INSTITUTE OF SCIENCE, NAGPUR.

(An Autonomous Institute of Government of Maharashtra)

DEPARTMENT OF PHYSICS

Syllabus

Master of Science (M.Sc.) Semester Pattern

Physics

(PHY/PG/2021/01)

(To be Implemented from 2021-2022)

M.Sc. (Semester Pattern) Syllabus
Semester wise Name of Papers
Subject - Physics

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<tr><th>Semester</th><th>Paper</th><th>Name of the Paper</th><th>Paper Code</th></tr>
<tr><td rowspan="6">I</td><td>I</td><td>Mathematical Physics</td><td>MPFS11</td></tr>
<tr><td>II</td><td>Complex Analysis and Numerical Methods</td><td>MPFS12</td></tr>
<tr><td>III</td><td>Electronics</td><td>MPFS13</td></tr>
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<tr><td>V</td><td>Practical Paper P1</td><td>MPFS15</td></tr>
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<tr><td rowspan="6">II</td><td>I</td><td>Quantum Mechanics I</td><td>MPFS21</td></tr>
<tr><td>II</td><td>Statistical Physics</td><td>MPFS22</td></tr>
<tr><td>III</td><td>Classical Mechanics</td><td>MPFS23</td></tr>
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<tr><td>V</td><td>Practical Paper P3</td><td>MPFS25</td></tr>
<tr><td>VI</td><td>Practical Paper P4</td><td>MPFS26</td></tr>
<tr><td rowspan="6">III</td><td>I</td><td>Quantum Mechanics II</td><td>MPSS31</td></tr>
<tr><td>II</td><td>Solid State Physics and Spectroscopy</td><td>MPSS32</td></tr>
<tr><td>III</td><td>Choose any one of the following
• (Core Elective E1.1) Materials Science I
• (Core Elective E1.2) X-ray I
• (Core Elective E1.3) Nanoscience and Nanotechnology I
• (Core Elective E1.4) Atomic and Molecular Physics I
• (Core Elective E1.5) Applied Electronics I</td><td>MPSS33</td></tr>
<tr><td>IV</td><td>• Choose any one of the following
• (Subject Centric Core Course S1.1) Nanoscience and Nanotechnology
• (Subject Centric Core Course S1.2) Quantum Computing
• (Subject Centric Core Course S1.3) Digital Electronics and Microprocessor</td><td>MPSS34</td></tr>
<tr><td>V</td><td>Practical Paper P5 (for core course)</td><td>MPSS35</td></tr>
<tr><td>VI</td><td>Practical Paper P6(for elective papers)</td><td>MPSS36</td></tr>
<tr><td rowspan="2">IV</td><td>I</td><td>Nuclear and Particle Physics</td><td>MPSS41</td></tr>
<tr><td>II</td><td>Solid State Physics</td><td>MPSS42</td></tr>
</table>

	III	**Choose any one of the following** • (Core Elective E2.1) Materials Science II • (Core Elective E2.2) X-ray II • (Core Elective E2.3) Nanoscience and Nanotechnology II • (Core Elective E2.4) Atomic and Molecular Physics II • (Core Elective E2.5) Applied Electronics II	**MPSS43**
	IV	• **Choose any one of the following** • (Subject Centric Core Course S2.2) Experimental Techniques in Physics • (Subject Centric Core Course S2.3) Communication electronics • (Subject Centric Core Course S2.4) Electro-Acoustics	**MPSS44**
	V	Practical Paper P7 (for core course)	**MPSS45**
	VI	Practical Paper P8 Project Work (Theoretical/Experimental work, Thesis submission and Defence)	**MPSS46**

Ex. MPSS32 : M -M.Sc, P-Physics, S-Second Year, S3- Semester-3, 2- Subject Paper-2

Marking Scheme of Syllabus

M. Sc. Physics Examination Scheme

M. Sc. Physics Semester-1

Code	Theory/ Practicals	Teaching Scheme			Credits	Examination Scheme					
						Duration (In Hours)	Maximum Marks		Total Marks	Minimum passing marks	
		Theory	Practical	Total			External Marks	Internal Assessment		Theory	Practical
MPFS11	Mathematical Physics	4	-	4	4	3	80	20	100	40	-
MPFS12	Classical Mechanics	4	-	4	4	3	80	20	100	40	-
MPFS13	Electronics	4	-	4	4	3	80	20	100	40	-
MPFS14	Electrodynamics I	4	-	4	4	3	80	20	100	40	-
MPFS15	Practical I	-	8	8	4	3-8	100	-	100	-	40
MPFS16	Practical II	-	8	8	4	3-8	100	-	100	-	40
MPFSS1	Seminar-I (Sem I)	2	-	2	1	-	-	25	25	10	-
	TOTAL	**18**	**16**	**34**	**25**	**-**	**520**	**105**	**625**	**170**	**80**

M. Sc. Physics Semester-2

Code	Theory/ Practicals	Teaching Scheme			Credits	Examination Scheme					
						Duration (In Hours)	Maximum Marks		Total Marks	Minimum passing marks	
		Theory	Practical	Total			External Marks	Internal Assessment		Theory	Practical
MPFS21	Quantum Mechanics I	4	-	4	4	3	80	20	100	40	-
MPFS22	Statistical Physics	4	-	4	4	3	80	20	100	40	-
MPFS23	Classical Mechanics	4	-	4	4	3	80	20	100	40	-
MPFS24	Electrodynamics II	4	-	4	4	3	80	20	100	40	-
MPFS25	Practical 3	-	8	8	4	3-8	100	-	100	-	40
MPFS26	Practical 4	-	8	8	4	3-8	100	-	100	-	40
MPFSS2	Seminar-II (Sem II)	2	-	2	1	-	-	25	25	10	-
	TOTAL	**18**	**16**	**34**	**25**	**-**	**520**	**105**	**625**	**170**	**80**

M. Sc. Physics Semester-3

Code	Theory/ Practicals	Teaching Scheme			Credits	Examination Scheme					
						Duration (In Hours)	Maximum Marks		Total Marks	Minimum passing marks	
		Theory	Practical	Total			External Marks	Internal Assessment		Theory	Practical
MPSS31	Quantum Mechanics II	4	-	4	4	3	80	20	100	40	-
MPSS32	Solid State Physics and Spectroscopy	4	-	4	4	3	80	20	100	40	-
MPSS33	(1) Materials Science I (2) Atomic and Molecular Physics I (3) Applied Electronics-I	4	-	4	4	3	80	20	100	40	-
MPSS34	(1) Nanoscience and Nanotechnology (2) Digital Electronics and Microprocessors (3) Quantum Computing	4	-	4	4	3	80	20	100	40	-
MPSS35	Practical 5	-	8	8	4	3-8	100	-	100	-	40
MPSS36	Practical 6	-	8	8	4	3-8	100	-	100	-	40
MPSSS3	Seminar-III (Sem III)	2	-	2	1	-	-	25	25	10	-
	TOTAL	**18**	**16**	**34**	**25**	**-**	**520**	**105**	**625**	**170**	**80**

M. Sc. Physics Semester-4

Code	Theory/ Practicals	Teaching Scheme			Credits	Examination Scheme					
						Duration (In Hours)	Maximum Marks		Total Marks	Minimum passing marks	
		Theory	Practical	Total			External Marks	Internal Assessment		Theory	Practical
MPSS41	Solid State Physics	4	-	4	4	3	80	20	100	40	-
MPSS42	Nuclear and Particle Physics	4	-	4	4	3	80	20	100	40	-
MPSS43	(1) Materials Science II (2) Atomic and Molecular Physics II (3) Applied Electronics-II	4	-	4	4	3	80	20	100	40	-
MPSS44	(1) Experimental Techniques in Physics (2) Electroacoustics (3) Communication Electronics	4	-	4	4	3	80	20	100	40	-
MPSS45	Practical 5	-	8	8	4	3-8	100	-	100	-	40
MPSS46	Project	-	8	8	4	3-8	100	-	100	-	40
MPSSS4	Seminar-III (Sem III)	2	-	2	1	-	-	25	25	10	-
	TOTAL	**18**	**16**	**34**	**25**	**-**	**520**	**105**	**625**	**170**	**80**

SUBJECT: PHYSICS

M.SC. –I SEMESTER - I

MPFS11: PAPER- I MATHEMATICAL PHYSICS

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the concepts of mathematical physics regarding co-ordinate system, tensors, vector space
2. To disseminate the fundamental knowledge of Special functions and spherical harmonics
3. Provide opportunities for scientific study and creativity within a global context that will stimulate and challenge the students.

OUTCOMES:

1. Students gain knowledge of co-ordinate system, tensors, vector space,
2. They understand the special functions, their polynomial and applications
3. Apply the knowledge to solve problems based on above properties to strengthen their basics

Unit I **15 hrs.**

Curvilinear co-ordinate Systems, Physical ideas about gradient, divergence, and Curl, Fourier Series: Definition, Dirichlet's condition, Convergence, Fourier Integral and Fourier transform, Convolution theorem, Parseval's identity, Applications to the solution of differential equations,

Unit II15 hrs.

Elementary ideas about tensors, Cartesian tensors, differential of Cartesian tensors, gradient, divergence and curl, Laplacian of Cartesian tensors. Non-Cartesian tensors. Tensor densities and capacities. Differentiation of Non-Cartesian tensors, Christoffel symbols. gradient, divergence and curl, Laplacian of Non-Cartesian tensors Laplace transform of elementary functions – Inverse Laplace transforms – Methods of finding Inverse Laplace transforms – Heaviside expansion formula – Solutions of simple differential equations

Unit III **15 hrs.**

Linear vector spaces - linear independent bases, Dimensionality, inner product, matrices, linear transformation, Matrices- Inverse, Orthogonal and Unitary matrices, Cayley Hamilton theorem, eigen vectors and eigen value problem, Diagonalization, Complete orthonormal sets of function.

Unit-IV **15 hrs.**

Linear differential equations, Special Function- Laguerre, Hermite, Legendre polynomials, Special Bessel's function, Spherical harmonics, Generating Function and recursion relations, differential and integral form.

References:

1.Matrices and Tensor in Physics: A.W.Joshi

2. Mathematical Physics: H.K.Dass

3. Vector analysis – Newell

SUBJECT: PHYSICS

M.SC. –I SEMESTER - I

MPFS12: PAPER- II COMPLEX ANALYSIS AND NUMERICAL METHODS

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the knowledge of complex functions
2. To disseminate the fundamental knowledge of computational methods
3. Provide opportunities for scientific study and creativity

OUTCOMES:

1. Students gain knowledge of complex functions
2. They gain knowledge of various computational methods
3. Apply the knowledge to solve problems based on above properties to strengthen their concepts

Unit I **15 hrs.**

Definition of Complex Numbers, Equality of Complex Number, Complex Algebra, Conjugate Complex Numbers, Geometrical representation of Complex Number, Geometrical representations of the sum, difference, product and quotient of Complex Number, Cauchy Rieman Conditions, Analytic functions, multiply connected regions, Cauchy Theorem, Cauchy Integration formula, Derivatives, problems

Unit II **15 hrs.**

Singularities- Poles, Branch Points, Calculus of Residues-Residues Theorem, Cauchy Principle value, Pole Expansion of Meromorphic Functions, Product expansion of entire Functions, problems

UNIT III **15 hrs.**

Methods for determination of zeros and linear and non-linear single variable algebraic and transcendental equations, (Bisection method, false position method, iteration method, Newton-Raphson method, secant method), Finite differences. Newton's formulae (no proofs)

Unit IV **15 hrs.**

Lagrange's interpolation, Divided differences. Numerical integration, trapezoid rule, simpson's $1/3_{rd}$ rule, Simpson's $3/8_{th}$ rule, Linear least squares. Euler and RungeKutta methods for solving ordinary differential equations. (No proofs)

References:

1. Introductory Methods of Numerical Analysis: S S Sastry
2. Computer Oriented Numerical Methods: V Rajaraman
3. R. V. Churchill, Complex variables and Applications, 7th Edition McGraw Hill
4. Computer oriented Numerical Methods: R.S.Salaria
5. Mathematical Physics: H.K.Dass
6. Higher Engineering Mathematics: B. S. Grewal

SUBJECT: PHYSICS

M.SC. –I SEMESTER - I

MPFS13: PAPER- III ELECTRONICS

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the deep knowledge of solid state electronic devices
2. To disseminate the fundamental knowledge of digital and communication circuits and their profound applications
3. Provide opportunities for scientific study and creativity within a global context that will stimulate and challenge the students.

