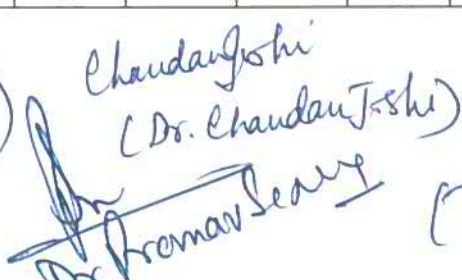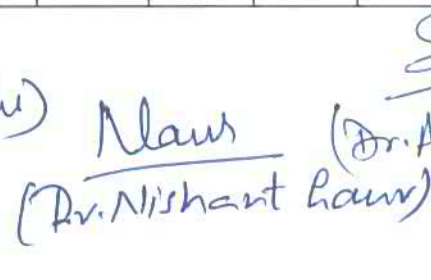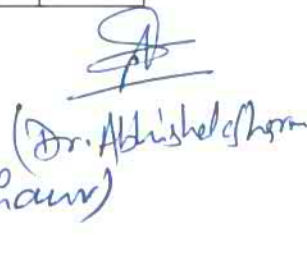
Suggested Books

1. F. Reif: Fundamentals of Statistical and Thermal Physics, McGraw Hill.
2. K. Huang: Statistical Mechanics, John Wiley & Sons.
3. L. D. Landau and E. M. Lifshitz: Statistical Physics, Butterworth-Heinemann.
4. Richard P. Feynman: Statistical Mechanics, West View Press.

Course Outcomes: Student shall be able to

CO1. define and discuss the concepts of microstate and macrostate of a model system

CO2. define and discuss the concepts and roles of entropy and free energy from the view point of statistical mechanics

CO3. define and discuss the Boltzmann distribution and the role of the partition function

CO4. apply the machinery of statistical mechanics to the calculation of macroscopic properties resulting from microscopic models of magnetic and crystalline systems

CO5. define the Fermi-Dirac and Bose-Einstein distributions; state where they are applicable; understand how they differ and show when they reduce to the Boltzmann distribution.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	H		M			H		H		

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(Dr. Nishant Gaur)

CO2		L			M			M		
CO3		L					H		L	
CO4			M							M
CO5	L			H		L			H	

H = Highly Related; M = Medium; L = Low

QUANTUM MECHANICS- II

Code: MPH007B   **Credit(s): 4**

Unit-I
Density Matrices: Basic definition and properties. Pure and Mixed states.
Quantum Entanglement and Quantum Teleportation (Introduction)
Quantum Computing: Basic Idea of Quantum Computation and Quantum Information Theory.

Unit-II
Approximation Methods
Time Independent Approximation Methods: Variational Methods, WKB method, tunneling.
Perturbation Theory: Non-degenerate perturbation theory, degenerate case, Stark effect, Zeeman effect and other examples.

Unit-III
Time-dependent Perturbation Theory: Interaction Picture;Constant and harmonic perturbations; Fermi Golden rule; Sudden and adiabatic approximations. Beta decay as an example.

Unit-IV
Scattering Theory: Differential cross-section, scattering of a wave packet, integral equation for the scattering amplitude, Born approximation, method of partial waves, low energy scattering and bound states, resonance scattering.

Unit-V
Symmetry in Quantum Mechanics: Symmetry Operations and Unitary Transformations, conservation principles, space and time translation, rotation, space inversion and time reversal, symmetry and degeneracy.
Identical Particles: Meaning of identity and consequences; Symmetric and anti-symmetric wavefunction; incorporation of spin, symmetric and antisymmetric spin wave function of two identical particles, Slater's determinant, Pauli exclusion principle.

Suggested Books
1. Claude Cohen-Tannoudji, Bernard Diu, Frank Laloe: Quantum Mechanics, Wiley.
2. Albert Messiah: Quantum Mechanics, Dover Publications.
3. S. Flugge: Quantum Mechanics, Springer.
4. L. I. Schiff: Quantum Mechanics, Mc-Graw Hill.
5. J. J. Sakurai: Modern Quantum Mechanics, Pearson Education.
6. E. Merzbecher: Quantum Mechanics, John Wiley.

Course Outcomes:
CO-1: Understand the idea of 'Quantum Computers', 'Quantum Entanglements', 'Quantum Information Theory' and train them with techniques of 'Density Matrices'.

CO-2: Understand various 'Time Independent Approximation Methods in Physics' such as 'WKB Approximation', 'Variational Method', and ''.

CO-3: Understand 'Time Dependent Perturbation Methods' including 'Fermi's Golden Rule of Quantum Mechanics'.

CO-4: Understand nitty-gritty of 'scattering theory'.

CO-5: Understand 'symmetries in Quantum Mechanics' and conservation of symmetries.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1			H			L			L	
CO2		L			L			M		
CO3	M									M
CO4						H				H
CO5			L	M			H		M	

H = Highly Related; M = Medium L = Low

CLASSICAL ELECTRODYNAMICS-II
(Classical Electrodynamics in Matter and Medium)

Code: MPH008B   **Credit(s): 4**

Unit-I
Special techniques for calculating potentials

Laplace's Equation: Laplace's equation in one dimension. Laplace's equation in two dimensions. Laplace's equation in three dimensions. Boundary conditions and Uniqueness theorems. Conductors and second uniqueness theorem

Unit-II
The Method of Images: The classic image problem. The induced surface charge. Other image problems

Multi-pole Expansion: Approximate potentials at large distances. The monopole and dipole terms. Origin of coordinates in multi-pole expansion. The electric field of an electric charge

Unit-III
Electro-magnetic waves in conducting and non-conducting media

Electro-magnetic waves in non-conducting media: Monochromatic plane waves in vacuum. Energy and momentum of electro-dynamic waves. Propagation through linear media. Reflection and transmission at normal and oblique incidence

Unit-IV
Electromagnetic Waves in Conductors: The modified wave equation. Monochromatic plane waves in conducting media. Reflection and transmission at conducting surface

Dispersion: The frequency dependence of ε, μ and σ. Dispersion in non-conductors. Free electrons in conductors and plasma

Guided waves: Wave guides. TE waves in rectangular wave-guides. The coaxial transmission lines

(Prof. Y. K. Vijay)

(Dr. Chandan Joshi)

(Dr. Nishant Laur)

Dr. Pranav Saxena

(Dr. Abhishek Shyam)

Unit-V
Magneto-Hydrodynamics and Plasma Physics
Introduction and definitions. MHD equations. Magnetic Diffusion: Viscosity and Pressure. Pinch effect: instabilities in pinched plasma column. Magneto-hydrodynamics waves. Plasma Oscillations: Short wave length limit of plasma oscillations and Debye shielding distance

Suggested Books
1 L. D. Landau & Lifshitz: Classical Theory of Electrodynamics; Pergamon Press.
2 L. D. Landau & Lifshitz: Electrodynamics of continuous media; Pergamon Press.
3 J. D. Jacksson: Classical Electro-dynamics; John Wiley.
4 David J. Griffiths: Introduction to Electro-dynamics; Prentice Hall.
5 Panofsky & Phillip: Classical electrodynamics and magnetism.
6 N. N. Rao: Elements of Engineering Electromagnetics, Pearson Education.

Course Outcomes: Student shall be able to
CO1: Explain classical electrodynamics based on Maxwell's equations including its formulation in covariant form.
CO2: Solve the electromagnetic problems with the help of electrodynamic potentials and superpotentials, and make a detailed account for gauge transformations and their use
CO3: Formulate and solve electrodynamic problems in relativistically covariant form in four-dimensional spacetime.
CO4: Calculate the electromagnetic radiation from localised charges which move arbitrarily in time and space, taking into account retardation effects.
CO5: Calculate the electromagnetic radiation from radiating systems, like oscillating electric and magnetic dipoles (aerials, localised charge and current distributions)

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	*PO2*	*PO3*	*PO4*	*PO5*	*PO6*	*PO7*	*PSO1*	*PSO2*	*PSO3*
CO1	H				M		L	H		
CO2		H	H			M			L	
CO3		M		L	H			M		
CO4		H	M		L				M	
CO5			H	L		M			M	

H = Highly Related; M = Medium L = Low
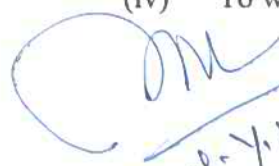
COMPUTATIONAL PHYSICS

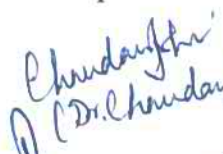**Code: MPH009B**   **Credit(s): 4**
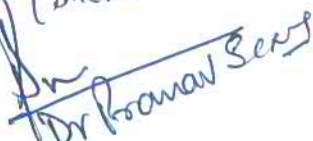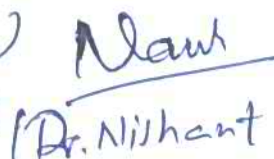
Students are required to learn the following computational exercises using MATLAB/Mathematica/other tools with at least two from each unit.
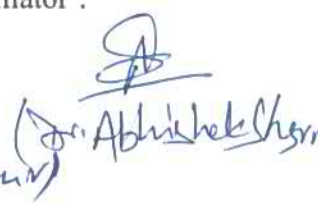(i)   Evaluation of integrals
(ii)   To write programmes to solve differential equations
(iii)   To write programme to evaluate Schrödinger's equation of motion.
(iv)   To write programe to evaluate problem of 'Quantum Linear Harmonic Oscillator'.

(v)   To write programme to evaluate Heisenberg's equation of motion.

(vi)   Stochastic methods, especially Monte Carlo methods.

(vii) Specialized partial differential equation methods, for example the finite difference method and the finite element method

(viii) The matrix eigen value problem – the problem of finding eigen values of very large matrices, and their corresponding eigenvectors (eigen states in quantum physics).