OUTCOMES:

1. Students understand the elementary basic semiconductor devices and their applications for various purposes
2. They understand the basics of digital systems and communication systems
3. Apply the knowledge to solve problems based on above properties to strengthen their basics

Unit I **15 hrs.**

Electronics Semiconductor discrete devices (characteristic curves and physics of p-n junction), Schottky, Tunnel and MOS diodes, Bipolar junction transistor, junction field effect transistor (JFET), Metal-oxide-Semiconductor Field effect transistor (MOSFET), unijunction transistor (UJT) and silicon-controlled rectifier (SCR), Opto-electronic devices (Photo-diode, solar cell, LED, LCD and photo transistor), Diffusion of impurities in silicon, growth of oxide.

Unit II **15 hrs.**

Applications of semiconductor devices in linear and digital circuits- Zener regulated power supply, Transistor (bipolar, MOSFFT, JFET) as amplifier, coupling of amplifier stages (DC, RC and Transformer coupling), RC-coupled amplifier, dc and power amplifier Feedback in amplifiers and oscillators (phase shift, Hartley, Colpitts and crystal controlled) clipping and clamping circuits. Transistor as a switch OR, AND and NOT gates (TIL and CMOS gates).

Unit III **15 hrs.**

Digital integrated circuits- NAND and NOR gates building block, X-OR gate, simple combinational Circuits -Half and full address, Flip-Flops, Multivibrators (using transistor) and sweep generator (using transistors, UJT and SCR). shift registers, counters, A/D and D/A converters, semiconductor memories (ROM, RAM, and EPROM, basic, architecture of 8-bit microprocessor (INTEL 8085). Linear integrated circuits-Operational amplifier and its applications-Inverting and non-inverting amplifier, adder, integrator, differentiator, waveform generator, comparator and Schmit trigger, Butterworth active filter, phase shifter,

Unit IV **15 hrs.**

Communication Electronics-Basic principle of amplitude frequency and phase modulation. Simple circuits for amplitude modulation and demodulation, digital (PCM) modulation and demodulation. Fundamentals of optical communication, Microwave Oscillators (reflex, klystron, magnetron and Gunn diode), Cavity resonators. Standing wave detector.

References:

1. A. Malvino and D. J. Bates: Electronic Principles (Mc Graw Hill Education, India)
2. Boylstad&Neshishkey, “Electronic devices & circuits” , PHI
3. Milliman, J. Halkias, “integrated elctronics”, Tata McGraw Hill
4. J. J. CatheySchaum’s Outlines “Electronic Devices & Circuits” Tata McGraw Hill.
5. J. D. Ryder,” Electronics Fundamentals and Applications”, John Wiley-Eastern Publications.
6. George Kennedy, “ Electronic Communication Systems”, Tata McGraw Hill.

SUBJECT: PHYSICS

M.SC. –I SEMESTER - I

MPFS14: PAPER- IV ELECTRODYNAMICS I

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the knowledge of electrostatics and magneto statics
2. To disseminate the fundamental knowledge of time varying fields
3. Provide opportunities for scientific study and creativity

OUTCOMES:

1. Students gain deep knowledge of various laws and theorems and expressions of electrostatics and magneto statics
2. They gain knowledge of time varying fields
3. Apply the knowledge to solve problems based on above properties to strengthen their concepts

Unit I **15 hrs.**

Electrostatics: Coulomb's law, Electric field, Charge distribution, Dirac delta function, Field lines, Gauss's law and applications, Differential form of Gauss's law, Electric potential, Poisson and Laplace's equations, Electrostatic potential energy.

Unit II **15 hrs.**

Electrostatics: Boundary value problems, Uniqueness theorems, Green's theorem, Method of images, Method of separation of variables (Cartesian Coordinates, Spherical and Cylindrical Coordinates), Multipole expansion.

Unit III **15 hrs.**

Magnetostatics: Biot-Savart law, Ampere's law, Differential form of Ampere's law, Vector potential, Magnetic field of a localized current distribution, magnetic moment, Magnetostatics boundary conditions, Magnetic Shielding.

Unit IV **15 hrs.**

Time varying fields: Faraday's law, Maxwell's displacement current, Maxwell's equations, Maxwell's equations in matter, Scalar and vector potentials, Gauge Transformation, Wave equations, Poynting's theorem, Conservation laws.

References:

1. Introduction to Electrodynamics, David J. Griffith, Prentice Hall of India Private Limited.
2. Classical Electrodynamics, John D. Jackson, Wiley Eastern Limited.
3. Classical Electrodynamics, Tung Tsang, World Scientific Publishing Private Limited.

SUBJECT: PHYSICS

M.SC. –I SEMESTER - I

MPFS15: PAPER- V PRACTICAL PAPER P1

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the practical knowledge of various computational methods and programming
2. To disseminate the practical knowledge of simple computer language and syntax
3. Provide opportunities for scientific study, experimentally

OUTCOMES:

1. Students develop experimental skills in programming to execute computational methods
2. They analyze experimental limitations and precautions
3. They become skillful to design and perform experiments with good accuracy

Note: instructor can introduce new and relevant experiments which are not in the list.

List of Practical:

1. To find the largest or smallest of a given set of numbers.
2. Bubble sort.
3. To generate and print first hundred prime numbers.
4. Matrix multiplication.
5. To generate and print an odd, ordered magic square.
6. Other exercises involving conditions, loop and array
7. Lagrange Interpolation.
8. Method of successive approximation
9. Bisection Method
10. Newton-Raphson Method.
11. Gaussian Elimination
12. Linear Least Squares Fit.
13. Simpson's rule integration.
14. Computation of special functions

SUBJECT: PHYSICS

M.SC. –I SEMESTER - I

MPFS16: PAPER- VI PRACTICAL PAPER P2

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the practical knowledge of basic component's characteristics
2. To disseminate the practical knowledge of digital and communication electronics
3. Provide opportunities for scientific study, experimentally

OUTCOMES:

1. Students develop experimental skills in amplifiers, diode, BJT, FET, logic gates, modulators and demodulators
2. They analyze experimental limitations and precautions
3. They become skillful to design and perform experiments with good accuracy

Note: instructor can introduce new and relevant experiments which are not in the list.

List of Practical:

1. Design of a regulated power supply.

2. Characteristics and applications of silicon-controlled rectifier.

3. Design of common emitter Power transistor amplifier.

4. Experiments on bias stability.

5. Negative feedback (Voltage series / shunt and current series / shunt).

6. Astable, Monostable and Bistable multivibrator.

7. Experiment on FET and MOSFET characterization and application as an amplifier.

9. Experiment on Uni-junction transistor and its application.

10. Digital – I: Basic, TTL, NAND and NOR.

11. Digital – II: Combinational logic.

12. Flip-Flops.

13. Study of modulation (FM, AM, etc.).

14. Operational Amplifier.

15. Differential Amplifier.

16. Microprocessor.

17. Verification of Biot-Savart law.

18. Verification of Faraday's Law

SUBJECT: PHYSICS

M.SC. –I SEMESTER - II

MPFS21: PAPER- I QUANTUM MECHANICS I

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the concepts of quantum mechanics with respect to initial development and various representations
2. To disseminate the fundamental knowledge of angular and generalized angular momenta
3. Provide opportunities for scientific study and creativity within a global context that will stimulate and challenge the students.

OUTCOMES:

1. Students gain knowledge of quantum mechanics with respect to initial development and various representations
2. They the fundamental knowledge of angular and generalized angular momenta
3. Apply the knowledge to solve problems based on above properties to strengthen their basics

Unit- I **15 hrs.**

Time dependent and time-independent Schrodinger equation, continuity equation, wave packet, admissible wave functions, stationary states. Formalism of wave mechanics, expectation values, quantum mechanical operators for position and momentum in the coordinate representation, Construction of quantum mechanical operators for other dynamical variables from those of position and momentum, Ehrenfest's theorem, momentum eigen functions in the coordinate Representation, box normalization and Dirac delta function. Coordinate and momentum representations, Schrodinger equation in momentum representation,

Unit-II **15 hrs.**

Brief revision of linear vector spaces, inner or scalar product, Schwarz inequality, state vectors, general formalism of operator mechanics vector, operator algebra, commutation relations, eigen values and eigen vectors, Hermitian operators degeneracy, orthogonality eigenvectors of Hermitian operators, noncommutativity of two operators and uncertainty in the simultaneous measurements of the corresponding dynamical variables, the fundamental expansion postulate, representation of state vector, Dirac's bra-ket notations. Matrix representation of operators, change of basis, unitary transformations, quantum dynamics, Schrodinger, Heisenberg, and interaction picture.

Unit-III **15 hrs.**

Solution of Schrodinger equation for simple problems, 1-D Square well, step and barrier potentials, 1-D harmonic oscillator, zero-point energy. harmonic oscillator problem by operator method. Angular momentum operator, commutation relations, expression for L_2 operator in spherical polar coordinates, Role of L_2 operators in central force problem, eigen value problem for L_2 , separation of Schrodinger equation in radial and angular parts, solution of radial equation for hydrogen atom, 3-d square well potential, parity of wave function, parity operator.

Unit-IV **15 hrs.**

Generalized angular momentum, raising, and lowering operators, matrices for J_2, Jx, Jy, Jz operators, Pauli spin matrices, Addition of angular momenta, Clebich-Gordon Coefficient, spin angular momentum, spin momentum functions.

References:

1. Quantum mechanics: L.I.Schiff
2. Quantum mechanics: Mathews and Venkatesan
3. Quantum mechanics :Ghatak and Loknathan
4. Quantum mechanics: B.Craseman and J.D.Powell
5. Modern quantum mechanics: J.J.Sakurai
6. Quantum Theory D. Bohm, (Asia Publishing House)

SUBJECT: PHYSICS

M.SC. –I SEMESTER - II

MPFS22: PAPER- II STATISTICAL PHYSICS

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the knowledge of classical and quantum stastics
2. To disseminate the fundamental knowledge of phase transition phenomenon
3. Provide opportunities for scientific study and creativity

OUTCOMES:

1. Students gain knowledge of Maxwell's Boltzman, Bose-Einstein and Fermi-Dirac stastics
2. They gain knowledge of terminology and kinetics of phase transitions
3. Apply the knowledge to solve problems based on above properties to strengthen their concepts

Unit I **15 hrs.**

Fundamentals of classical statistical mechanics, microstate and macrostate, distribution function, Liouville's theorem, Gibbs Paradox, ensembles (micro-canonical, canonical and grand-canonical), partition function, free energy and connection with thermodynamic quantities, energy, and density fluctuations

Unit II **15 hrs.**

Fundamentals of quantum statistical mechanics, BE and FD Statistics, Symmetry of wave functions, Boltzmann limit of Bosons and Fermions, Ideal Bose system: Bose-Einstein condensation, Behaviour of ideal Bose gas below and above Bose temperature, Photons and liquid helium as bosons.

Unit III **15 hrs.**

Ideal Fermi system: Weak and strong degeneracy, Fermi function, Fermi energy, Behaviour of ideal Fermi gas at absolute zero and below Fermi temperature, Fermionic condensation, Free electrons in metals as fermions, Electronic specific heat, Cluster expansion for classical gas, Virial equations of states.

Unit IV **15 hrs.**

Phase transition: Phase transition of first and second order, Landau theory of phase transition, Ising model, Order parameter, Critical exponents, Scaling hypothesis, Random walk, Brownian motion, Langevin theory, Correlation function and fluctuation dissipation theorem, Fokker-Planck equation. Weiss theory of ferromagnetism.

Text and Reference Books:

1. Fundamentals of Statistical Physics: B. B. Laud
2. Statistical Mechanics: R. K. Pathria
3. Statistical Mechanics: S. K. Sinha
4. Statistical and Thermal Physics: F. Reif
5. Statistical Mechanics: K. Huang
6. Statistical Mechanics: Loknathan and Gambhir
7. Statistical Physics: Landau and Lifshitz

SUBJECT: PHYSICS

M.SC. –I SEMESTER - II

MPFS23: PAPER- III CLASSICAL MECHANICS

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the deep knowledge of Newtonian, Lagrangian and Hamiltonian of the classical particles
2. To disseminate the fundamental knowledge of rigid dynamics and central force motion
3. Provide opportunities for scientific study and creativity within a global context that will stimulate and challenge the students.