(ix) Understanding Molecular dynamics by computational means. Understanding Computational fluid dynamics.

(x) Understanding Computational Magneto-hydrodynamics

Suggested Books

1. Andi Klein and Alexander Godunov, Introductory Computational Physics (2006)
2. Rubin H. Landau, José Páez and Cristian C. Bordeianu and A Survey of Computational Physics: Introductory Computational Science.

Course Outcomes: Student shall be able to-

CO1: demonstrate knowledge in essential methods and techniques for numerical computation in physics

CO2: apply Monte Carlo method and other simulation methods to solve deterministic as well as probabilistic physical problems

CO3: employ appropriate numerical method to interpolate and extrapolate data collected from physics experiments

CO4: use appropriate numerical method to solve the differential equations governing the dynamics of physical systems

CO5: formulate and computationally solve a selection of problems in physics, use the tools, language (MATLAB/C++) and conventions of physics to test and communicate ideas and explanations

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1		H		M				H		
CO2			L			M		M		
CO3	M		L				H		L	
CO4					M					M
CO5		L			H				H	

H = Highly Related; M = Medium; L = Low

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(Dr. Chandan Joshi)

(Dr. Nishant Gaur)

(Dr. Abhishek Sharma)

Dr Pranav Saraf

ADVANCED PHYSICS LAB

Code: MPH010B   **Credit(s): 6**

Students have to perform any ten experiments

1. Complete study of characteristics of Photovoltaic Cells (Solar Cells).
2. To study temperature variation of resistivity for a semi-conductor and to obtain band gap using *Four Probe method*.
3. To verify *Hartmann's formula* using constant deviation spectrograph.
4. To study *ESR* and determine g-factor for a given spectrum.
5. To find e/m of electron using *Zeeman effect*.
6. To determine *internal friction* at the *grain boundaries of solids* using *torsional pendulum*.
7. To study a *driven mechanical osciallator*.
8. To study *coupled pendulums*.
9. To study the *dynamics of a lattice* using electrical analog.
10. To study the variation of rigidity of a given specimen as a function of the temperature.
11. Verification of *Bragg's law* using microwaves.
12. Study of analog to digital and digital to analog conversion.

Course Outcomes: Student shall be able to

CO-1. How to determine the lattice structure, lattice parameter and crystallite size?
CO-2. Measurement and analysis of various laws of physics.
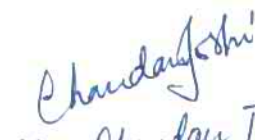CO-3. Determination of characteristics of Photovoltaic Cells (Solar Cells).
CO-4. Determine *Zeeman effect*.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1			L			M		H		
CO2		H					H		L	
CO3					M					M
CO4		L			M		L		M	

H = Highly Related; M = Medium; L = Low

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Dr. Roman Sen

NUCLEAR PHYSICS

Code: MPH011B   **Credit(s): 4**

Unit-I
Interaction of radiation and charged particle with matter (No derivation): Law of absorption and attenuation coefficient; Photoelectric effect, Compton scattering, pair production; Klem-Nishima cross sections for polarized and unpolarized radiation, angular distribution of scattered photon and electrons, Energy loss of charged particles due to ionization, Bremsstrahlung; energy target and projectile dependence of all three processes, Range-energy curves; Straggling.

Unit-II
Nucleon-Nucleon Scattering and Potentials : Partial wave analysis of the neutron-proton scattering at low energy assuming central potential with square well shape, concept of the-scattering length, coherent scattering of neutrons by protons in (ortho and para) Hydrogen molecule; conclusions of these analyses regarding scattering lengths, range and depth of the potential; the effective range theory (in neutron-proton scattering) and the shape independence of nuclear potential; A qualitative discussion of Proton- Proton scattering at low energy: General features of two-body scattering at high energy Effect of exchange forces: Phenomenological Hamada- Johnston hard core potential and Reid hard core and soft core potentials; Main features of the One Boson Exchange Potentials (OBEP) no derivation.

Unit-III
Two Nucleon system and Nuclear Forces: General nature of the force between nucleons, saturation of nuclear forces, charge independence and spin dependence, General forms of two nucleon interaction, central, noncentral and velocity dependent potentials, Analysis of the ground state (3S1) of Deuteron using a square well potential, range-depth relationship, excited states of deuteron, Discussion of the ground state of Deutron under noncentral force, calculation of the electric quadru-pole and magnetic dipole moments and the D-state admixture.

Experimental Techniques: Gas filled counters; Scintillation counter, Cerenkov counters; Solid state detectors; Surface barrier detectors; Electronic circuits used with typical nuclear detectors; Multiwire proportion chambers; Nuclear emulsions, techniques of measurement and analysis of tracks; Proton synchrotron; Linear accelerations; Acceleration of heavy ions.

Unit-IV
Nuclear Shell Model: Single particle and collective motions in nuclei: Assumptions and justification of the shell model, average shell potential, spin orbit coupling; single particle wave functions and level sequence; magic numbers; shell model predictions for ground state parity; angular momentum, magnetic dipole and electric-quadrupole moments; and their comparison with experimental data; configuration mixing; single particle transition probability according to the shell model; selection rules; approximate estimates for the transition probability and Weisskopf units: Nuclear isomerism.

Unit-V
Collective Nuclear Model: Collective variable to describe the cooperative modes of nuclear motion; Parametrization of nuclear surface; A brief description of the collective model Hamiltonian (in the quadratic approximation); Vibrational modes of a spherical nucleus, Collective modes of a deformed even-even nucleus and moments of, inertia; Collective spectra and electromagnetic transition in even nuclei and comparison with experimental data; Nilsson model for the single particle states in deformed nuclei.

Nuclear gamma and beta decay: Electric and magnetic multipole moments and gamma decay probabilities in nuclear system (no derivations), Reduced transition probability, Selection rules; zero- zero transition. General characteristics of weak interaction; nuclear beta decay and lepton capture; electron energy spectrum and Fermi- Kurie plot; Fermi theory of beta decay (parity conserved selection rules Fermi and Gammaw-Teler) for allowed transitions; ft-values; General interaction Hamiltonian for beta

decay with parity conserving and non conserving terms; Forbidden transitions ,Experimental verification of parity violation; The V-A interaction and experimental evidence.

Suggested Readings

1. J. M Blatt and V. E. Weisskipf: Theoretical Nuclear Physics.
2. R. D. Evans: The Atomic Nucleus, McGraw-Hills, 1955.
3. H. Enge: Introduction to Nuclear Physics, Addition-Wesley, 1970.
4. E. Segre: Nuclei and Particles, Benjamin, 1977.
5. W. E. Burcham: Elements of Nuclear Physics, ELBS, Longman, 1988.
6. B. L. Cohen: Concpt of Nuclear Physics, Tata Mc-Graw Hills, 1988.
7. I. Kaplan: Nuclear Physics, Addison Wesley, 1963.
8. R. M. Singru: Introductory Experimental Nuclear Physics.
9. M. K. Pal: Nuclear Structlire: Affiliated East-West Press, 1982.
10. R. R. Roy and B. P. Nigam: Nuclear Pbysics, Willey-Easter, 1979.

Course Outcomes: Student shallbe able to-

CO-1: To impart knowledge about basic nuclear physics properties

CO-2: understanding of related reaction dynamics.

CO-3: basic properties of nucleus and nuclear models

CO-4: to study the nuclear structure properties.

CO-5: various aspects of nuclear reactions will give idea how nuclear power can be generated.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1		H		M				H		
CO2			L			M		M		
CO3	M		L				H		L	
CO4					M					M
CO5		L			H				H	

H = Highly Related; M = Medium; L = Low

QUANTUM MECHANICS-III
(Relativistic Quantum Mechanics)

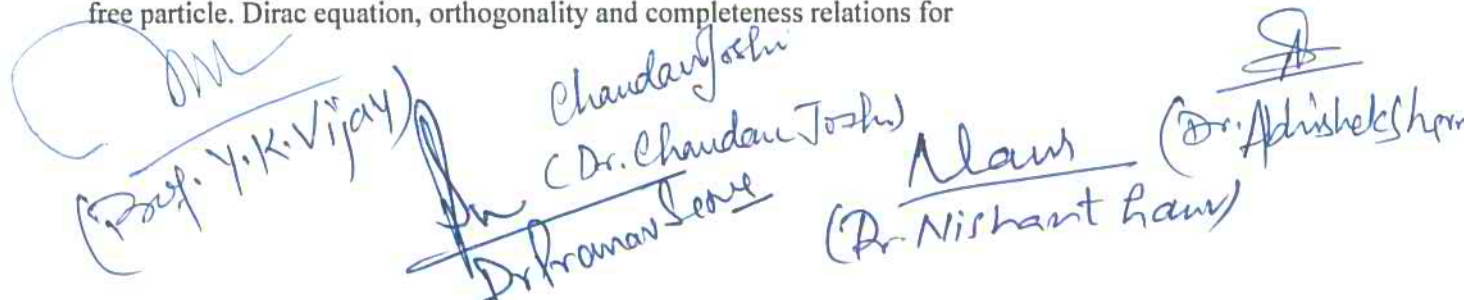**Code: MPH012B**   **Credit(s): 4**

Unit-I

Relativistic Formulation of Quantum Mechanics: Attempt for relativistic formulation of quantum theory, The Klein-Gordon equation, Probability density and probability current density, solution of free particle KG equation in momentum representation, interpretation of negative probability density and negative energy solutions.

Unit-II

Dirac equation for a free particle, properties of Dirac matrices and algebra of gamma matrices, non-relativistic correspondence of the Pauli equation (inclusive of electromagnetic interaction). Solution of the free particle. Dirac equation, orthogonality and completeness relations for

Dirac spinors, interpretation of negative energy solution.

Unit-III

Symmetries of Dirac Equation : Lorentz covariance of Dirac equation, proof of covariance and derivation of Lorentz boost and rotation matrices for Dirac spinors, Projection operators involving four momentum and spin, Parity (P), Charge conjugation(C), time reversal (T) and CPT operators for Dirac spinors, Billinear covariants, and their transfonnations behaviour under Lorentz transfonnation, CP, T and CPT, expectation values of coordinate and velocity, involving only, positive energy solutions and the associated problems, inclusion of negative energy solution, Zitter- bewegung, Klein paradox.

Unit-IV

The Quantum Theory of Radiation: Classical radiation field, transversality condition, Fourier decomposition and radiation oscillators, Quantization of radiation oscillator, creation, annihilation and number operators; photon states, photon as a quantum mechanical excitations of the radiation field, fluctuations and the Uncertainty relation, validity of the classical description, matrix element for emission and absorption, spontaneous emission in the-dipole approximation.

Unit-V

Rayleigh scattering. Thomson scattering and the -Raman effect, Radiation damping and Resonance fluorescence.

Quantization of identical Bosons.

Suggested Books

1. Ashok Das and A.C. Millissions: Quantum Mechanics- A Modern Approach (Garden and Breach Science Publishers).
2. E. Merzbaker: Quantum Mechanics, Second Edition (John Wiley and sons)
3. Bjorken and Drell : Relativistic Quantum Mechanics (MGraw Hill).
4. J. J. Sakuri: Advanced Quantum Mechanics (John Wiley).

Course Coutcomes: Student shall be able to-

CO-1: Understand the basic tenets of 'Relativistics Quantum Mechanics'

CO-2: Understand Dirac's equation and practice of Algebra of Dirac's matrices.

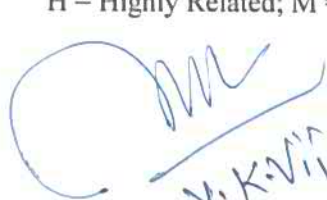CO-3: Understand and realize the symmetries of Dirac's equation.

CO-4: Understand 'theory of radiation quantization' to the students.
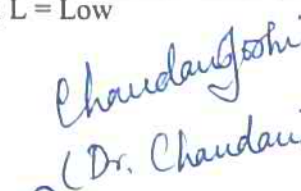
CO-5: Understand techniques of 'quantization of identical Bosons'.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1		H		M				H		
CO2			L			M		M		
CO3	M		L				H		L	
CO4					M					M
CO5		L			H				H	

H = Highly Related; M = Medium; L = Low

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(Dr. Chandan Joshi)   (Dr. Abhishek Sharma)

Dr. Pramoan Seay (Dr. Nishant Laur)

ADVANCED SOLID STATE PHYSICS

Code: MPH013B   **Credit(s): 4**

Unit-I
Lattice Vibrations and Thermal Properties: Interrelations between elastic constants C11, C12 and C44 wave propagation and experimental determination of elastic constant of cubic crystal, vibrations of linear mono and diatomic lattices, Determination of phonon dispersion by inelastic scattering of neutrons.

Unit-II
Band Theory: Block theorem, Kronig Penny model, effective mass of electrons, Wigner-Seitz approximation, NFE model, tight binding method and calculation of density for a band in simple cubic lattice, pseudo potential method.

Unit-III
Semiconductors: law of mass action, calculation of impurity conductivity, ellipsoidal energy surfaces in Si and Ge, Hall effect, recombination mechanism, optical transitions and Schockely-Read theory excitons, photoconductivity, photo-Luminescence. Points line, planar and bulk defects, colour centres, F-centre and aggregate centres in alkali halides.
Theory of Metals: Fermi- Dirac distribution function, density of states, temperature dependence of Fermi energy, specific heat, use of Fermi. Dirac statistics in the calculation of thermal conductivity and electrical conductivity, Widemann- Franz ratio, susceptibility, width of conduction band, Drude theory of light, absorption in metals.

Unit-IV
Magnetism: Larmor diamagnetism.Paramagnetism, Curie Langevin and Quantum theories. Susceptibility of rare earth and transition metals. Ferromagnetism: Domain theory, Veiss molecular field and exchange, spin waves: dispersion relation and its experimental determination by inelastic neutrons scattering, heat capacity. Nuclear Magnetic resonance: Conditions of resonance, Black equations. NMR-experiment and characteristics of an absorption line.

Unit-V
Superconductivity: (a) Experimental results: Meissner effect, heat capacity, microwave and infrared properties, isotope effect, flux quantization, ultrasonic attenuation, density of states, nuclear spin relaxation, Giver and AC and DC, Josephson tunnelling. (b) Cooper pairs and derivation of BCS Hamiltonian. Results of BCS theory. High T_C superconductors. Superconductivity at room temperature. Applications of Superconductors: SQUIDS. Cryotrons. Magnetic-Levitation.
Spin Waves and Plasma: The idea of plasmons.

Suggested Books
1. Charles Kittel, Introduction to Solid State Physics, 7th Edition, John Wiley and Sons, Inc.
2. A. J. Dekkar, Solid State Physics, Macmillan India Limited, 2000.
3. J. S. Blackmore, Solid State Physics, Cambridge University Press, Cambridge.
4. N. W. Ascroft and N. D. Mermin, Solid State Physics, (Harcourt Asia, Singapore 2003).
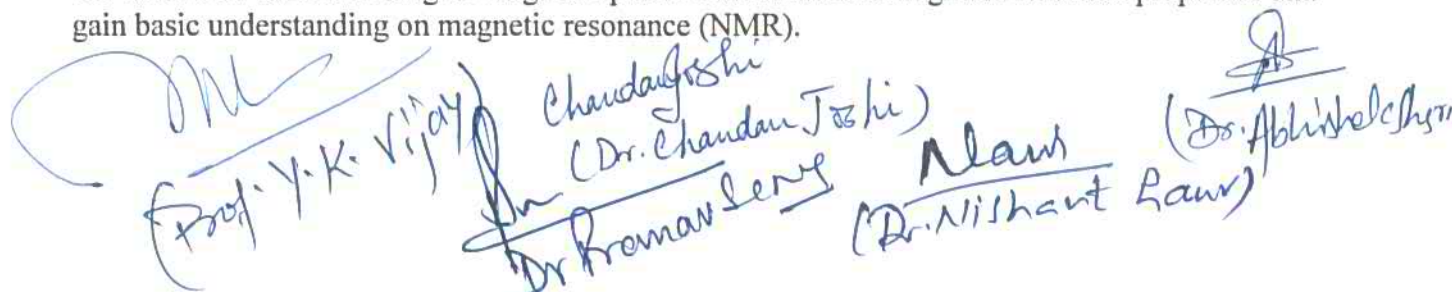5. S. O. Pillai, Solid State Physics, Wiley Eastern.

Course Outcomes: Student shall be able to-
CO1. have an understanding in different approaches to study band structures of solids
CO2. have an understanding of the properties of metals on the basis of the free electron gas models.
CO3. have an understanding of the essence of lattice vibrations and thermal properties.
CO4. have an understanding of magnetic phase transitions and magnetic structure properties and gain basic understanding on magnetic resonance (NMR).

CO5. have an understanding of the basic knowledge on (low temperature) superconductivity in type I and type II super conductors.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1		H	H		M			H		
CO2				L			M	M		
CO3	M			L					L	
CO4						M				M
CO5		L	L			H			H	

H = Highly Related; M = Medium; L = Low

SOLAR ENERGY AND ENERGY STUDIES

Code: MPH014B   **Credit(s): 4**

Unit-I

Heat conduction: Differential equation of heat conduction, Initial and boundary conditions. methods of solving heat conduction problems : separation of variable method for one dimension, steady and non steady state method: Theory and measurement of thermal conductivity and thermal diffusivity by transient plane source techniques.

Unit-II

Convective Heat Transfer: Theory of convective heat transfer, Laminar and turbulent flow, Boundary layer theory. Heat transfer in duct.

Characteristics of solar Radiation: Solar radiation at the earth surface, direct, diffuse and global radiation, Elements of solar radiations geomatary, empirical equations for predicting the availability of solar radiations, computation of insolations on a tilted surface. Atmospheric attenuation, solar radiation measurements.

Unit-III

Flat Plate solar collectors: Selective absorber surfaces. Transparatent plates. Collector energy losses. Thermal analysis of flat plate water and air heating collectors. Collector performance testing. Simple appliances working with flat plate collectors: solar cooker; water heater, air dryer and stills.
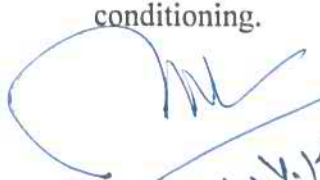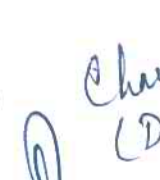
Unit-IV

Concentrating collectors: Optical concentration, flat plate collectors with plane reflectors, cylindrical parabolic concentrating collectors. Tracking requirements.
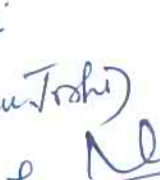
Thermal Energy Storage and Solar Thermal Devices: Water storage. Stratification of water storage, Packed bed storage. Phase change storage. Chemical storage. Solar pond. Economics of solar energy appliances. Efficiences in differnet storages.space conditioning.

Unit-V

Solar space conditioning: Energy requirements in buildings,Performance and design of Passive system architecture, Absorption refrigereation cycle, Performances of solar absorption air conditioning.

(Prof. Y.K.Vijay)   Chandan Joshi (Dr. Chandan Joshi)   (Dr.Abhishek Sharma)

Dr Pramod Sen (Dr. Nishant Kaur)

Essentials of wind energy: Classifications and Description of Wind machines. Performances of wind machine (soladity factor Y(Lamda); Energy in the wind.