OUTCOMES:

1. Students understand the Newtonian, Lagrangian and Hamiltonian equations of the classical particles
2. They understand the basics of rigid dynamics and central force motion
3. Apply the knowledge to solve problems based on above properties to strengthen their basics

Unit-I **15 hrs.**

Survey of elementary principles of mechanics of a particle, Dynamical systems, Phase space dynamics, stability analysis, constraints & their classifications, D'Alemberts Principle, Variational Principle, Lagrange's equation, Hamilton's Principle

Unit-II **15 hrs.**

Conservation theorems and symmetry properties, Hamiltonian formalism, Hamiltons equations, Routh's procedure for cyclic coordinates, conservation laws Canonical transformations, Poisson brackets and Poisson theorems, Hamilton-Jacobi Theory

Unit-III **15 hrs.**

Central force motion, reduction to one body problem, equations of motions and first integrals, classification of orbits for inverse square central forces. Two body collisions, Rutherford scattering in laboratory and centre-of-mass frames.

Unit-IV **15 hrs.**

Rigid body dynamics, Euler’s angles, Euler’s theorem, moment of inertia tensor, eigen values and principal axis transformation, non-inertial frames and Pseudo forces, Periodic motion, small oscillations, normal modes.

References:

1. Classical Mechanics: H. Goldstein

2. Classical Mechanics: N.C.Rana and P.S.Joag

SUBJECT: PHYSICS

M.SC. –I SEMESTER - II

MPFS24: PAPER- IV ELECTRODYNAMICS II

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the knowledge of electromagnetic waves and solutions under different fields
2. To disseminate the fundamentals of motion of a charged particles in EM field, wave guides
3. Provide opportunities for scientific study and creativity

OUTCOMES:

1. Students gain deep knowledge of electromagnetic waves and solutions under different fields
2. They gain knowledge of a charged particles in EM field, wave guides
3. Apply the knowledge to solve problems based on above properties to strengthen their concepts

Unit-I **15 hrs.**

Scalar waves: Plane waves, spherical waves, phase and group velocities and wave packets Vector waves: Electromagnetic plane waves, harmonic plane waves, elliptic linear and circular polarization, Stokes parameters (iii) Reflection and refraction of plane waves, Fresnel polarization on reflection and refraction, (iv) Propagation in dielectric films.

Unit-II **15 hrs.**

Symmetries of Maxwell equations: Lorentz transformations, Covariance of electrodynamics, Lorentz gauge condition, equation of continuity and Maxwell equations, electrodynamics field tensor and its transformation.

Unit-III **15 hrs.**

Motion of a charge in EM fields: Lorentz force, motion in uniform, static, electric and magnetic fields and combined static EM fields. Electric dipole, electric quadrupole and magnetic dipole radiation, Radiation by a moving charge: Lienard-Wiechert potentials of a point charge, Larmor's formula, Angular distribution of radiation. Fields and radiation of a localized oscillating source, Bremsstrahlung, Synchrotron radiation.

Unit-IV **15 hrs.**

Wave guides: fields on the surface and within a hollow metallic conductor, TE, TM, TEM modes in a rectangular and cylindrical wave guide, Resonant Cavities, Dielectric waveguides.

References:

1.Introduction to Electrodynamics: David Griffiths (PHI)

2. Electrodyanamics J. D. Jackson
3. Introduction to Electrodynamics, A. Z. Capri and P. V. Panat (Narosa)
4. Classical theory of fields, Landau &Lifshitz
5. Electrodynamics, W. Panofsky and M. Phillips
6. Principles of Optics, M. Born & E. Wolf Pergamon Press
7. Electromagnetism and Classified Theory, A. D. Barut, Dover

SUBJECT: PHYSICS

M.SC. –I SEMESTER - II

MPFS25: PAPER- V PRACTICAL PAPER P3

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the practical knowledge of modern physics experiments
2. To disseminate the practical knowledge of magnetic and electric field based experiments
3. Provide opportunities for scientific study, experimentally

OUTCOMES:

1. Students develop experimental skills in modern physics and magnetic and electric field based experiments
2. They analyze experimental limitations and precautions
3. They become skillful to design and perform experiments with good accuracy

Note: instructor can introduce new and relevant experiments which are not in the list.

List of Practical:

1. Study of B-H Curve
2. Determination of e/m of electron by normal Zeeman effect using Febry Perot Etalon.
3. Determination of Lande's factor of DPPH using ESR spectrometer
4. Determination of e/m by Thomson method.
5. Determination of e/m by Busch's helical beam method.
6. Study of paramagnetic to ferromagnetic phase transition.
7. Study of Paramagnetic salt by Guoy's balance
8. Differential scanning Calorimetry
9. Determination of Plank's constant.
10. Determination of Stephan's constant.
11. Simulation of Ising model.
12. Location of critical point in Ising model using Binder cumulant.
13. Simulation of random walk.
14. Simulation of mean field model of para-ferro transition.
15. Numerical solution of particle in a box.
16. Simulation of Maxwell's velocity distribution.

SUBJECT: PHYSICS

M.SC. –I SEMESTER - II

MPFS26: PAPER- VI PRACTICAL PAPER P4

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the practical knowledge of laser and fiber optics based experiments
2. To disseminate the practical knowledge of interferometers
3. Provide opportunities for scientific study, experimentally

OUTCOMES:

1. Students develop experimental skills in interferometer experiments and laser and fiber optics based experiments
2. They analyze experimental limitations and precautions
3. They become skillful to design and perform experiments with good accuracy

Note: instructor can introduce new and relevant experiments which are not in the list.

List of Practical:

1. Study of Focault pendulum
2. Study of Bifilar pendulum
3. Numerical aperture determination of Fibre optics cable
4. Study of bending loss in fiber optic waveguide
5. Thickness of thin wire with lasers
6. Measurement of wavelength of He-Ne laser light using ruler.
7. To study Faraday effect using He-Ne laser.
8. Simulation of simple pendulum
9. Simulation of compound pendulum
10. Simulation of planetary motion.
11. Study of four beam interferometer.
12. Study of characteristics of a Laser Diode

SUBJECT: PHYSICS

M.SC. –II SEMESTER - III

MPSS31: PAPER- I QUANTUM MECHANICS II

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the concepts of quantum mechanics with respect perturbation, variational WKB techniques
2. To disseminate the fundamental knowledge of identical particles and scattering
3. Provide opportunities for scientific study and creativity within a global context that will stimulate and challenge the students.

OUTCOMES:

1. Students gain knowledge of respect perturbation, variational WKB techniques
2. They the fundamental knowledge of identical particles and scattering
3. Apply the knowledge to solve problems based on above properties to strengthen their basics

Unit-I **15 hrs.**

Time independent perturbation theory, first order perturbation theory applied to nondegenerate states, second order perturbation extension to degenerate state, Application of perturbation theory to the ground state energy, He atom (calculation given in Pauling and Wilson), Normal and anomalous Zeeman effect, First order Stark effect in the ground and first excited states of H atom and second order Stark effect of H atom, an-harmonic oscillator.

Unit II **15 hrs.**

Time dependent perturbation theory, transition rate, Fermi Golden rule, constant perturbation harmonic in time, radiative transitions, absorption, and induced emission, atomic radiation, dipole approximation, Einstein's atomic radiation, Einstein's A and B coefficients and their calculations. Approximation methods: W. K. B. method and its application to barrier penetration. Variational principle and its application to simple cases like ground state of He atom and deuteron in Yukawa potential.

Unit III **15 hrs.**

System of identical particles, exchange and transposition operators, totally symmetric and antisymmetric wave function and their expressions for a system of non-interacting particles, statistics of systems of identical particles, Relation of statistics with spin, Ortho and para states of the helium atom and their perturbation by Coulomb repulsion. Hamiltonian of a molecule, Born-Oppenheimer approximation, outline of Heitler-London theory of the hydrogen molecule. Scattering theory, scattering cross-section in laboratory and centre of mass system, scattering by a central potential, Partial wave method, phase shifts and their importance, scattering by a square well potential and a perfectly rigid sphere, resonance scattering.

Unit IV **15 hrs.**

Relativistic wave equation, the Klein-Gordon equation, and initial difficulties in interpreting its solutions, Dirac's relativistic equation, Dirac's matrices, explanation of the spin of the electron, equation for an electron in an electromagnetic field and explanation of the magnetic moment due to the electron spin, spin-orbit interaction, solution for hydrogen atom in Dirac's theory, negative energy states and their qualitative explanations.

References:

1. E. Merzbacher, Quantum Mechanics (Wiley and Sons-Toppon)
2. J. L. Powell and B. Crasemann, Quantum mechanics (B I Publications)
3. L. I. Schiff, Quantum Mechanics (McGraw-Hill)
4. Quantum Mechanics: Aruldhas
5. Pauling and Wilson, Introduction to Quantum Mechanics
6. A.K. Ghatak and Lokanathan, Quantum Mechanics (Macmillan, India)
7. Quantum Mechanics: 500 problems with Solutions: Aruldhas (PHI)

SUBJECT: PHYSICS

M.SC. –II SEMESTER - III

MPSS32: PAPER- II SOLID STATE PHYSICS AND SPECTROSCOPY

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the knowledge of solid state physics, atomic and molecular spectra
2. To disseminate the fundamental knowledge of solid state physics, atomic and molecular spectra
3. Provide opportunities for scientific study and creativity

OUTCOMES:

1. Students gain knowledge of solid state physics, atomic and molecular spectra
2. They gain knowledge of solid state physics, atomic and molecular spectra
3. Apply the knowledge to solve problems based on above properties to strengthen their concepts

Unit-I **15 hrs.**

Order in Solids-Crystal classes and system, 2d and 3d lattices, Space groups, b Concept of point group, bonding of common crystal structure; reciprocal lattice, diffraction and structure factor, Miller and Bravais indices, Bonding, diffraction, and structure factor in solids, short- and long-range order in liquids and solids, liquid crystals, quasicrystals and glasses

Unit II **15 hrs.**

Defects: Vacancies, point defects, line defects and stacking faults, Burgers vector and Burger circuit, presence of dislocation, dislocation motion, perfect and imperfect dislocations, slip planes and slip directions, dislocation reactions **Dielectric Properties**: -Polarization mechanisms, Clausius-Mossotti equation, piezo, pyro and ferroelectricity

Unit III **15 hrs.**

Atomic Structure and Atomic Spectra: Quantum states of an electron in an atom. Electron spin. Spectrum of helium and alkali atom. Some features of one-electron and two electron atoms, Relativistic corrections for energy levels of hydrogen atom, hyperfine structure and isotopic shift, width of spectrum lines, LS & JJ couplings. Inner shell vacancy, X-rays and Auger transitions. chemical shift. Frank-Condon principle.

Unit IV **15 hrs.**

Molecular Structure and Molecular Spectra: Types of molecules, Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules. Morse potential energy curve, Molecules as vibrating rotator, Vibration spectrum of diatomic molecule, PQR branches. Elementary discussion of Raman, ESR and NMR spectroscopy, chemical shift

References:

1. Physics of Atoms and Molecules: Bransden and Joachain.
2. Introduction to Atomic Spectra: H.E. White.
3. Solid State Physics, Charles Kittel, John Willey & Sons
4. Molecular Spectra and Molecular Spectroscopy (Vol. 1), G. Herzberg
5. Introduction to Atomic Spectra: HG Kuhn
6. Fundamentals of molecular spectroscopy, C.B. Banwell
7. Introduction to molecular Spectroscopy , G. M. Barrow
8. Introduction to Solid State Physics: C. Kittle
9. Materials Science and Engineering: V. Raghavan
10. Solid State Physics: S. O. Pillai (New Age International 2006)

SUBJECT: PHYSICS

M.SC. –II SEMESTER - III

MPSS33: PAPER- III (CORE ELECTIVE E1.1): MATERIALS SCIENCE I

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the deep knowledge of phase diagram, phase transformation
2. To disseminate the fundamental knowledge of diffusion in solids, solid state ionics and solid state devices
3. Provide opportunities for scientific study and creativity within a global context that will stimulate and challenge the students.