Suggested Books
1. Heat Condution: M. Necati Ozisik-John Wiley & Sons.
2. Hand Book of Heat transfer Application: Edited by Warren M. Rohsenow, James P. Harnou and Ejup N. Ganic.
3. Conduction of Heat in Solids: H.S., Carslas and J.C.Jsegar, Oxford Clarendon Press 1959.
4. Heat and Mass Transfer: A Luikov, Mir Publichers Moscow.
5. Thermal conductivity of Solids: J.E. Parrot and Audrey D. Stuckers : Pion Limited, London.
6. Solar energy Thermal Processs : Dluffie and Backman. Wiley & Sons. New York.
7. Solar Energy Engg.: Jui Sheng Haieh,Prentic Hall, New Jersey.

Course Outcomes: Student shall be able to-
CO-1: explain the principles that underlie the ability of various natural phenomena to deliver solar energy
CO-2: outline the technologies that are used to harness the power of solar energy
CO-3: discuss the positive and negative aspects of solar energy in relation to natural and human aspects of the environment.
CO-4: will design the solar devices and different types of collectors.
CO-5: analyze the different modes of heat transfer.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1		H	H		M			H		
CO2				L			M	M		
CO3	M			L					L	
CO4						M				M
CO5		L	L			H			H	

H = Highly Related; M = Medium; L = Low

NUCLEAR PHYSICS LAB
Code: MPH015B   Credit(s): 6
(Experiments in Nuclear Physics)
Students have to perform all ten experiments
1. To study G.M. detector characteristics and determine operating voltage of a G.M. tube.
2. To study random nature of radioactive decay using G.M. counter.
3. To determine the resolving time of G.M. counting set up (single and double source methods).
4. To study the absorption of β- particles and determine end point energy using G.M. counter.
5. To determine absorption coefficient of γ- rays.
6. Study of secular equilibrium in radioactive decay.

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(Dr. Chandan Joshi)

(Dr. Nishant Laur)

Dr Pranav Saxena

(Dr Abhishek Sharma)

7. To determine end point energy of β- particles using Scintillation counter.
8. To study Compton scattering of γ- rays using Scintillation counter.
9. Study of absorption curve of α- particles using semiconductor detectors.
10. Study of specific energy loss and straggling of α- particles using semiconductor detectors.

Suggested Books
1. Nuclear Detectors: Knoll.
2. Experimental Nuclear Physics: S.S. Kapoor and Ramamurthy; Tata McGraw Hill.

Course Outcomes: Student shall be able to-
CO-1: to train the students for advanced techniques in nuclear physics
CO-2: how to operate a GM counter?
CO-3: how to find the absorption coefficient of different materials?
CO-4: how to handle nuclear materials and nuclear safely management

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1		H	H		M			H		
CO2				L			M	M		
CO3	M			L					L	
CO4					M					M

H = Highly Related; M = Medium; L = Low

SEMESTER-IV

QUANTUM FIELD THEORY

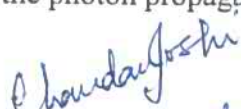**Code: MPH016B**   **Credit(s): 4**

Unit-I
Scalar and vector fields: Classical Lagrangian field theory, 'Euler-Lagrange's equation, Lagrangian density for electromagnetic field. Occupation number representation for simple harmonic oscillator, linear array of coupled oscillators, secondquantization, of identical bosons, second quantization of the real Klein Gordan field and complex, Klein-Gordan field, the meson propagator.
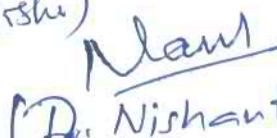
Unit-II
The occupation number representation for fermions, second quantization of the Dirac filed, the femion propagator, the electromagnetic interaction and gauge invariance, covariant quantization of the free electromagnetic field, the photon propagator.

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(Dr. Chandan Joshi)

(Dr. Nishant Lauw)

(Dr. Abhishek Sharma)

Dr. Pramod Jerry

Unit-III

S-matrix formulation: *S*-matrix expansion. Wick's theorem. Diagrammatic representation in configuration space, the momentum representation, Feynman diagrams of basic processes, Feynman rules of QED.

Unit-IV

Specific Processes: Applications of *S* matrix formalism: the Coulomb scattering, Bhabha scattering, Moller scattering, Compton scattering and pair production. Weak interaction by means of V-A theory.

Unit-V

Path Integral Formalism: Applications

Suggested Readings

1. F. Mandal & G. Shaw: Quantum Field Theory, John Wiley.
2. J. M. Ziman: Elements of Advance Quantum Theory, Cambridge University Press.

Course Outcomes: Student shall be able to-

CO1: Understand the basics of quantum field theory and provide some motivation for the use of fields to describe fundamental particle physics; apply abstract concepts to real-world situations.

CO2: Understand the notion of a path integral in quantum mechanics and field theory and the connection between the path integral formalism and the operator (scattering) formalism.

CO3: Demonstrate an understanding of field quantisation and the expansion of the scattering matrix

CO4: Quantize a free scalar field theory using canonical quantization and derive Feynman diagrams.

CO5: Use the language of Feynman diagrams in quantum field theory for electromagnetic processes, and calculate amplitudes, cross sections of scattering of particles based on Feynman diagrams.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	H					M				L
CO2		L			H				M	
CO3	L				H			M		
CO4		L	H							M
CO5		M				M				H

H = Highly Related; M = Medium L = Low

(Prof. Y. K. Vijay)

(Dr. Chandan Joshi)

(Dr. Nishant Gaur)

(Dr. Pranav...)

(Dr. Abhishek...)

INSTRUMENTATION TECHNIQUES

Code: MPH017B   Credit(s): 4

Unit-I

Classification: Absolute and Secondary instruments, indicating instruments, control, balancing and damping, construction details, characteristics, errors in measurement.

Wattmeters: Induction type, single phase and three phase wattmeter's, compensations.

Energy meters: AC Induction type single phase and three phase energy meter compensation, creep, error, testing.

Frequency meters: Vibrating reed type, electrical resonance type

Transducer: Strain Gauges, Thermistors, Thermocouples. Linear Variable Differential Transformer (LVDT) Capacitive Transducers, Peizo-Electric transducers. Optical Transducer, Torque meters, inductive torque transducers, electric tachometers, photo electric tachometers.

Unit-II

Electronic Instruments

CRO: Block Diagram, sweep generation, vertial amplifiers, use of CRO in measurement of frequency, phase, Amplitude and rise time of a pulse.

Digital Multimeter: Block diagram, principle of operation, Accuracy of measurement

Electronic Voltmeter:

Transistor Voltmeter, Block diagram, principle of operation, accuracy of measurement: metering amplifier.

Unit-III

Power Semiconductor Devices

Power Diodes: Types, characteristics

Thyristors: SCR, Static V-I characteristics of SCR, two transistor analogy of SCR, dynamic characteristics of SCR, Gate characteristics of SCR, Thyristor ratings, DIAC, TRIAC, GRO, UJT.

Power Transistors: Power BJT, Power MOSFETS, IGBT.

Triggering Circuits: R- Triggering, R-C Triggering, UJT triggering, Design of UJT triggering circuit, Cosine law triggering, triggering circuit using pulse train.

Thyristor commutation circuits: Class-A, Class-B, Class-C, Class-D, Calss-E, Class-F commutation circuits. Series and parallel operation of thyristors, protection of thyristors : di/dt protection, dv/dt protection, design of snubber circuit, overvoltage protection, over current protection.
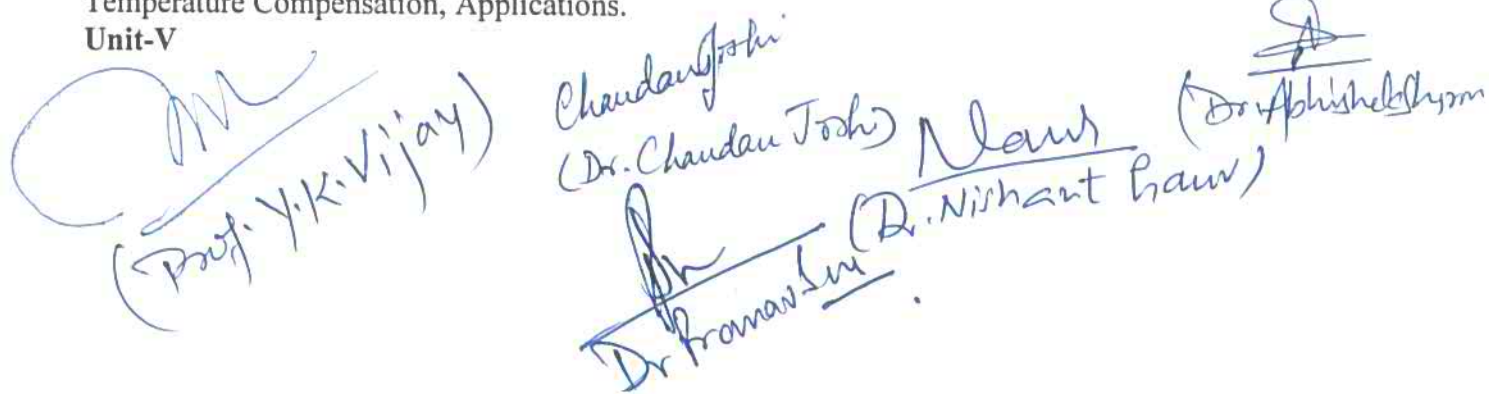
Unit-IV

Sensors and Transducers

Basic concepts and Classification: Introduction, System Configuration, Problem Analysis, Basic Characteristics of Measuring Devices, Calibration

Transducer classification: Introduction, Electrical Transducer, Classification, Basic Requirements of a Transducer. Introduction, Principles of Transduction, Digital Transducers, Level Measurements

Strain Measurement: Introduction, Factors affecting Strain Measurements, Types of Strain Gauges, Theory of Operation of Resistance Strain Gauges, Types of Electrical Strain Gauges, Materials for Strain Gauges, Gauging Techniques and Other Factors, Strain Gauge Circuits, Temperature Compensation, Applications.

Unit-V

Pressure Transducer: Introduction, Diaphragms, Other Elastic Elements, Transduction Methods, Force- Balance Transducer, Solid State Devices, Thin Film Pressure Transducers, Piezoelectric Pressure Transducer, Vibrating Element Pressure Sensors, Pressure Multiplexer, Pressure Calibration

Temperature Transducer: Introduction, Temperature Scales, Mechanical Temperature Sensors, Resistance- Type Temperature Sensors, Platinum Resistance Thermometer, Thermistors. Thermocouples, Solid-State Sensors, Quartz

Thermometer, Temperature Measurement by Radiation Methods, Optical Pyrometer, Calibration of Thermometers.

Force and Torque transducer: Introduction, Force-Measuring Sensor- Load Cell, Effect of Temperature Variations, Dynamic Response of Elastic Transducers, Digital Force Transducers, Force-Balance Device, Hydraulic Load Cell, Electronic Weighing System, Torque Measurement.

Vibration Transducers: Introduction, Characteristic of Vibration, Analysis of Vibration-Sensing Devices, Vibration- Sensing Devices, Signal Conditioners, Shock Measurements, System Characteristics, Vibration Exciters, Calibration.

Suggested Books

1. A Course in Elec. & Electronic Measurement and Instrumentation: A.K. Sawhney Dhanpat Rai & Sons, New Delhi, 1995.
2. Electronic Instrumentation and measurement techniques: W.O. Cooper, Prentice Hall of India Limited, New Delhi, 1992.
3. Electronic measurement & Instrumentation systems: Larry Jones & A foster Chin
4. Electronic measurement & measuring Instruments: Golding & Waddis A H Wheeler & Company, Calcutta, 1993.
5. Instrumentation Devices & Systems : C.S. Rangan, G.R. Sarma, V.S.V. Mani, 2nd Edition, Tata McGraw Hill publishers.
6. Instruments and Transducers: D.V.S. Murty, PHI.
7. Power Electronics: M.H. Rashid, Pearson Publication
8. Cengage Power Electronics Principles and Applications: Jacob, Learning.
9. Power Electronics: V.R. Murty, Oxford Publication

Course Outcomes: Student shall be able to-

CO-1: An ability to apply knowledge of mathematics, science, and engineering

CO-2: An ability to design and conduct experiments, as well as to analyze and interpret data
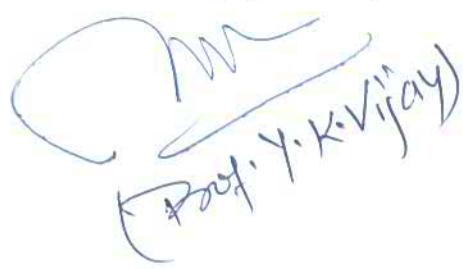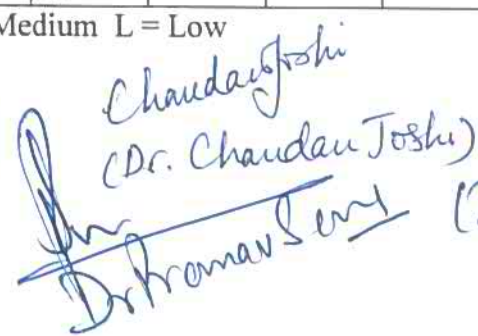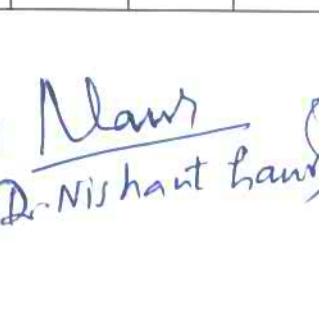
CO-3: An ability to design a system, component, or process to meet desired needs within realistic constraints

CO-4: An ability to function on multidisciplinary teams

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	H					M				L
CO2		L			H				M	
CO3	L				H			M		
CO4		L	H							M

H = Highly Related; M = Medium L = Low

ELECTIVE COURSES
(To be opted in Semester IV)

GENERAL RELATIVITY AND COSMOLOGY

Code: MPH018B   **Credit(s): 4**

General Theory of Relativity

Principle of equivalence. Metric formulation and tensor nature of gravitational field. Geodesic motion in curved space-time. Gradient, divergence, curl, and curvature and torsion in General Relativity. Bianchi identity and curvature tensor. Einstein's field equation and gravitation. Schwarzchild metric and solutions of Einstein's equation. Three crucial tests of Einstein's theory of gravitation. Killing vectors. Theory of gravitational waves. Singularities of Schwarzchild metric and Penrose diagrams. Ray-Chaudhary equation.

Cosmology

Einstein's model of Universe. De-Sitter Universe. Friedman-Robertson-Walker-Lemaitre model of the Universe. Big-Bang and the Physics of the early Universe. Particle and the Nucleo-synthesis in the early Universe. Various phase transitions and time-line of the Universe. Inflationary cosmology and generation of density perturbations. Alternative cosmologies: Quasi-Steady State Theory of the Universe.

Suggested Readings

1. S. Weinberg: General Relativity, Gravitation and Cosmology, Wiley.
2. Peacock J. A.: Cosmological Physics, Cambridge University Press.
3. Meissner, Kip Thorn and John Wheeler, Gravitation and Cosmology, Benjamin Feeman.
4. J. V. Narlikar: Introduction to Cosmology, Cambridge University Press.

CO-1: describe the science of cosmology and its relation to other fields of science
CO-2: identify and describe cosmology's current unanswered questions
CO-3: explain how the scientific method and quantitative arguments are used in cosmology

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	H					M				L
CO2		L			H				M	
CO3	L				H			M		

H = Highly Related; M = Medium L = Low

ASTROPHYSICS

Code: MPH019B   **Credit(s): 4**

Astrophysics: Overview

The structure, origin, and evolution of the major components of the Universe: planets, stars, and galaxies. Formation of the Sun and planets.

Luminosity and magnitudes of stars. Saha'a ionisation equation.

Astrophysical processes: Basics of electromagnetic radiations; Statistical mechanics of Astrophysical phenomena; Radiative processes; Spectra; Neutral fields and plasma in Astrophysics.

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(Dr. Chandan Joshi)

(Prof. Y. K. Vijay)

Pranav Jos (Dr. Nishant Gaur)

(Dr. Abhishek Sharma)

Stellar evolution; X-ray sources, Binary stars, Pulsars, Quasars and other compact stars. The origin and search for life in the Universe.

Structure Formation and the Evolution of the Universe

Structure formation in the early Universe. Galaxy formation. Elliptical and spiral galaxies. Rotational curves of galaxies and signatures of dark matter. Physics of the inter-stellar and inter-gallactic media. Star formation. Radiative transfer and stellar mechanics. Chandrashekhar limit and life-cycles of stars: Supernovae-Adult stars-Red Giants-Black Holes/White Dwarfs. The idea of White holes and Brown Dwarfs.

Suggested Books

1. Arnab Rai Chaudhary: Astrophysics for Physicists, Cambridge University Press.
2. T. Padmanabhan: Theoretical Astrophysics-I, Cambridge University Press.
3. T. Padmanabhan: Theoretical Astrophysics-II, Cambridge University Press.
4. T. Padmanabhan: Theoretical Astrophysics-III, Cambridge University Press.

Course Outcomes: Student shall be able to-

CO-1: Describe the features of objects in the Solar System (i.e. Sun, planets, moons, asteroids, comets, planetary interiors, atmospheres, etc.) giving details of similarities and differences between these objects

CO-2: detail the presently accepted formation theories of the solar system based upon observational and physical constraints

CO-3: detail changes which are observed when viewing the sky daily, weekly, monthly, annually and longer period of time and demonstrate an understanding of the reasons behind any observed changes

CO-4: demonstrate an understanding of the basic properties of the Sun and other stars

CO-5: explain stellar evolution, including red giants, supernovas, neutron stars, pulsars, white dwarfs and black holes, using evidence and presently accepted theories

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	H					M				L
CO2		L			H				M	
CO3	L				H			M		
CO4		L	H							M
CO5			M			M				H

H = Highly Related; M = Medium L = Low

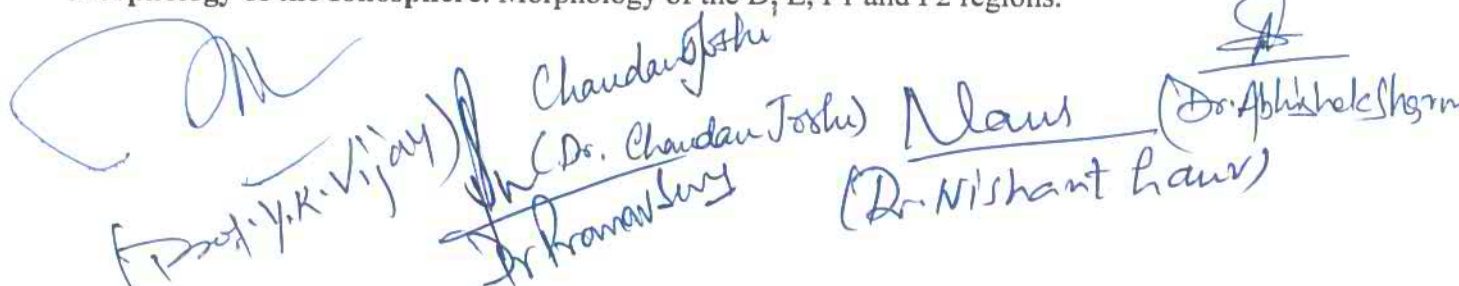# IONOSPHERIC PHYSICS

Code: MPH020B   **Creidt(s): 4**

Sun: Structure of Sun. Thermonuclear Reactions in the core of the Sun. Convection and radiative transfer. Photosphere, Chromosphere and Corona. Nanoflares. Sun Spots and Solar Cycle. Solar Cycle and Weather on the Earth.