OUTCOMES:

1. Students understand the phase diagram, phase transformation
2. They understand the basics of diffusion in solids, solid state ionics and solid state devices
3. Apply the knowledge to solve problems based on above properties to strengthen their basics

Unit-I **15 hrs.**

Equilibrium and kinetics: Stability and metastability, Basic thermodynamic functions, Statistical nature of entropy, Kinetics of thermally activated process.

Phase diagrams: The phase rule, free energy composition diagram, correlation between free energy and phase diagram, calculation of phase boundaries, thermodynamics of solutions, single component system (water), two component system containing two phases and three phases, Binary phase diagrams having intermediate phases, Binary phase diagrams with eutectic system. Lever principle, maximum, minimum, super lattice, miscibility gap, microstructure changes during cooling, application to zone refining.

Unit – II **15 hrs.**

Phase transformations: Time scale for phase changes, peritectic reaction, eutectoid and eutectic transformations, order disorder transformation, transformation diagrams, dendritic structure in alloys, transformation on heating and cooling, grain size effect on rate of transformation at constant temperature and on continuous cooling, grain size effect on rate of transformation, nucleation kinetics, growth kinetics, interface kinetics leading to the crystal growth.

Unit-III **15 hrs.**

Diffusion in solids: Fick's laws and their solutions, the Kirkendall effect, mechanism of diffusion, temperature dependence of diffusion co-efficient, self-diffusion, interstitial diffusion, the Snoek effect in diffusion, diffusion in ionic crystals, diffusion path other than the crystal lattice, thermal vibrations and activation energy, diffusion of carbon in iron.

Solid State Ionics: Definition, classification, and characteristic properties of solid electrolytes. Complex impedance spectroscopy, Arrhenius theory of ionic conductivity. Chemical sensors: Nernst equation, potentiometer and amperometry sensors for various gases, electrochemical redox-reaction, advantages of electrochemical sensors.

UNIT-IV **15 hrs.**

Solid state energy devices: Fundamental of Solar cells, Primary and secondary solid-state cells, advantages of lithium batteries, ion intercalation compounds for secondary cell, open circuit voltage and short circuit current, intercalation compounds for secondary cell, open circuit voltage and short circuit current, Energy density, power density. Fuel cells –advantages and disadvantages, classification, efficiency- emf of fuel cells, hydrogen/oxygen fuel cell, criteria for the selection electrode and electrolyte, methanol fuel cell, solid oxide fuel cells, phosphoric acid fuel cells, molten carbonate fuel cell, proton exchange membrane fuel cell, biochemical fuel cell.

References:

1. Vanvellak: Materials Science.
2. V. Raghvan: Materials Science.
3. D. Kingery: Introduction to ceramics.
4. R. E. Reedhil: Physical metallurgy.
5. Martin Start Sharger: Introductory materials.
6. Kittel: Solid state physics, Vth edition.
7. M. A. Azaroff: Elements of crystallography
8. Introduction to solid state theory: Modelung.

SUBJECT: PHYSICS

M.SC. –II SEMESTER - III

MPSS33: PAPER- III (CORE ELECTIVE E1.2): X-RAY I

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the knowledge of fundamentals of X-rays
2. To disseminate the fundamentals of absorption X-rays, X-ray spectroscopy, chemical effects in X-ray spectra
3. Provide opportunities for scientific study and creativity

OUTCOMES:

1. Students gain deep knowledge of fundamentals of X-rays
2. They gain knowledge of absorption X-rays, X-ray spectroscopy, chemical effects in X-ray spectra
3. Apply the knowledge to solve problems based on above properties to strengthen their concepts

Unit-I **15 hrs.**

Production of X-rays: Continuous and characteristic X-ray spectra. X-ray emission from thick and thin targets. Efficiency of X-ray production. Various types of demountable and sealed X-ray tubes. Basics of high-tension circuits and vacuum systems used for the operation of X-ray tubes. Synchrotron radiation: Production and properties of radiation from storage rings, Insertion devices.

Unit II **15 hrs.**

Absorption of X-rays: Physical process of X-ray absorption. Measurement of X-ray absorption coefficients. Units of dose and intensity. Radiography, Microradiography and their applications.
X–ray fluorescence: Fluorescence yield. Auger effect. X–ray fluorescence analysis and its applications. Techniques and applications of Photoelectron spectroscopy and Auger electron spectroscopy.

Unit III **15 hrs.**

X-ray spectroscopy: Experimental techniques of wavelength and energy dispersive x-ray spectroscopy. Bragg and double crystal spectrographs. Focusing spectrographs. Dispersion and resolving power of spectrographs, Photographic and other methods of detection, resolving power of detectors.

X–ray emission and absorption spectra. Energy level diagram. Dipole and forbidden lines, Satellite lines and their origin, Regular and irregular doublets. Relative intensities of Xray lines.

Unit IV **15 hrs.**

Chemical Effects in X-ray Spectra: Chemical effects in X-ray spectra. White line, Chemical Shifts of absorption edges, Fine structures (XANES and EXAFS) associated with the absorption edges and their applications.

Dispersion Theory: Dispersion theory applied to X-rays, Calculation of the dielectric constant, Significance of the complex dielectric constant, Refraction of X-rays, Methods for measurement of refractive index

References:

1. A. H. Compton and S. K. Allison: X-rays in Theory and Experiment

2. J. A. Nielsen and D. Mc. Morrow: elements of Modern X-ray Physics.

3. M. A. Blokhin: X-ray Spectroscopy.

4. E. P. Bertin: Principles and Practice of X-ray Spectrometric Analysis.

5. C. Bonnelle and C. Mande: Advances in X-ray Spectroscopy.

6. D. C. Koningsberger and R. Prins: X-ray Absorption Principles, Applications, Techniques of EXAFS, SEXAFS and XANES.

7. C. Kunz: Synchrotron Radiation.

SUBJECT: PHYSICS

M.SC. –II SEMESTER - III

MPSS33: PAPER- III (CORE ELECTIVE E1.3): NANOSCIENCE AND NANOTECHNOLOGY I

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the deep knowledge of nanoscience
2. To disseminate the fundamental knowledge of synthesis, characterization and applications of nanoparticles
3. Provide opportunities for scientific study and creativity within a global context that will stimulate and challenge the students.

OUTCOMES:

1. Students understand the nanoscience fundamentals
2. They understand the basics knowledge of synthesis, characterization and applications of nanoparticles
3. Apply the knowledge to solve problems based on above properties to strengthen their basics

Unit-I **15 hrs.**

Introduction to Nanoscience: Free electron theory (qualitative idea) and its features, Idea of band structure, Density of states for zero, one, two and three dimensional materials, Quantum confinement, Quantum wells, wires, dots, Factors affecting to particle size, Structure property relation, Size dependence properties. Determination of particle size, Increase in width of XRD peaks of nano-particles, Shift in photoluminescence peaks, Variation on Raman spectra of nano-materials.

Unit II: **15 hrs.**

Synthesis of Nanomaterials*:* Physical methods**:** High energy Ball Milling, Melt mixing, Physical vapour deposition, Ionised cluster beam deposition, Laser ablation, Laser pyrolysis, Sputter deposition, Electric arc deposition, Photolithography.

Chemical methods**:** Chemical vapour deposition, Synthesis of metal & semiconductor nanoparticles by colloidal route, Langmuir-Blodgett method, Microemulsions, Sol-gel method, Combustion method, Wet chemical method

Unit III: **15 hrs.**

Nanomaterials Characterizations*:* X-ray diffraction, UV-VIS spectroscopy, Photoluminescence spectroscopy, Raman spectroscopy, Transmission Electron Microscopy, Scanning Electron Microscopy, Scanning Tunnelling Electron Microscopy, Atomic Force Microscopy, Vibration Sample Magnetometer, Spintronics

Unit IV: 15 hrs.

Special Nanomaterials and Properties*:* Carbon nanotubes, porous silicon, Aerogels, Core shell structures. Self-assembled nanomaterials. Metal and semiconductor nanoclusters Mechanical, Thermal, Electrical, Optical, Magnetic, Structural properties of nanomaterials

References:

1. Nanotechnology: Principles &Practicals. Sulbha K. Kulkarni, Capital Publishing Co.New Delhi.

2. Nanostructures & Nanomaterials Synthesis, Properties & Applications**.** Guozhong Cao, Imperials College Press London.

3.Nanomaterials: Synthesis, Properties & Applications**.** Edited by A.S. Edelstein &R.C.Commorata.Institute of Physics Publishing, Bristol & Philadelphia.

4. Introduction to Nanotechnology. C.P. Poole Jr. and F. J.Owens, Wiley Student ed.

5. Nano: The Essentials. T.Pradeep , McGraw Hill Education.

6. Handbook of Nanostructures: Materials and Nanotechnology. H. S. Nalwa Vol 1- 5, Academic Press, Bostan.

7. Hand Book of Nanotechnology, Bhushan

8. Nanoscience and Technology: Novel Structure and Phenomena. Ping and Sheng

SUBJECT: PHYSICS

M.SC. –II SEMESTER - III

MPSS33: PAPER- III (CORE ELECTIVE E1.4): ATOMIC AND MOLECULAR PHYSICS I

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the knowledge of atomic spectra like electron spin, helium and alkali spectra NMR spectra
2. To disseminate the fundamentals of rotational and vibrational and electronic spectra
3. Provide opportunities for scientific study and creativity

OUTCOMES:

1. Students gain deep knowledge of atomic spectra like electron spin, helium and alkali spectra NMR spectra
2. They gain knowledge of rotational and vibrational and electronic spectra
3. Apply the knowledge to solve problems based on above properties to strengthen their concepts

Unit-I **15 hrs.**

Quantum states of an electron in an atomic Electron spin, spectrum of hydrogen, Helium and alkali atoms, Relativistic corrections for energy levels of hydrogen; Basic principles of interaction of spin and applied magnetic field. Concepts of NMR spectroscopy concepts of spin-spin and spin-lattice relaxation, chemical shift; spin-spin coupling between two and more nuclei; chemical analysis using NMR. Mossbauer effect-Recoil less emission of gamma rays, chemical shift, magnetic hyperfine interaction

Unit II **15 hrs.**

Electron spin resonance, experimental setup, hyperfine structure and isotopic shift, width of spectral lines, LS & JJ coupling, Zeeman, Paschen Back & Stark effect. Spontaneous and Stimulated emission, Einstein A & B Coefficients; LASERS, optical pumping, population inversion, rate equation, modes of resonators and coherence length, Role of resonant cavity, three and four level systems, Ammonia MASER, ruby, He-Ne, CO2, dye and diode lasers, Lasers applications

Unit III **15 hrs.**

Rotational, vibrational and Raman spectra of diatomic molecules, Quantum theory, Molecular polarizability, Intensity alteration in Raman spectra of diatomic molecules, Experimental setup for

Raman spectroscopy in the structure determination of simple molecules. polyatomic molecules, symmetric top asymmetric top molecules. Hunds rule.

Unit IV **15 hrs.**

Electronic spectra of diatomic molecules, Born Oppenheimer approximation, Vibrational Coarse structure of electronic bands, intensity of electronic bonds, Franck Condon principle, and selection rules, dissociation and pre dissociation, dissociation energy, rotational fine structure of electronic bands. General treatment of molecular orbitals, Hund's coupling cases.

References:

1. Molecular Spectroscopy: - Jeane L. McHale.
2. Mossbauer spectroscopy –M. R. Bhide.
3. NMR and Chemistry – J. W. Akitt.
4. Structural Methods in inorganic chemistry, E.A V.Ebsworth, D. W. H.Rankin, S.Crdock.
5. Introduction to Atomic Spectra – H. E. White.
6. Fundamental of Molecular Spectroscopy – C. B. Banwell.
7. Spectroscopy Vol. I, II and III, Walker and Straghen.
8. Introduction to Molecular Spectroscopy – G. M. Barrow.
9. Spectra of diatomic molecules – Herzberg.
10. Molecular spectroscopy – Jeanne L. McHale.