Ionosphere: Production of Ionosphere. Different layers of the Ionosphere. Photochemical reactions in the Ionosphere. Loss reactions. Equation of continuity. Air Glow and Aurora.

Morphology of the Ionosphere: Morphology of the D, E, F1 and F2 regions.

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(Dr. Chandan Joshi)   (Dr.Abhishek Sharma)
Dr. Kamal Singh   (Dr. Nishant Kaur)

Passage of the Electromagnetic waves through Ionosphere: Dispersion. A wave in the continuous medium of specific dielectric constant. Polarization of E-M waves. Curves of *R(X)*. Quasi-Longitudinal (QL) and Quasi-Transverse (QT) approximations.

The Role of Ionosphere in the communication of Radio waves. The *Skip* distance.

Magnetosphere: Formation of the Earth's Magnetosphere. Its role in controlling the Solar wind, plasma particles and protecting life on the Earth. Physics of the Magnetosphere associated phenomena.

Suggested Books

1. C. Donald Ahrenes: Essentials of Meteorology (3rd Edition).
2. James R. Holton: Dynamic Meteorology (4th Edition), Elsevier- Academic Press.

Course Outcomes: Student shall be able to

CO-1: detail the main features and formation theories of the various types of observed galaxies, in particular the Milky Way

CO-2: explain the evolution of the expanding Universe using concepts of the Big Bang and observational evidence

CO-3: use information learned in class and develop observation skills to be able to explain astronomical features

CO-4: observations obtained via telescopic observations or data provided through computer simulations

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	H					M				L
CO2		L			H				M	
CO3		L	H							M
CO4			M			M				H

H = Highly Related; M = Medium L = Low

ATMOSPHERIC PHYSICS AND WEATHER SCIENCE

Code: MPH021B   **Credit(s): 4**

Unit-I

Atmosphere and its constituents: Synoptic observations- surface and upper air. Preparation of weather charts and their analysis, Diurnal variation of temperature, pressure, relative humidity, clouds etc.

Tropical meteorology : Easterly Waves, ET-ITCZ, Inversion.

Extratropical Meteorology: Air mass, Fronts- Frontogenesis and Frontolysis, Extratropical Cyclones and Anticyclones, Jet Streams

Unit-II

Synoptic systems: Winter - Western disturbance, Rossby Waves, Westerly Jet Stream, Fog, Cold Wave etc. Summer - Thunderstorms, Dust storms, Heat wave, Cyclonic disturbances. Monsoon - Onset, Activity, Withdrawal, Breaks,

Depressions, Easterly Jet Stream. Post Monsoon - Cyclones in the Indian Seas, N.E. Monsoon.

Unit-III

Global Climatology: Global distribution of pressure and temperature at m.s.l. in winter and summer, distribution of annual rainfall and its variability, distribution of moisture and clouds. Vertical distribution of temperature. General circulation of atmosphere.

Development of monsoons. Major categories of world climates.

Unit-IV

Indian Climatology - Different seasons, Distribution of Means Sea level

Pressure/temperature in different seasons, Wind circulation and temperature distribution over India in lower, middle and upper troposphere in different seasons. Indian rainfall in different seasons. Indian summer monsoon, onset, withdrawal, rainfall distribution, inter annual variability of monsoon. Main synoptic pressure systems causing weather over India in different seasons.

Suggested Books

1. Atmosphere, Weather and Climate R.J. Barry and R.G. Chorley (Methuen Publication)
2. South West Monsoon" by Y.P. Rao (IMD Publication) .
3. An Introduction to Meteorology by S. Pettersen
4. Elements of meteorology by Miller, Thompson and Paterson
5. General Meteorology by H.R. Byer
6. Monsoon by P.K. Das
7. Tropical Meteorology by T.N. Krishnamurthy
8. Tropical Meteorology by Riel.
90. Tropical Meteorology Vol 1, 2, 3, by G.C. Asnani

CO-1: identify the requirements and limitations of instrumentation for modern astrophysical observations;

CO-2: apply physics principles to the interpretation of a broad range of astrophysical observations;

CO-3: explain the basic issues involved in present day astrophysical investigations;

CO-4: demonstrate an understanding of our present picture of the cosmos on a large scale.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	H					M				L
CO2		L			H				M	
CO3		L	H							M
CO4			M			M				H

H = Highly Related; M = Medium   L = Low

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(Dr. Chandan Joshi)

(Dr. Abhishek Sharma)

(Dr. Nishant Laur)

(Dr Praman Sexan)

PARTICLE PHYSICS- I

Code: MPH022B   **Credit(s): 4**

Unit-I

Elementary particles and the fundamental forces. Quarks and leptons. The mediators of the electromagnetic, weak and strong interactions. Interaction of particles with matter; particle acceleration, and detection techniques. Symmetries and conservation laws.

Unit-II

Bound states. Discoveries and observations in experimental particle physics and relation to theoretical developments. Symmetries, group theory, The gourp SU(2), Finite Symmetry Group: P and C, SU(2) of Isospin, The group SU(3)

Unit-III

Quark and Antiquark states: Mesons, Three quark states:Baryon, color factors, Asymptotic freedom. Charged and neutral weak interactions. Electroweak unification.

Decay rates and Cross sections: Feynman diagrams Introduction to Feynman integrals. The Dirac equation. Feynman rules for quantum electrodynamics (no derivation). Moller scattering, trace theorems and properties of gamma matrices, helicity representation at high energies., the electron propagator, the photon propagator.

Unit-IV

Structure of Hadrons: form factors, e-p scattering, inelastic e-p scattering, Bjorken scaling, Partons, gluons, deep inelastic scattering, evolution equations for parton densities.

QCD: Electron positron annihilation into hadrons, heavy qwuark production, three jet events, QCD corrections, Perturbative QCD, Drell-Yan process
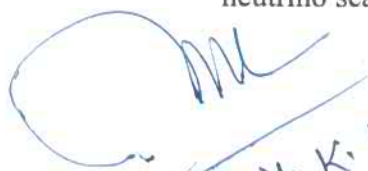
Unit-V

Weak Interactions: Parity violation, V-A form of weak interaction, Nuclear beta decay, muon decay, pion decay, charged curre nt neutrino electron scattering, neutrino quark scattering, weak neutral currents, the Cabibo angle, weak mixing angles, CP invariance.
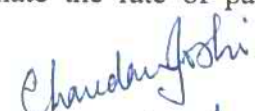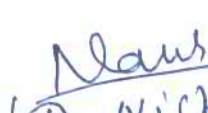
Suggested Books

1. Francis Halzen and Allan D. Martin, Quarks and Leptons: An Introductory Course in Modern Particle Physics, John Wiley and Sons
2. B.R. Martin and G. Shaw, Particle Physics, 2nd edition, J. Wiley and Sons (1997).
3. The Review of Particle Physics, (Particle Data Group)
4. David Griffiths: Introduction to Elementary Particles.
5. Byron Roe: Particle Physics at the New Millennium.
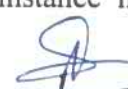6. Donald Perkin: Introduction to high energy physics.

Course Outcomes: Student shall be able to-

CO1: Basic knowledge nuclear and particle physics. Knowledge and understanding of the elementary particle interactions. Capability of relating the theory predictions and measurements.

CO2: Conservations laws in nuclear and particle physics, to determine which nuclear processes and particle processes are allowed and why?

CO3: the Symmetries and Group Theory, bound states of matter and antimatter; the concept of Feynman diagrams to estimate the rate of particle physics processes, for instance in neutrino scattering

(Prof. Y. K. Vijay)

Chandan Joshi
(Dr. Chandan Joshi)

(Dr. Abhishek Sharma)

(Dr. Nishant Laur)

Dr. Pranav Seng

CO4: Quantitatively comparison of theory and experiments for scattering and disintegration processes (Decay rates and cross sections). Formulate the basic elements of calculations of cross sections and decay rates in particle physics

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	H					M				L
CO2		L			H				M	
CO3		L	H							M
CO4			M			M				H

H = Highly Related; M = Medium L = Low

PARTICLE PHYSICS- II

Code: MPH023B   **Credit(s): 4**

Unit-I
Gauge Symmetries: U(1) Local gauge invariance and QED, Non-abelian gauge invariance and QCD, mnassive gauge bosons, spontaneous breakdown of symmetry, the Higgs mechanism.
Unit-II
Local gauge invariance and Yang-Mills fields: Lagrangian of the Spontaneous symmetry breaking and the Higgs mechanism, The Weinberg-Salam model and beyond.
Unit-III
Standard Model of Particle Physics: Unified models of weak and electromagnetic interactions, flavor group, flavor-changing neutral currents. Weak isospin.
Unit-IV
Quark and lepton mixing: CP violation. Neutrino oscillations.CKM quark mixing matrix, GIM mechanism, rare processes, neutrino masses, seesaw mechanism
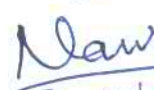**Unit-V**
QCD confinement and chiral symmetry breaking, instantons, strong CP problem

Suggested Books
1. Francis Halzen and Allan D. Martin, Quarks and Leptons: An Introductory Course in Modern Particle Physics, John Wiley and Sons
2. B.R. Martin and G. Shaw, Particle Physics, 2nd edition, J. Wiley and Sons (1997).
3. Particle Data Group, The Review of Particle Physics,
4. David Griffiths, Introduction to Elementary Particles
5. Byron Roe Particle Physics at the New Millennium
6. Donald Perkin, Introduction to high energy physics).
7. Martin and Shaw, Particle Physics

(Prof. Y.K. Vijay)   Chandanjoshi
                          (Dr. Chandan Joshi)   (Dr. Abhishek Sharma

                          Nawr   Dr Promav Sing
                          (Dr. Nishant Lawr)

Course Outcomes: Student shall beable to-
CO1: to understand the role that global and local symmetries play in modern elementary particle physics and to become acquainted with the concept of symmetry breaking;
CO2: Explain the important properties of elementary particles, and their interactions, in the Standard Model of particle physics. Describe essential experimental results which have lead to the formulation of the Standard Model.
CO3: to introduce the experimental motivation and theoretical framework of the Standard Model (SM) for Electroweak (EW) and Strong interactions (QCD)
CO4: to understand the theoretical framework of Neutrino physics, Higgs mechanism, CKM mass mixing matrix, experiments from accelerators physics
CO5: to develop tools to enable the quantitative calculation of tree-level electroweak cross-sections; to provide a foundation for more advanced studies in particle physics.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	H					M				L
CO2		L			H				M	
CO3	L				H			M		
CO4		L	H							M
CO5			M		M					H

H = Highly Related; M = Medium L = Low

CONDENSED MATTER PHYSICS-I

Code: MPH024B   **Credit(s): 4**

Unit-I

Structure Factor: Static structure factor and its relation with the pair correlation function. Determinationof structure factor by X-ray and neutron scattering. Inelastic neutron scattering and dynamic structure factor, space time correlation function and its relation with dynamic structure factor, properties of space time correlation function. Langevin's equation for Browninan Motion and its modifications. Velocity autocorelatiion function, mean square displacement, Relation between velocity autocorelation function and diffusion coefficient.

Unit-II

Liquid Metals: Metallic interactions-Kinetic energy, electrostatic exchange and correlation, Pseudopotential formalism, diffraction model, structure factor, form factor for local and nonlocal potentials, energy eigen states, dielectric screening. Energy wave number characteristics, calculation of phonone dispersion of liquid metals. Band structure energy in momentum and direct space. Ziman's resistivity formula, Green function method for energy bands in liquid metals.

Unit-III

Quantum Liquids: Distinction between classical and quantum liquids, critetria for freezing, phase diagram of He4, He I and He II Tisaza's two fluid model, entropy filter, Fountain effect, superfluid film vehicle, Viscosity and specific heat of He4, first sound, second sound, third

sound and fourth sound, Landau theory: Rotons and Phonis, t-matrix theory of superfluid He. Basic differences in superfluidity in He3 and He4.

Unit-IV

Exotic Solids: Structure and symmetries of liquids, liquid crystals and amorphous solids. Aperiodic solids and quasicrystals; Fibonanccy sequence, Penrose lattices and their extension to 3-dimensions, Special carbon solids. Fullerences and tubules; formation and characterization of fullerences and tubules. Single wall and multivwall carbon tubules. Electronic properties of tubules. Carbon nanotubule based electronic based devices Definition and properties of nanostrctured materials. Methodsof synthesis of nanostructured materials. Special experimental techniques for characterization of nanostrcutred materials. Quantum size effect and its applications.

References Books

1. Egelestaff: In Introduction to the Liquid State (Chapters 2, 3, 5, 6, 7 and 8.)
2. Hansen and McDonald : Theory of Simple Liquids, (Chapters 3, 5, 7, and 9).
3. D. Pines and P. Nozier: The Theory of Quantum Liquid.
4. W.A. Harison: Pseudopotentials in the Theory of Metals Benjamin.
5. March, yound and Saupenthe - Many Body Problems.
6. March and Tosi: Atomic Motions in Liquids.
7. March, Tosi and Street: Amorphous Solids and the Liquid State, Plenum, 1985.
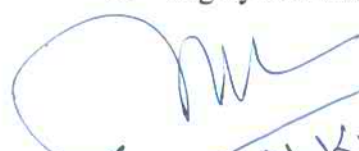8. Dugdale: Electrical Properties of Metals an Alloys.
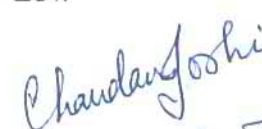
Course Outcomes: Student shall be able to-

CO-1 Explain the significance and value of condensed matter physics, both scientifically and in the wider community

CO-2 Critically analyse and evaluate experimental strategies, and decide which is most appropriate for answering specific questions

CO-3 Research and communicate scientific knowledge in the context of a topic related to condensed matter physics, in either a technical or non-specialist format

CO-4. Apply key analysis techniques to typical problems encountered in the field

CO-5. Gain and apply discipline-specific knowledge, including self-directed research into the scientific literature.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	H					M				L
CO2		L			H				M	
CO3	L				H			M		
CO4		L	H							M
CO5			M			M				H

H = Highly Related; M = Medium L = Low

(Prof. Y.K. Vijay)

(Dr. Chandan Joshi)

(Dr.Abhishek Chopra

(Dr. Nishant Kaur)

(Dr. Raman Jove

CONDENSED MATTER PHYSICS-II

Code: MPH025B   Credit(s): 4

Phase Transformation and Alloys: Equilibrium transformation of first and second order. Equilibrium diagrams. Phase rule. Interpretation of phase diagrams. Substitutional solid solutions. Vegard's law, intermediate phases, Hume-Rothery rules. Interstitial phases (carbides, nitrides, hydrides, borides). Martensitic transitions. structure factor of liquid metal alloys, behaviour of s(q), radial distribution function g(r) and relationship between s(q) and g(r)

Disordered Systems: Disorder in condensed Matter, Substitutional, positional and topographical disorder. Short adn long range order. Spinning, sputtering and ion-implantation techniques, glass Transiton, glass formatino ability, nucleation and growth processess. Anderson model for random system and electron localization, mobility edge, qualitative application of the idea of amorphous semicodnuctors and hopping conduction. Metglasses, Models for structure of metalglasses. Structure factor of binary metallic glasses and it relationship with the radial distribution functinos. Discussion of electric, magnetic and mechanical properties of glassy system.

Structure determination/characterization: Basic theory of X-ray diffraction. Indexing of Debye-Scherer patterns powder samples, examples from some cubic and non-cubic symmetries. Neutron diffraction-basic interactions, corss section, scatterign length and structure factor. Mossbauer effect, hyperfine parameters-Isomer shift, quadrupole splittign and Zeeman splitting. Application 0Valence adn corrdiantin, site symmetry magnetic behaviour. Discussion in context of Fe57.

Electronic Structure Determination: Basic principles of X-ray, photo-emission and positron annihilation techniques. qualitative discussion of experimental arrangement and typical results for both simple as well as transition metals.
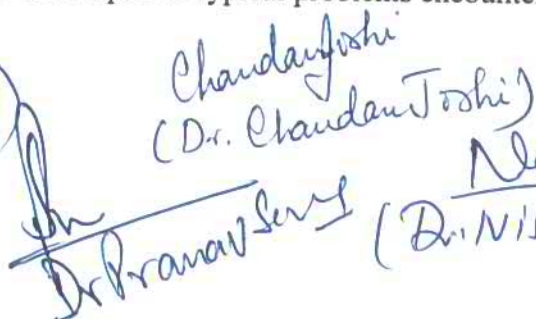
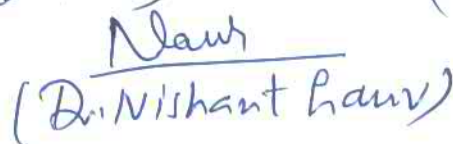## Suggested Books (for Condensed Matter Physics I & II)
1. Egelstaff: An introduction to the liquid state (Chapters 2, 3, 5, 6, 7 and 8).
2. Hansel and Mc Donald: Theory of Simple liquids (Chapters 3, 5, 8 and 9).
3. D.Pines and P. Nozier- The theory of quantum liquids.
4. W.A. Harison: Pseudo potentials in the theory of metals.
5. March, Yound and Saupenthe: Many Body Problems.
6. March and Tosi: Atomic Motins in Liquids.
7. March, Tosi and Street: Amorphous solids and the Liquids State, Plenum, 1985.
8. Dugdale: Electrical Properties of Metals and Alloys.
9. M. Shimoji: Liquid Metals.
10. P.I. Taylor: A. Quantum Approach to the Solid State, Prentice Hall.

Course Outcomes: Student shall be able to-
CO-1 Explain the significance and value of condensed matter physics, both scientifically and in the wider community
CO-2 Critically analyse and evaluate experimental strategies, and decide which is most appropriate for answering specific questions
CO-3 Research and communicate scientific knowledge in the context of a topic related to condensed matter physics, in either a technical or non-specialist format
CO-4. Apply key analysis techniques to typical problems encountered in the field

CO-5. Gain and apply discipline-specific knowledge, including self-directed research into the scientific literature.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	H					M				L
CO2		L			H				M	
CO3	L				H			M		
CO4		L	H							M
CO5			M			M				H

H = Highly Related; M = Medium L = Low

DIGITAL ELECTRONICS

Code: MPH026B   **Credit(s): 4**

Analog Circuits: Integrated Circuits (Qualitative Treatment only): Active and Passive components. Discrete Circuit Component. Wafer. Chip. Advantages and Drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (Basic Idea and Definitions Only). Classification of ICs. Fabrication of Components on Monolithic ICs. Examples of Linear and Digital ICs.

Operational Amplifiers (Use Black Box approach): Basic Characteristics of Op-Amps. Characteristics of an Ideal Op-Amp. Feedback in Amplifiers . Open-loop and Closed-loop Gain. Frequency Response. CMRR. Virtual ground.

Applications of Op-Amps: (1) Inverting and Non-inverting Amplifiers, (2) Adder, (3) Subtractor, (4) Unity follower, (5) Differentiator, (6) Integrator, (7) Zero Crossing Detector.