SUBJECT: PHYSICS

M.SC. –II SEMESTER - III

MPSS33: PAPER- III (CORE ELECTIVE E1.5): APPLIED ELECTRONICS I

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the knowledge of OPAMP, communication electronics and Microprocessor,
2. To disseminate knowledge of microwave devices
3. Provide opportunities for scientific study

OUTCOMES:

1. Students gain deep knowledge of OPAMP, communication electronics and Microprocessor,
2. They gain knowledge of knowledge of microwave devices
3. Apply the knowledge to solve problems based on above properties to strengthen their concepts

Unit-I **15 hrs.**

Operational Amplifiers, Block diagram of a typical operational amplifier, analysis, open loop configuration, inverting and non-inverting amplifiers, operational amplifier with negative feedback, voltage series feedback, effect of feedback on close loop gain, input resistance output resistance bandwidth and output offset voltage, voltage follower. Practical operational amplifier, input offset voltage, input bias current, input off set current, total output off set voltage, CMRR, frequency response, dc and ac amplifier, summing, scaling and averaging amplifier, instrumentation amplifier, integrator and differentiator. Application of Op-Amp as fixed and variable voltage regulator. Oscillators principles- Barkhausen criterion for oscillations, The phase shift oscillator, Weinbridge oscillator, LC tunable oscillator, multi-vibrators, mono-stable and astable, comparators, square wave and triangular wave generators

UNIT II **15 hrs.**

Communication electronics: Amplitude modulation, generation of AM waves, demodulation of AM waves, DS BSC modulation, generation of DSBSC waves, coherent detection DSBSC wave, SSB modulation, generation and detection of SSB waves, Vestigial sideband modulation, frequency division multiplexing (FDM). Microwave communication: Advantage and disadvantage of microwave transmission, loss in free space propagation of microwaves, atmospheric effect on propagation, Fresnel zone problem, ground refection, fading sources, detector components, antennas used in microwave communication systems

Unit – III **15 hrs.**

Microprocessor: Introduction to microcomputers, Memory. Input-output devices, interfacing devices.8085 CPU, architecture, bus timing, de-multiplexing, the address bus, generating control signals, instruction set, addressing modes, illustrative programmes, assembly language programmes, looping, counting, and indexing, counters and timing delay, stack and sub routings. read only memory (ROM) and applications. Random access memory (RAM) and applications, Digital to analogue converters. Ladder and weighted register types, analog to digital converters, successive approximations and dual slop converters, application of DAC and ADC

Unit – IV **15 hrs.**

Microwave devices: Klystrons, magnetrons, and travelling wave tubes, velocity modulation, basic principle of two cavity klystrons and reflex klystrons, principle of operation of magnetrons, Helix travelling wave tubes, wave modes, transferred electron devices, gunn effect, principle of operation, modes of operation, read diode, IMPATT diode, TRAPATT diode.

References:

1. Electronic devices and circuit theory: RobortBoylested and L. Nashdsky (PHI).
2. OP-Amps and linear integrated circuits: Ramakanth A. Gayakwad (PHI 2nd Edn).
3. Digital principles and Applications: A. P. Malvino and D. P. Leach (Ma-GrawHill).
4. Microprocessor architecture, programming and Application with 8085/8086, Ramesh S. Gaonkar (Wiley-Estern).
5. Microelectronics: Jacob Millman (Mc-Graw Hill International).
6. Optoelectronics: Theory and Practices: Edited by Alien Chappal (Mc Graw Hill).
7. Microwaves: K. L. Gupta (Wiley Ester New Delhi).
8. Advanced electronics communication systems: Wayne Tomasi (Phi Edn).
9. Fundamentals of microprocessors and Micro-computers: B. Ram. (Dhanpat Rao and Sons.).

SUBJECT: PHYSICS

M.SC. –II SEMESTER - III
MPSS34: PAPER- IV (SUBJECT CENTRIC CORE COURSE S1.1) NANOSCIENCE AND NANOTECHNOLOGY

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the knowledge of Nanomaterial synthesis and characterization
2. To disseminate the fundamentals of special nanomaterials
3. Provide opportunities for scientific study and creativity

OUTCOMES:

1. Students gain deep knowledge of Nanomaterial synthesis and characterization
2. They gain knowledge of special nanomaterials
3. Apply the knowledge to solve problems based on above properties to strengthen their concepts

Unit-I **15 hrs.**

Introduction to quantum physics, electron as waves, wave mechanics, Schrödinger equation and particle in a box, Free electron theory (qualitative idea) and its features, Idea of band structure, Density of states for zero-, one-, two- and three-dimensional materials, Quantum confinement, Quantum wells, wires, dots, Factors affecting to particle size, Size dependence properties. Determination of particle size, Increase in width of XRD peaks of nano-particles, Shift in photoluminescence peaks, Variation on Raman spectra of nanomaterials.

Unit II: Nanomaterials Synthesis **15 hrs.**

Physical methods: High energy ball milling, Physical vapour deposition, Ionised cluster beam deposition, Laser ablation, Laser pyrolysis, Sputter deposition, Electric arc deposition, Photolithography.

Chemical methods: Chemical vapour deposition, Synthesis of metal & semiconductor nanoparticles by colloidal route, Langmuir-Blodgett method, Microemulsions, Sol-gel
method, Chemical bath deposition, Wet chemical method.

Unit III: Nanomaterials Characterizations **15 hrs.**

X-ray diffraction, UV-VIS spectroscopy, Photoluminescence spectroscopy, Raman spectroscopy, Transmission Electron Microscopy, Scanning Electron Microscopy, Scanning Tunnelling Microscopy, Atomic Force Microscopy, Vibration Sample Magnetometer.

Unit IV: Special Nanomaterials and Properties **15 hrs.**

Special Nanomaterials: Carbon nanotubes, porous silicon, Aerogels, Core shell structures. Self-assembled nanomaterials. Properties of nanomaterials: Mechanical, Thermal, Electrical, Optical, Magnetic, Structural.

References:

a. Nanotechnology: Principles & Practicals. Sulbha K. Kulkarni ,Capital Publishing Co.New Delhi.

b. Nanostructures & Nanomaterials Synthesis, Properties & Applications. Guozhong Cao, Imperials College Press London.

c. Nanomaterials: Synthesis, Properties & Applications. Edited by A.S. Edelstein & R.C.Commorata. Institute of Physics Publishing, Bristol & Philadelphia.

d. Introduction to Nanotechnology. C.P. Poole Jr. and F. J.Owens, Wiley Student Edition.

e. Nano: The Essentials. T.Pradeep , McGraw Hill Education.

f. Handbook of Nanostructures: Materials and Nanotechnology. H. S. Nalwa Vol 1-5, Academic Press, Bostan..

g. Nanoscience and Technology: Novel Structure and Phenomena. Ping and Sheng

h. Hand Book of Nanotechnology, Bhushan

SUBJECT: PHYSICS

M.SC. –II SEMESTER - III

MPSS34: PAPER- IV (SUBJECT CENTRIC CORE COURSE S1.2) QUANTUM COMPUTING

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the knowledge of Quantum computing and quantum algoritham
2. To disseminate the practical knowledge of Quantum entanglement, quantum Cryptography
3. Provide opportunities for scientific study

OUTCOMES:

1. Students gain deep knowledge of Quantum computing and quantum algoritham
2. They gain knowledge of Quantum entanglement, quantum Cryptography
3. Apply the knowledge to solve problems based on above properties to strengthen their concepts

Unit-I **15 hrs.**

Introducing quantum mechanics:

Quantum kinematics, quantum dynamics, quantum measurements. Single qubit, multiqubits, gates. Density operators, pure and mixed states, quantum operations, environmental effect, decoherence. Quantum no-cloning, quantum teleportation.

Unit 2 **15 hrs.**

Introduction to quantum algorithms:

Deutsch-Jozsa algorithm, Grover's quantum search algorithm, Simon's algorithm. Shor's quantum factorization algorithm.

Unit 3 **15 hrs.**

Quantum Cryptography:

Cryptography, classical cryptography, introduction to quantum cryptography. BB84, B92 protocols. Introduction to security proofs for these protocols.

Unit 4 **15 hrs.**

Quantum Entanglement:

Quantum correlations, Bell's inequalities, EPR paradox. Theory of quantum entanglement. Entanglement of pure bipartite states. Entanglement of mixed states. Peres partial transpose criterion. NPT and PPT states, bound entanglement, entanglement witnesses

References:

Nielsen, Michael A., and Isaac L. Chuang. *Quantum Computation and Quantum Information.* Cambridge, UK: Cambridge University Press, September 2000. ISBN: 9780521635035.

N. David Mermin "Quantum Computer Science: An introduction" Cambridge University Press (2007).

SUBJECT: PHYSICS

M.SC. –II SEMESTER - III
MPSS34: PAPER- IV (SUBJECT CENTRIC CORE COURSE S1.3) DIGITAL ELECTRONICS AND MICROPROCESSOR

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the knowledge of microprocessor and digital electronics
2. Provide opportunities for scientific study

OUTCOMES:

1. Students develop of microprocessor and digital electronics
2. Apply the knowledge to solve problems based on above properties to strengthen their concepts

Unit-I **15 hrs.**

Logic gates: Characteristics of TTL, ECL, CMOS circuits with reference to fan in / out noise, speed, power dissipation with suitable examples. Simplifying logic circuits: Algebraic method SOP (minterm) and POS (maxterma) forms. Karnaugh mapping Fundamental products, pairs, gaurds, octats, Don't s care conditions. Complementary Karnaugh map. Diagonal adjacencies. NAND-NAND and NOT-NOR networks. Applications of K maps to half adder, full adder. Arithmetic circuits: Number representation. Binary point, negative numbers, sign and magnitude. 1s and 2 s complement adder, parallel binary adder, BCD addition, parallel BCD adder, binary multiplication and division

Unit – II **15 hrs.**

Multiplexers, demultiplexers: IC 74150 multiplexer and IC 74154 demultiplexer. Tristate buffers, their use in bus organization. Key board encoders, BCD, octal, Hex and scanned matrix keyboard. A/D and D/A converters: Weighted resistor and R-2R ladder D/A converters. A/D converter –parallel comparator and Application. ADC 0808, 08116/08117, DAC 0800, look up table, measurement of electrical and physical quantities.

Unit -III: **15 hrs.**

Memories Allied Devices: Design consideration of Bipolar RAM, MOS memory and dynamic RAM, ROM, EXROM and CCD. Read/Write operation. Expanding memory size word size and word capacity. FIFO and LIFO. Study of 7489 RAM and 745370 RAM and other chip. Magnetic bubble memories. Floppy disks-track and sector organization, data format Winchester disk (hard disk).

Unit – IV: **15 hrs.**

Microprocessor Architecture: Introduction to architecture, pin configuration etc. of 8086, The parts of up. CPU, memory requirements, numerical data, and representation of characters, microprocessor instructions, program storage, and instruction execution fetch and execute cycles, addressing modes including simple memory paging, direct scratch and pad addressing. The instruction set including memory reference, immediate conditional jump-shift, change control, stack and program counter, subroutines, flow charts, masking, simple programs. I/O Systems: Program interrupts including multiple interrupt priorities. Interfacing memory mapping, memory mapped, and I/P mapped I/O. Use of decoders, I/O posts. IC 8212, IC 8155 and IC8255 (with block diagram of internal circuits) Typical programs using these ICS.

References:

1. Design of Digital Systems: P. C. Pitman (Galgotia Pub).
2. Digital Computer Electronics: A. P. Malvino (TMH).35
3. Digital Fundamentals: T. L. Floyd (Universal Book Stall).
4. Theory and Problems of Digital Principles: R. L. Tokheim (TMH).
5. Modern Digital Electronics: R. P. Jain (TMH).

SUBJECT: PHYSICS

M.SC. –II SEMESTER - III

MPSS35: PAPER- V PRACTICAL PAPER P5

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the practical knowledge of spectroscopy and solid state experiments
2. To disseminate the practical knowledge of X-ray diffraction
3. Provide opportunities for scientific study, experimentally

OUTCOMES:

1. Students develop experimental skills in ionization potential, X-ray diffraction, stark effect, molecular spectra etc.
2. They analyze experimental limitations and precautions
3. They become skillful to design and perform experiments with good accuracy

Note: instructor can introduce new and relevant experiments which are not in the list.

List of Practical: (for core course)

1. Determination of ionization potential of lithium
2. X-ray diffraction by TELEXOMETER.
3. Study of emission spectra of iron (Iron arc).
4. Determination of Dissociation Energy of Iodine Molecule by photography of the absorption band of Iodine in the visible region.
5. Study of Stark effect
6. Study of Molecular Spectra
7. Determination of Rydberg's constant
8. Determination of Plank's constant
9. Study of Crystals
10. Study of line spectra

SUBJECT: PHYSICS

M.SC. –II SEMESTER - III

MPSS36: PAPER- VI PRACTICAL PAPER P6

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the practical knowledge of various optional subjects
2. Provide opportunities for scientific study, experimentally

OUTCOMES:

1. Students develop experimental skills in knowledge of various optional subjects
2. They analyze experimental limitations and precautions
3. They become skillful to design and perform experiments with good accuracy

Note: instructor can introduce new and relevant experiments which are not in the list.

General Practical: List of Practical:

1. Crystal structure determination by powder diffraction.
2. Study of microstructures of metal alloys.
3. Dislocation in alkali halide crystals.
4. Crystal growth from slow cooling of the melt.
5. Thermal analysis of binary alloy.
6. Differential thermal analysis of BaTiO3-PbTiO3 solid solution.
7. To study electrochemical method of corrosion control.
8. Dielectric behaviour of LiNbO3 and BaTiO3 in crystals and ceramics.
9. Electrical conductivity of ionic solids.
10. To test hardness of a material by Brinell hardness tester.
11. Photo elasticity study.
12. Multiple beam interferromentric study of surfaces.
13. Thermal conductivity of bad conductor.
14. Thermal expansion coefficient of metals.
15. Study of transport property in solid electrolytes.
16. Verification Nernst law/Oxygen sensor.
17. Determination of Thermoelectricity Power.

X-Rays

1. Study of Crystal Models.
2. X-ray Diffraction Photograph of a Metal Foil by transmission (Hull Method).
3. X-ray Diffraction Photograph of a Metal Foil by Back Reflection.
4. Powder Photograph by Debye Scherrer Method, Computer Analysis.
5. Laue Photograph and Gnomonic Projection.
6. Rotation oscillation Photograph.
7. Diffraction of X-rays by Liquids.
8. Bragg's Spectrometer: Uhler and Cooksey's method. 55
9. Bent Crystal (Cauchois) Transmission Type Spectrograph: Study of K and L
Absorption Edges.
10. Bent Crystal (Cauchois) Transmission Type Spectrograph: Study of K and L emission Spectra.
11. Measurement of Intensities of Emission Lines, Computer Analysis.
12. Study of Satellite Lines. 13. Analysis of XANES Spectrum, Computer Analysis.
14. Analysis of EXAFS Spectrum, Computer Analysis.
15. Determination of Planck's constant by X-rays.
16. X-ray Fluorescence Spectrum Analysis.
17. Absorption Coefficient for X-rays by G. M. / Scintillation Counter.
18. Characteristics of G. M. tube.
19. Compton Effect.
20. Operation of a Demountable X-ray Tube.

Nanoscience and Nanotechnology

1. Synthesis of metal oxide nanoparticles by wet chemical method.
2. Deposition of thin films by spray pyrolysis technique.
3. Synthesis of inorganic nanomaterials by combustion method.
4. Synthesis of nanomaterials by sol-gel method.
5. Synthesis of conducting polymer nanofibres by chemical oxidation method.
6. Study of optical absorption of nanoparticles.
7. Determination of particle size of nanomaterials from x-ray diffraction.
8. Study of photoluminescence of well-known luminescent nanoparticles.

9. Deposition of thin films by spin coating method.
10. Thermoluminescence study of nanomaterials.
11. Deposition of thin films by dip coating technique.
12. Study of particle size effect on luminescence.
13. Electrical characterization of nanostructured materials.
14. Synthesis of metal oxide nanoparticles by hydro-thermal method.
15. Deposition of thin film in vacuum.
16. Electrical resistivity of nanomaterials using four probe methods
17. Photoluminescence study of prepared red/blue/green luminescent nanomaterials.
18. Characterization of nanomaterials using SEM/TEM.
19. Computer modelling methods for studying materials on a wide variety of length and time scales.

Atomic and Molecular Physics

1. Study of line spectra on photographed plates/films and calculation of plate factor.
2. Verification of Hartman's dispersion formula.
3. Study of sharp and diffuse series of potassium atom and calculation of spin orbit interaction constant.
4. Determination of metallic element in a given inorganic salt.
5. To record the spectrum of CN violet bands and to perform vibrational analysis.
6. To record the visible bands of ALO and to perform vibrational analysis.
7. To photograph and analyse the reddish glow discharge in air under moderate pressure.
8. To photograph the analyse the whitish glow discharge in air under reduced pressure.
9. To perform vibrational analysis of a band system of N2.
10. To perform vibrational analysis of band system of C2
11. To photograph and analyse the line spectrum of Calcium atom.
12. To record/analyse the fluorescence spectrum of a sample.
13. To record/analyse the Raman spectrum of a sample.
14. Study of Hyperfine structure of the green line of mercury.
15. To photograph the (O, O) band of CuH and to perform rotational analysis.
16. Flashing & quenching in Neon Gas.
17. E/m of electron.
18. Experiments on Prism/Grating Spectrometer.

19. Wavelength of laser light.
20. Faraday effect with laser.
21. Michelson interferometer.
22. Analysis of ESR Spectra of transition metals.
23. Analysis of H-atom spectra in minerals.
24. Measurements of dielectric constant of polymer sheet at low frequency.
25. E.S.R. of DPPH.
26. To measure the dielectric constant and polarisation of unknown liquid.
27. To measure the dielectric constant of unknown wood at microwave frequency
28. To measure the ultrasonic velocity in unknown liquid.
29. He-Ne Layer
30. To study polarization of sodium light
31. To study polarization of light using Babinet compensator

SUBJECT: PHYSICS

M.SC. –II SEMESTER - IV
MPSS41: PAPER- I NUCLEAR AND PARTICLE PHYSICS

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the knowledge of nuclear properties, decay processes, elementary particles
2. To disseminate the fundamental knowledge of particles counters
3. Provide opportunities for scientific study and creativity

OUTCOMES:

1. Students gain knowledge of nuclear properties, decay processes, elementary particles
2. They gain knowledge of particles counters
3. Apply the knowledge to solve problems based on above properties to strengthen their concepts

Unit-I **15 hrs.**

Basic nuclear properties; size, radii, shape, and charge distribution, spin, parity, mass, binding energy, semi-empirical mass formula, liquid drop model, nuclear stability, laws of radioactive decay. Nature of nuclear force, elements of deuteron problem, n-n scattering, charge independence and charge symmetry of nuclear forces. Electric and magnetic moments of nuclei. Evidence for nuclear shell structure, single particle shell model-its validity and limitations.

Unit 2: **15 hrs.**

Elementary properties of alpha-, beta-, and gamma-, decay of nuclei, their classification, characteristics and selection rules. Elementary theories of alpha-, beta-, and gamma-, decay. Nuclear reactions- conservation laws, mechanism, and cross section. Nuclear reaction mechanism, compound nucleus, direct reactions. Fission and fusion reactions, nuclear energy, elements of nuclear power.

Unit 3: **15 hrs.**

Interaction of charged particles and electromagnetic radiation with matter. Principles of nuclear radiation detectors: G-M counter, proportional counter, Na(Tl) scintillation detector, semiconductor detectors. Elementary principles of particle accelerators: linear accelerators, Van de Graaf, cyclotron, betatron, synchrocyclotron, ion beam accelerators.

Unit 4: **15 hrs.**

Classification of elementary particles, strong, weak, and electromagnetic interaction. Gellmann-Nishijima formula Properties of hadrons, baryons, mesons, leptons, and quarks- their quantum numbers, charge, mass, spin, parity, iso-spin, strangeness etc. Symmetry and conservation laws. Elements of quark model and standard model. Higgs boson.

References:

1) Introductory Nuclear Physics: Kenneth S Krane, Wiley, New York ,1988.

2) Nuclear and Particle Physics: Brian Martin.

3) Atomic and Nuclear Physics: S.N. Ghoshal.

4) Introduction to Particle Physics: D. Griffiths.

5) Introduction to Nuclear Physics: F. A. Enge, Addison Wesley (1975)

6) Introductory Nuclear Physics: Burcham

SUBJECT: PHYSICS

M.SC. –II SEMESTER - IV
MPSS42: PAPER- II SOLID STATE PHYSICS

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the concepts of band theory and lattice dynamics
2. To disseminate the fundamental knowledge of Free electron theory and superconductivity
3. Provide opportunities for scientific study and creativity within a global context that will stimulate and challenge the students.

OUTCOMES:

1. Students gain knowledge of band theory and lattice dynamics
2. They the fundamental knowledge of Free electron theory and superconductivity
3. Apply the knowledge to solve problems based on above properties to strengthen their basics

Unit-I **15 hrs.**

Band Theory: Bloch theorem, the Kronig- Penney model, construction of Brillouin zones, extended and reduced zone schemes, effective mass of an electron, tight binding approximation. Fermi surface. Magnetic Properties: Quantum theory of paramagnetism, magnetism of iron group and rare earth ions, exchange interactions. Pauli paramagnetic susceptibility

Unit II **15 hrs.**

Lattice Dynamics: Energy of atomic motions, adiabatic principle, harmonic approximation, cyclic boundary condition. Lattice vibrations of linear monoatomic and diatomic chains. Dispersion relations, acoustic and optical phonons. Theories of lattice specific heat, Dulong and Petit's law, Einstein, and Debye models, T^3 law, Born procedure, anharmonicity and thermal expansion.

Unit III **15 hrs.**

Free Electron Theory: Electrons moving in one- and three-dimensional potential wells, quantum state and degeneracy, density of states, electrical and thermal conductivity of metals, relaxation time and mean free path, the electrical resistivity of metals, thermionic emission. Seebeck effect, thermoelectric power.

Semiconductors: Free carrier concentration in semiconductors, Fermi level and carrier concentration in semiconductors, effect of temperature on mobility, electrical conductivity of semiconductors, Hall effect in conductors and semiconductors

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Unit IV **15 hrs.**

Superconductivity, Type I and II super conductors, Meissner effect, isotope effect, London equation, coherence length, elements of B. C. S. theory, tunnelling DC and AC Josephson effect, Ginzberg-Landau Theory macroscopic quantum interference. Josephson junction. High temperature superconductor (elementary).

References:

1. C. Kittle: Introduction to Solid State Physics (2nd and 4th Edition).
2. A. J. Dekker: Solid State Physics.
3. Kubo and Nagamiya: Solid State Physics.
4. Feynman Lectures: Vol. III.
5. Board and Huano: Dynamical Theory of Crystal Lattice.
6. N. W. Ashcroft and D. Mermin: Solid State Physics.

SUBJECT: PHYSICS

M.SC. –II SEMESTER - IV

MPSS43: PAPER- III (CORE ELECTIVE E2.1) MATERIALS SCIENCE II

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the deep knowledge of mechanical response of materials, synthesis concept
2. To disseminate the fundamental knowledge of processing of materials and structure determination
3. Provide opportunities for scientific study and creativity within a global context that will stimulate and challenge the students.

OUTCOMES:

1. Students understand the mechanical response of materials, synthesis concept
2. They understand the basics of of processing of materials and structure determination
3. Apply the knowledge to solve problems based on above properties to strengthen their basics

Unit-I **15 hrs.**

Mechanical response of Materials: Elasticity, model of elastic response, inelasticity, viscoelasticity, stress-strain curves, concept of various mechanical properties such as hardness, yield strength, toughness, ductility, yield toughness, ductility, brittleness, stiffness, young modulus, shear modulus, shear strength, Frenkel model, Peierls-Nabarro relation, Plastic deformation, Corrosion and degradation of materials – electrochemical considerations – passivity forms of corrosion – corrosion inhibition.

Spintronics and Photonics: Spin glass, magnetic bubbles, domain walls, magnetic multilayers, magnenites, GMR and CMR, DMS materials. Photonic band gap materials.

Unit – II **15 hrs.**

Concept of Synthesis: Concept of equilibrium and nonequilibrium processing and their importance in materials science. Synthesis of materials: Physical method – Bottom up: cluster beam evaporation, Ion beam deposition, Gas evaporation, Chemical method – Hydrothermal, combustion, bath deposition with capping techniques and top down: Ball milling. Solvated metal atom dispersion – thermal decomposition – reduction methods – colloidal and micellar approach.

Unit-III **15 hrs.**

Processing of materials: Metallic and non-metallic, Ceramics and other materials. Only basic elements of powder technologies, compaction, sintering calcination, vitrification reactions, with different example, phenomenon of particle coalescence, porosity. Quenching: concept, glass formation structural characterization.