Timers (Use Black Box approach): 555 Timer and its Applications: Astable and Monostable Multivibrator.

Digital Circuits: Difference Between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. AND, OR and NOT Gates (Realization using Diodes and Transistor). NAND AND NOR Gates. Exclusive OR and Exclusive NOR Gates.

Boolean algebra: De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Minterms and Maxterms. Conversion of a Truth Table into an Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.
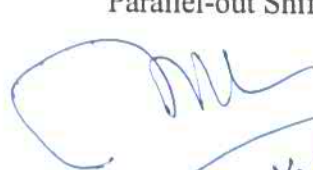
Data processing circuits: Basic Idea of Multiplexers, De-multiplexers, Decoders, Encoders, Parity Checkers.

Memories: Read-only memories (ROM), PROM, EPROM.

Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement Method). Half Adders and Full Adders and Subtractors (only up to Eight Bits).

Sequential Circuits: RS, D, and JK Flip-Flops. Level Clocked and Edge Triggered Flip-Flops. Preset and Clear Operations. Race-around Conditions in JK Flip-Flops. Master-Slave JK Flip-Flop (As Building Block of Sequential Circuits).

Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out, and Parallel-in-Parallel-out Shift Registers (only up to 4 bits).

(Prof. Y. K. Vijay)

Chandan Joshi
(Dr. Chandan Joshi)

(Dr. Abhishek)

Dr. Roman Surya Nauw
(Dr. Nishant Lauw)

Counters: Asynchronous and Synchronous Counters. Ring Counters. Decade Counter. D/A and A/D conversion: D/A converter – Resistive network. Accuracy and Resolution.

Suggested Books

1. D. P. Leach & A. P. Malvino: Digital principles and applications (Glencoe, 1995).
2. Thomas L. Floyd: Digital Fundamentals, 3rd Edition, Universal Book Stall, India, 1998.
3. Robert F Coughlin and Frederick F Driscoll: Operational Amplifiers and Linear Integrated Circuits, 4th Edition, PHI, 1992.
4. R. A. Gayakwad: Op-Amps and Linear Integrated Circuits, Pearson, 2000.

Course Outcomes: Student shall be able to-

CO-1 Have a thorough understanding of the fundamental concepts and techniques used in digital electronics.

CO-2 To understand and examine the structure of various number systems and its application in digital design.

CO-3 The ability to understand, analyze and design various combinational and sequential circuits.

CO-4 Ability to identify basic requirements for a design application and propose a cost effective solution.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	H					M				L
CO2		L			H				M	
CO3		L	H							M
CO4			M			M				H

H = Highly Related; M = Medium L = Low

MICROWAVE ELECTRONICS AND COMMUNICATION
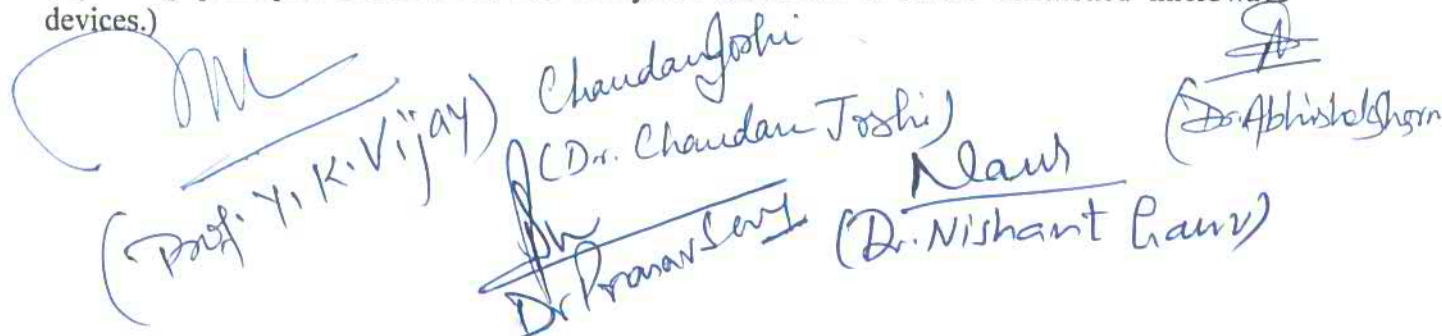**Code: MPH027B**   **Credits: 4**

Microwave Wave Guides: Rectangular wave guides: TE, TM and TEM modes in wave guides, power transmission in wave guide, power losses in wave guide, excitation modes in wave guide, Characteristics of standard wave guides.

Microwave Components: microwave cavities, microwave attenuators, Scattering parameters, E-H tunner, directional coupler, circulators and isolators, Phase shifter.

Microwave Tubes: Linear beam: klystrons, reflex klystrons, TWTs. Microwave Crossed Field Tubes: Magnetrons, forward wave crossed field amplifier (FWCFA), high power gyrotrons. (Operating principle, construction & analytical treatment of above mentioned microwave tubes.)

Microwave Solid State Devices: Microwave tunnel diodes, microwave FETs, gunn effect diodes, RWH Theory, LSA diodes, Impatt diodes, PIN diodes, ruby laser, MESFETs and HEMT. (Operating principle, construction and analytical treatment of above mentioned microwave devices.)

Microwave Measurements: Detection of microwave power: measurement of microwave low and high power, thermister parameters, thermister mounts, barreters, direct reading barreters bridges, Measurement of wavelengths: single line cavity coupling system, Transmission cavity-wave meter and reaction wavemeter, measurement of VSWR, measurements of attenuation, input impedance.

Microwave Antennas: Different types of antennas.

Modulation and Demodulation: Types of Modulation. Amplitude Modulation. Modulation Index. Analysis of Amplitude Modulated Wave. Sideband Frequencies in AM Wave. CE Amplitude Modulator. Demodulation of AM Wave using Diode Detector. Idea of Frequency, Phase, and Digital Modulation.

Suggested Books

1. R.E.Collin: Foundation of Microwave Engg, McGraw Hill.
2. Samul Liao: Microwave Devices and Circuit, PHI.
3. Sisodia and Raghuvanshi: Microwave Circuits and Passive Devices, Wiley Eastern.
4. David M. Pozar, Microwave Engineering, JohnWiley& Sons, Inc.
5. Roddy.D.: "Microwave Technology" Reston Publications (1986).

6. Chatterjee R. "Microwave Engineering "East West Press (1988).
7. Rizzi.P."Microwave Engineering Passive circuits". Prentice Hall (1987).
8. Clock.P.N. "Microwave Principles and Systems" Prentice Hall (1986).

Course Outcomes: Student shall be able to-

CO-1 This course provides the foundation education in microwave devices , amplifier and oscillators. It also includes RF filter design and mixer.

CO-2 To discuss the microwave amplifiers and oscillators basic operation, characteristics, parameters ,limitations, various microwave components like E&H plane Tee, Magic tee &phase shifters.

CO-3. Analyze and deign basic microwave amplifiers, particularly klystrons, magnetron, and RF filters, basic RF oscillator and mixer models.
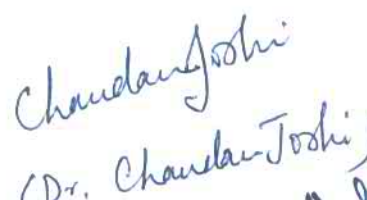
CO-4 Become proficient with microwave measurement of power, frequency and VSWR, impedance for the analysis and design of circuits
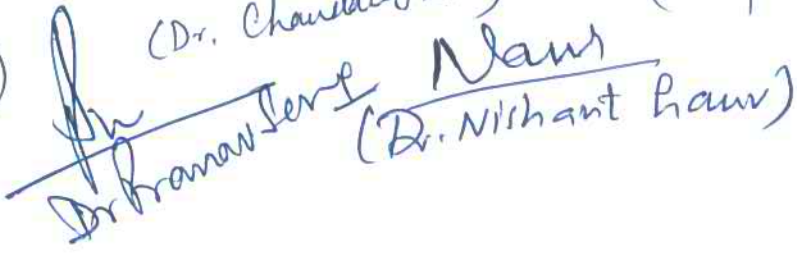
MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	H					M				L
CO2		L			H				M	
CO3		L	H							M
CO4			M			M				H

H = Highly Related; M = Medium L = Low

(Prof. Y.K. Vijay)   (Dr. Chandan Joshi)   (Dr. Abhishek Sharma)

Dr Pranav Devi Nama   (Dr. Nishant Laur)

PROJECT (DISSERTATION)

Code: MPH031B   **Credit(s): 12**

Work at any University/ Academic Inst./ Research Lab

MPH032B: Seminar (Presentation of Project Work)   **Credit(s): 4**

Course Outcomes: Student shall be able to-

CO-1: be able to apply the relevant knowledge and skills, which are acquired within the technical area, to a given problem.

CO-2: within given constraints, even with limited information, independently analyze and discuss complex inquiries/problems and handle larger problems on the advanced level within the technical area.

CO-3: Reflect on, evaluate, and critically assess one's own and others' scientific results.

CO-4: Be able to document and present one's own work, for a given target group, with strict requirements on structure, format, and language usage.

CO-5: Be able to identify one's need for further knowledge and continuously develop one's own competencies.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:
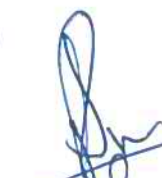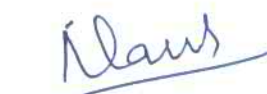
Course Outcome	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	H					M				L
CO2		L			H				M	
CO3		L	H							M
CO4			M			M				H

H = Highly Related; M = Medium L = Low

(Prof. Y.K.Vijay)

Chandan Joshi
(Dr. Chandan Joshi)

(Dr. Abhishek Sharma

Dr. Pranav Sedery

(Dr. Nishant Gaur)