Diffraction techniques: interpretation of x-ray powder diffraction patterns, Identification & quantitative estimation of unknown samples by X-ray powder diffraction technique Electron and neutron diffraction.

Unit –IV **15 hrs.**

Structural determination by fluorescent analysis. Theory and method of particle size analysis. Integral breadth method, Warren-Averbach's Fourier method, profile fitting method. Microscopic techniques –TEM, SEM & STEM.AFM, EDX and XPS.

References:

1. Basic Solid-State Chemistry, 2nd Edition, Anthony R. West, John Wiley & Sons, 1996.

2. New Directions in Solid State Chemistry, C. N. R. Rao and J. Gopalakrishnan, Cambridge University Press, Cambridge, 1986.

3. Chemical approaches to the synthesis of inorganic materials, C. N. R. Rao Wiley Eastern Ltd.1994.

4. Materials Science and Engineering – An Introduction, W. D. Callister Jr. John Wiley & Sons,1991.

5. Materials Science, J. C. Anderson, K. D. Leaver, R. D. Rawlings and J. M. Alexander, 4th Edition, Chapman & Hall (1994).

6. Nanostructured Materials and Nanotechnology, Hari Singh Nalwa, Academic Press (1998).

SUBJECT: PHYSICS

M.SC. –II SEMESTER - IV
MPSS43: PAPER- III (CORE ELECTIVE E2.2) X-RAY II

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the knowledge of fundamentals of crystals
2. To disseminate the fundamentals of scattering of X-rays, X-ray crystallography, and structure analysis
3. Provide opportunities for scientific study and creativity

OUTCOMES:

1. Students gain deep knowledge of fundamentals of crystals
2. They gain knowledge of scattering of X-rays, X-ray crystallography, and structure analysis
3. Apply the knowledge to solve problems based on above properties to strengthen their concepts

Unit-I **15 hrs.**

Space lattice and unit cell of a crystal, Choice of a unit cell, Crystal systems, Bravais lattices, Crystal faces and internal arrangement, Miller indices, Law of rational indices, Indices of a direction. Point groups, Space groups. Perspective projections: Gnomonic projection, Stereographic projection, Orthographic projection. Reciprocal lattice concept: Graphical construction, Relation to interplanar spacing, Interpretation of Bragg's law.

Unit II **15 hrs.**

Scattering of X-rays: Thomson scattering, Compton scattering, Wave mechanical treatment of scattering, scattering by a pair of electrons, Theory of scattering by a helium atom, Scattering by many electrons, Experiments on scattering by monatomic and polyatomic gases, liquids and amorphous solids.

Unit III **15 hrs.**

Physical Basis of X-ray Crystallography: Atomic and crystal structure factors, Structure factor calculations, The integrated intensity of reflection. Different factors affecting the intensity of diffraction lines in a powder pattern. Dynamical theory X-ray diffraction. The Fourier Transform, electron density projections in crystals, Application to X-ray diffraction.

Unit IV **15 hrs.**

Experimental Methods of Structure Analysis: Laue method, Debye-Scherrer method, rotation Oscillation method, Weisenberg camera, the sources of systematic errors and methods of attaining precision. Principles of energy dispersive and time analysis diffractometry. Methods of detecting and recording diffraction patterns. Structures of metals and alloys. Phase transformations, Order-disorder phenomenon. Super lattice lines. Determination of grain size.

Other Diffraction Techniques: Electron and neutron diffraction techniques and their applications. Comparison with X-ray diffraction.

Reference Books:

1. A. H. Compton and S. K. Allison: X-rays in Theory and Experiment.
2. N. F.M. Henry, H. Lipson and W. A. Wooster: The interpretation of X-ray Diffraction Photographs.
3. K. Lonsdale: Crystals and X-rays.
4. B. D. Cullity: elements of X-ray Diffraction.
5. M. M. Woollfson: X-ray Crystallography.
6. M. J. Buerger: X-ray Crystallography.
7. Bacon: Neutron Physics.

SUBJECT: PHYSICS

M.SC. –II SEMESTER - IV
MPSS43: PAPER- III (CORE ELECTIVE E2.3) NANOSCIENCE AND NANOTECHNOLOGY II

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the deep knowledge of nanophotonics and nanomagnetics
2. To disseminate the fundamental knowledge of nanoelectronics and nanocomposites
3. Provide opportunities for scientific study and creativity within a global context that will stimulate and challenge the students.

OUTCOMES:

1. Students understand the concepts of nanophotonics and nanomagnetics
2. They understand the basics knowledge of of nanoelectronics and nanocomposites
3. Apply the knowledge to solve problems based on above properties to strengthen their basics

Unit-I **15 hrs.**

Nanophotonics: Fundamentals of photonics and photonic devices, Lasers, CFLs, LEDs, OLEDs, Wallpaper lighting, Display devices, X-ray imaging nanophosphers, Photo therapy lamps and its applications, Nanomaterials for radiation, Dosimetery special for thermoluminescence. Optical stimulated luminescence, Luminescence solar concentration.

Unit – II: Nanomagnetics: **15 hrs.**

Basics of Ferromagnetism, effect of bulk nano structuring of magnetic properties, dynamics of nanomagnets, nanopore containment, giant and colossal magnetoresistance, applications in data storage, ferrofluids, Superparamagnetism, effect of grain size, magneto-transport, Magneto-electronics, magneto-optics, spintronics.

Unit – III: **15 hrs.**

Nanoelectronics: Top down and bottom-up approach, CMOS Scaling, Nanoscale MOSFETs, Limits to Scaling, System Integration, Interconnects; NanoDevices: Nanowire Field Effect Transistors, FINFETs, Vertical MOSFETs, Other Nanowire Applications, Tunneling Devices, Single Electron Transistors, Carbon nanotube transistors, Memory Devices,

Unit – IV: **15 hrs.**

Nanocomposites*:* Classification of nanocomposites, Metallic, ceramic and polymer nanocomposites, Tribology of polymeric nanocomposites, Nano ceramic for ultra-high temperature MEMS, Optimizing nanofiller performance in polymers, Preparation techniques, Graphene/Fullerene/Carbon nanotube (CNT) polymer nanocomposites, One dimensional conducting polymer nanocomposite and their applications

References:

1. H.S.Nalwa; Hand book of Nanostructure materials and nanotechnology; (Vol.1-5), Acad. Press, Boston, 2000
2. C.P.Poole Jr., F.J.Owens; Introduction to Nanotechnology, John Wiley and sons, 2003
3. C. Furetta; Hand book of thermoluminescence; World Scientific Publ.
4. S.W.S. McKEEVER; Thermoluminescence in solids; Cambridge Univ. Press.
5. Alex Ryer; Light measurement hand book; Int. light Publ.
6. M.J.Weber; Inorganic Phosphors; The CRC Press.
7. T.J.Deming; Nanotechnology; Springer Verrlag, Berlin, 1999
8. W.D.Kalister Jr., Materials Science and Engineering, 6th Eds, WSE Wiley, 2003
9. Gusev; Nanocrystalline Materials
10. C. Delerue, M.Lannoo; Nanostructures theory and Modelling
11. Fausto, Fiorillo ; Measurement and Characterization of Magnetic materials
12. Bhushan; Hand Book of Nanotechnology
13. Janos H., Fendler; Nanoparticles and Nanostructured Films
14. T.Pradip; Nano: The Essentials
15. Liu; Hand Book of Advanced Magnetic Materials (4 Vol.)
16. Lakhtakia; Nanometer Structure.

SUBJECT: PHYSICS

M.SC. –II SEMESTER - IV

MPSS43: PAPER- III (CORE ELECTIVE E2.4) ATOMIC & MOLECULAR PHYSICS II

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the knowledge of time dependent quantum methods
2. To disseminate the fundamentals of saturation spectroscopy, raman stimulated scattering and matrix isolation spectroscopy
3. Provide opportunities for scientific study and creativity

OUTCOMES:

1. Students gain deep knowledge of time dependent quantum methods
2. They gain knowledge of saturation spectroscopy, raman stimulated scattering and matrix isolation spectroscopy
3. Apply the knowledge to solve problems based on above properties to strengthen their concepts

Unit-I **15 hrs.**

Time dependence in quantum mechanics, Time dependent perturbation theory, rate expression for emission, perturbation theory, calculation of polarizability. Quantum mechanical expression for emission rate. time correlation function and spectral Fourier transform pair, properties of time correlation functions and spectral time shape, Fluctuation dissipation theorem rotational correlation function and pure rotational spectra, Re-orientational spectroscopy of liquids.

Unit II **15 hrs.**

Saturation spectroscopy, Burning and detection of holes in Doppler broadened two level systems, Experimental methods of saturation spectroscopy in laser, Ramsey fringes, Saturation techniques for condensed matter application, Laser opto-galvanic spectroscopy. Two photon absorption spectroscopy, Selection rules, Expression for TPA cross section –photo acoustic spectroscopy, PAS in gaseous medium, Rosenzweig and Greshow theory, thermally thin, thick samples, Typical experimental set up, Application in Spectroscopy,

Unit III **15 hrs.**

Stimulated Raman scattering, Quantum mechanical treatment, Raman Oscillation Parametric instabilities, Electromagnetic theory of SRS. Vibronic interaction, Herzberg Teller theory, Fluorescence spectroscopy, Kasha’s rule, Quantum yield, non-radioactive transitions, Jablonski diagram, Time resolved fluorescence and determination of excited state lifetime. Light detectors, Single photon counting technique, Phase sensitive detectors.

Unit IV **15 hrs.**

Matrix isolation spectroscopy, Fourier transforms spectroscopy, Laser cooling. Molecular symmetry and group theory, Matrix representation of symmetry elementsof a point group, Reducible and irreducible representations, and character tables specially for C_{2v} and C_3 point group molecules, Normal coordinates normal modes, Application of group theory to molecular vibrations.

References:

1. Molecular Quantum Mechanics: P. W. Alkins and R. S., Fridman.
2. Quantum electron – A. Yariv.
3. Introduction to non-linear laser spectroscopy – M. D. Levenson.
4. Photoacoustics and its applications, Roseneweig.
5. J. M. Hollas, High resolution spectroscopy.
6. Cotton, Chemical Applications of Group Theory.
7. Herzberg, Molecular spectra and molecular structure II and III.
8. Demtroder, Laser spectroscopy and instrumentation.
9. King, Molecular spectroscopy.
10. Lakowicz, Principles of fluorescence spectroscopy.
11. Molecular Quantum Mechanics: P. W. Alkins and R. S., Fridman.

SUBJECT: PHYSICS

M.SC. –II SEMESTER - IV
MPSS43: PAPER- III (CORE ELECTIVE E2.5) APPLIED ELECTRONICS II

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the knowledge of communication electronics and computer communication system
2. To disseminate knowledge of microcomputers and memory devices
3. Provide opportunities for scientific study

OUTCOMES:

1. Students gain deep knowledge of communication electronics and computer communication system
2. They gain knowledge of microcomputers and memory devices
3. Apply the knowledge to solve problems based on above properties to strengthen their concepts

Unit-I **15 hrs.**

An Overview of Electronic Communication system; block diagram of an digital electronic Communication system, Pulse modulation systems, sampling theorem, lowpass and bandpass signals,PAM channel bandwidth for a PAM signal, Natural sampling, flat top sampling, signal recovery throughholding, quantization of signals, quantization, differential PCM delta modulation, adoptive delta modulation CVSD. Digital modulation techniques: BPSK, DPSK, QPSK, PSK, QASK, BFSK, FSK, MSK. Mathematical representation of noise, sources of noise, frequency domain representation of noise, Noise in Pulse Code and Delta modulation system, PCM transmission, calculation of quantization of noise, out pit signal power effect of thermal noise, outr signal to noise ratio in PCM, DM, quantization noise in DM, out put signal power, DM oput-put, signal to quantization noise ratio, effect of thermal noise in delta modulation, output signal to noise ratio in DM.

Unit – II: **15 hrs.**

Computer communication systems: Types of networks, design features of communication network, examples, TYMNET, ARPANET, ISDN, LAN. Mobile radio and satellite – time division multiplex access (TDMA) frequency division multiplex access (FDMA) ALOHA, Slotted ALOHA, Carrier sense multiple access (CSMA) Poisson distribution protocols.

Unit – III: **15 hrs.**

Microprocessor and Micro-computers: Microprocessor and architecture, Pin out and pin functions of 8086/8088 Internal microprocessor architecture, bus buffering and latching, Bus timings, ready and wait states, minimum mode versus and maximum mode. Real and protected mode of memory addressing, memory paging, addressing modes, data addressing modes, program memory addressing mode, stack memory addressing modes, instruction sets, data movement instruction, arithmetic and logic instruction, program control instruction, clock generator (8284A),

Unit –IV: **15 hrs.**

Memory and I/O Interface: Memory devices, ROM, RAM, DRAM, SRAM, Address decoding, 3-to-8-line decoder 74LS138, 8086, and 80386(16 bits) Memory interface, Introduction to I/O interface, Interfacing using 8255, Introduction to PIT 8254, Basic Communication device (UART) pin diagram and functioning of 16550 Interrupts: Basic interrupt processing, Hardware interrupt, expanding the interrupt structure, 8259A PIC.

References:

1. Principles of communication systems: Taub and Schilling (II Edn THM ,1994)

2. Principles of communication systems: Taub and Schilling GoutamSaha Third Edition

3. Communication systems: Simon Haykin (iii Edn John Wiley & Sons)

4. The intel microprocessors 8086/80188,80386,80486, Pentium and Pentium processor architecture, programming, and interfacing: Barry B. Brey (PHI iv Edn, 1999)

5. Microprocessor and interfacing, programming, and hardware: Douglas V. Hall (ii Edn, Mc GrawHill International edn. 1992)

6. The 80x86 IBMPC compatible computer: Muhammad Ali Maxidi and J.G. Mazidi (ii Edn.Prentice –Hall International.)

SUBJECT: PHYSICS

M.SC. –II SEMESTER - IV
MPSS44: PAPER- IV (SUBJECT CENTRIC CORE COURSE S2.1) EXPERIMENTAL TECHNIQUES IN PHYSICS

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the knowledge of radiation source, detectors and sensors
2. To disseminate the fundamentals of structure characterization, morphological and spectroscopic analysis
3. Provide opportunities for scientific study and creativity

OUTCOMES:

1. Students gain deep knowledge of radiation source, detectors and sensors
2. They gain knowledge of structure characterization, morphological and spectroscopic analysis
3. Apply the knowledge to solve problems based on above properties to strengthen their concepts

Unit-I **15 hrs.**

Radiation Sources, Detectors and Sensors: Different types of radiations (X-rays, UV-VIS, IR, microwaves and nuclear) and their sources

Detectors: gamma-rays, X-rays, UV-VIS, IR, microwaves and nuclear detectors

Sensors: Sensor's characteristics, Classification of sensors, Operation principles of sensors such as electric, dielectric, acoustic, thermal, optical, mechanical, pressure, IR, UV, gas and humidity with examples

Unit 2: **15 hrs.**

Structural Characterization and Thermal Analysis

X-ray Diffraction – Production of X-rays, Types (continuous and characteristics), Bragg's diffraction condition, principle, instrumentation (with filters) and working, Techniques used for XRD – Laue's method, Rotating crystal method, Powder (Debye-Scherrer) method, Derivation of Scherrer formula for size determination Neutron Diffraction: Principle, Instrumentation and Working

Thermal analysis: Principle, Instrumentation and Working: Thermo-gravimetric (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC); Graphical analysis affecting various factors. Numericals

Unit 3: **15 hrs.**

Morphological and Magnetic Characterization

Optical Microscopy: Principle, Instrumentation and Working of optical microscope.

Electron Microscopy: Principle, Instrumentation and Working of Scanning Electron Microscope (SEM), Field Emission Scanning Electron Microscope (FESEM) – Advantages over SEM, Transmission Electron Microscope (TEM), Selected Area Electron Diffraction (SAED)

Probe Microscopy: Principle, Instrumentation and Working of Scanning Tunneling Microscope (STM) and Atomic Force Microscope (AFM) Magnetic Characterization: Principle, Instrumentation and Working of Vibrating Sample Magnetometer (VSM), Analysis of Hysteresis loop, SQUID Technique: Principle, Instrumentation and Working. Numerical.

Unit 4: **15 hrs.**

Spectroscopic Analysis: Spectroscopic characterization (principle, instrumentation and working): Infra-Red (IR), Fourier Transform Infra-Red (FTIR), Ultraviolet-Visible (UV-VIS), Diffused Reflectance. Spectroscopy (DRS), X-ray Absorption (XPS), Electron Spin Resonance (ESR), Nuclear Magnetic Resonance (NMR). Numerical.

References:

1. Nuclear Radiation Detectors, S.S. Kapoor, V. S. Ramamurthy, (Wiley-Eastern Limited, Bombay)

2. Instrumentation: Devices and Systems, C.S. Rangan, G.R. Sarma and V.S.V. Mani, Tata Mc Graw Hill Publishing Co. Ltd.

3. Instrumental Methods of Chemical Analysis, G. Chatwal and S. Anand, Himalaya Publishing House

4. Instrumental Methods of Analysis by H.H. Willard , L.L. Merritt, J.A. Dean, CBS Publishers

5. Characterization of Materials, John B. Wachtman & Zwi. H. Kalman, Pub. Butterworth Heinemann (1992).

SUBJECT: PHYSICS

M.SC. –II SEMESTER - IV
MPSS44: PAPER- IV (SUBJECT CENTRIC CORE COURSE S2.2) COMMUNICATION ELECTRONICS

Marks- 100 **Time- 60 hours**

(This course cannot be offered to students opting for elective Applied Electronics-I and II)

OBJECTIVES:

1. To disseminate the knowledge of modulation and demodulation, propagation of radio waves
2. To disseminate the practical knowledge of antenna and transmission lines
3. Provide opportunities for scientific study

OUTCOMES:

1. Students gain deep knowledge of modulation and demodulation, propagation of radio waves
2. They gain knowledge of of antenna and transmission lines
3. Apply the knowledge to solve problems based on above properties to strengthen their concepts

Unit-I **15 hrs.**

Modulation AM and FM (Transmission and reception): Modulation, AM generation, Power consideration, Balanced modulator, SSB transmission, AM detection, AGC, Radio receiver characteristics, signal to noise ratio, FM analysis, noise considerations, generation, direct method and reactance tube method, FM transmitter, AFC, FM Propagation, phase discriminator.

UNIT II **15 hrs.**

(Propagation of radio waves) Ground wave, sky wave and space wave propagation. Ionosphere (Eccles- Larmer theory, magneto ionic theory).

UNIT III **15 hrs.**

(Antenna and TV) Antenna, HF antenna, Yagi antenna, loop antenna, Satellite communication, parabolic reflector, dish antenna, Fundamentals of image transmission, vestigial transmission, TV camera tubes, image orthicon, vidicon, TV transmitter, TV receiver and picture tubes.

UNIT IV **15 hrs.**

(Transmission Lines) Voltage and current relations on transmission line, propagation constant, characteristic impedance, impedance matching, quarter wave T/L as impedance transformer, attenuation along coaxial cable, cables of low attenuation, propagation of radio waves between two parallel lines, wave guide modes, TE10 mode and cut off wavelength, cavity resonator, light propagation in cylindrical wave guide, step index and graded index fibers, attenuation and dispersion in fibers.

References:

1. George Kennedy & Davis: Electronics Communication Systems
2. Millar & Beasley: Modern Electronics Communication
3. R.R Gulani: Monochrome and colour television (Wiley Eastern Limited)
4. Taub and Schilling: Principle of Communication Systems (TMH)
5. Simon Gaykuti: Communication Systems (John Wiley & Sons Inc. 1994)

SUBJECT: PHYSICS

M.SC. –II SEMESTER - IV

MPSS44: PAPER- IV (SUBJECT CENTRIC CORE COURSE S2.3) ELECTRO-ACOUSTICS

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the knowledge of ultasonics and acoustics
2. Provide opportunities for scientific study

OUTCOMES:

1. Students develop of ultasonics and acoustics
2. Apply the knowledge to solve problems based on above properties to strengthen their concepts

Unit-I **15 hrs.**

Fundamentals of ultrasonic, Acoustics interaction with liquids, Velocity in fluids, Absorption due to heat conduction and viscosity, single relaxation, internal degrees of freedom, Relaxation in binary mixtures, Normal and associated liquid essential difference in low and high amplitude ultrasonic wave propagation of low amplitude waves, ultrasonic generators piezoelectric effect. Propagation in Solids Attenuation due to electron phonon interaction; Phonon-Phonon interaction, Measurement Techniques, optical method, interference method, Pulse method, Sign-around method. Applications of ultra-sound in industrial and medical fields.

Unit - II **15 hrs.**

Architectural Acoustics, Classical ray theory. Decay of sound in live and in dead rooms, Measurement of reverberation time. Effect of absorption on reverberation, Sound absorption coefficient, absorbing materials and their uses. Fundamentals of musical scales. Physics of musical instruments. Public address system and music sound system for auditoria. Instruments used for acoustical tests. Underwater acoustics, Velocity of Sound in Seawater, sound transmission loss in seawater. Refraction Phenomena, Masking by noise and by reverberation, Passive detection hydrophone systems.

Unit – III **15 hrs.**

Loudspeakers, idealized direct radiator, Typical cone Speaker, Effect of voice coil parameters, Horn Loudspeakers, pressure response, Woofer, midrange and tweeter, Crossover networks, Fletcher

Munsion Curves, Baffles; Infinite type, vented type and acoustic suspension type, Microphones, Moving coil type, Carbon microphones, condenser microphones, Cardiod type, Polar response, Rating of microphone responses. Reciprocity theorem and calibration. RIAA equalization Preamplifiers, Tone control circuits, Equalization amplifiers, Noise filters, Dolby Noise Reduction, High Fidelity Stereo amplifiers, Recording and reproduction of sound.

Unit – IV **15 hrs.**

Noise Decibels and levels, dB Scales in acoustics, Reference Quantity for acoustic Power, intensity and pressure, Determination of overall levels from band levels, Basic sound measuring system using sound level meter. Octave band analyzer. Acoustic Calibrator, Definition of Speech interference levels (SIL), Noise criteria for various spaces. Nomogram relating SPL in octave bands to loudness in Tones, Computation of LL and SIL.

References:

1. Fundamentals of Acoustics: Kinsler and Fry, (Wiley Eastern).
2. Acoustics: Leo L. Beranek (John Wiley and Sons.).
3. Noise Reduction: L. L. Beranek.
4. Fundamentals of Ultrasonic: J. Blitz.
5. Ultrasonic Absorption: A. B. Bhatia.
6. Acoustical Test and Measurements: Don Davis

SUBJECT: PHYSICS

M.SC. –II SEMESTER - IV

MPSS46: PAPER- VI PRACTICAL PAPER P7

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the practical knowledge of general physics practical
2. Provide opportunities for scientific study, experimentally

OUTCOMES:

1. Students develop experimental skills in general physics practical
2. They analyze experimental limitations and precautions
3. They become skillful to design and perform experiments with good accuracy

Note: Instructor can introduce new and relevant experiments which are not in the list.

List of Practicals (for core course)

1. Measurement of resistivity of a semiconductor by four probe methods at two different temperatures and determination of band gap energy.
2. Measurement of Hall coefficient of given semiconductor: identification of type of semiconductor and estimation of charge carrier concentration.
3. Determination of Hall life of ‘In”.
4. Determination of range of Beta-rays from Ra and Cs.
5. G-M counter
6. Magnetoresistance by Hall effect
7. Determination of Dielectric constant
8. Random decay of nuclear disintegration using dice (or simulation)

SUBJECT: PHYSICS

M.SC. –II SEMESTER - IV

MPSS46: PAPER- V PRACTICAL PAPER P8

Marks- 100 **Time- 60 hours**

OBJECTIVES:

1. To disseminate the research skill
2. Provide opportunities for scientific projects

OUTCOMES:

1. Students develop experimental skills in research
2. They analyze experimental limitations, precautions and future scope

Project Work (Theoretical/Experimental work, Thesis submission and Defence)

Each student has to take a part time project for the duration of one semester (4^{th} semester) in the field of Physics under the supervision of assigned faculty. Student's M.Sc project thesis will be reviewed and he/she has to defense his/her thesis by giving 30 min seminar+Viva on the project results in front of the Examiners.