Maa Shakumbhari University, SAHARANPUR U.P.

माँ शाकुम्भरी विश्वविद्यालय, सहारनपुर, उत्तर प्रदेश

Syllabus of

M.Sc. Physics (Nanoscience)

M.S. University

Campus Saharanpur

(For fourth and fifth years of Higher education)

(As per guidelines of U.P. Government according to National Education Policy-2020 w.e.f. the session 2024-2025)

Members of the Board of Studies:

S. No	Name	Signature
1.	Prof. Garima Jain, Convener and Dean, Science faculty	
2.	Prof. Ashok kumar Dimri	
3.	Dr. Sanjay Kumar Singh	
4.	Prof. Beer Pal Singh, External Expert	
5.	Prof. R S Singh, External Expert	

Year	Semester	course Code	Course Title	Core Compulsory / Elective/ Value Added	Theory/ Practical / Project	Credits	Internal Marks	External Marks (Min Marks)	Total Marks	Minimum Marks (Int+Ext.)	Teaching Hours
Year-4 as per NEP-2020/Year-1	Semester-VII as per	0720101	Mathematical Methods	Core Compulsory	Theory	4	25	75(25)	100	40	60
		0720102	Classical Mechanics	Core Compulsory	Theory	4	25	75(25)	100	40	60
		0720103	Quantum Mechanics I	Core Compulsory	Theory	4	25	75(25)	100	40	60
		0720104	Semiconductor Physics and Devices	Core Compulsory	Theory	4	25	75(25)	100	40	60
		0720180	PHYSICS LAB I	Core Compulsory	Practical	4	-	100	100	40	60
	Semester-VIII as per	0820101	Statistical Mechanics	Core Compulsory	Theory	4	25	75(25)	100	40	60
		0820102	Electrodynamics Physics	Core Compulsory	Theory	4	25	75(25)	100	40	60
		0820103	Atomic and Molecular physics	Core Compulsory	Theory	4	25	75(25)	100	40	60
		0820104	Nuclear and Particle Physics	Core Compulsory	Theory	4	25	75(25)	100	40	60
		0820180	PHYSICS LAB II	Core Compulsory	Practical	4		100	100	40	60

Year-4 as per NEP-2020/Year-I	Semester-IXasperNEP-2020/Semester-III	0920101	OP-Amp Applications & Digital Electronics	Core Compulsory	Theory	4	25	75 (25)	100	40	60
		0920102	Condensed Matter Physics	Core Compulsory	Theory	4	25	75 (25)	100	40	60
		0920103	Introduction to Nano Science & Technology	Core Compulsory	Theory	4	25	75(25)	100	40	60
		0920180	Lab Work(based on the Contents of Theory Courses)	Core Compulsory	Practical	4	-	100	100	40	60
		0920165	Research Project	Core Compulsory	Project	4			100	40	
	Semester-XasperNEP-2020/Semester-IV	1020101	Quantum Mechanics-II	Core Compulsory	Theory	4	25	75 (25)	100	40	60
		1020102	Synthesis of Nanomaterials	Core Compulsory	Theory	4	25	75 (25)	100	40	60
		1020103	Characterization of Nano materials	Core Compulsory	Theory	4	25	75 (25)	100	40	60
		1020180	Lab Work (based on the contents of Theory Courses)	Core Compulsory	Practical	4	-	100	100	40	60
		1020165	Research Project	Core Compulsory	Project	4			100 .	40	

Programme/Class: **Master of Science/M.Sc**	Year: 4	Semester: 7
Subject: **PHYSICS**		
Course Code: **0720101**	Course Title: **Mathematical Methods**	

Course outcomes:
After completing this course students will be able to understand

- The research problems based on the complex variables and integral of complex functions,
- The solution of various mathematical equations using Laplace transformation.
- Fourier series and transformation in some spectroscopic analysis.
- Special functions and polynomials of this course which may imparts skills for direct employability.
- The use of mathematical methods in various branches of physics and engineering.

Credits: 4	Core Compulsory / Elective: Core compulsory
Max. Marks: 75 + 25	Min. Passing Marks: 40

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	**Special functions and polynomials** Legendre, Hermite and Laguerre polynomials and their generating functions. Recurrence relations and special properties of $P_n(x)$ as solution of Legendre differential equation. Rodrigues formula, orthogonality of $P_n(x)$, associated Legendre polynomials (Introduction only). Bessel function of first kind, generating function, recurrence relations, $J_n(x)$ as solution of Bessel differential equation, Expansion of $J_n(x)$ when n is half and odd integer, Integral representation	20
II	**Complex Analysis:** Complex Variables, Function of a complex variable, Analytic Function, Cauchy Riemann conditions, Complex Integration, Cauchy's integral theorem Cauchy's integral formula, Taylor's and Laurent's Series (without derivation) Singularities, zeros and residue of complex function, Cauchy's Residue theorem, Evaluation of definite integrals of the type: $\int_{-\infty}^{\infty} f(Sin\theta, Cos\theta)\, d\theta \quad \int_{-\infty}^{\infty} f(x)dx$ and $\int_{-\infty}^{\infty} f(x)e^{iax}dx$	15

III	**Fourier Series and Fourier Integral:** Fourier series, Even and Odd function, Half range expansion, Function of arbitrary period, Physical applications of Fourier Series analysis, Fourier integral, Fourier integral for even and odd functions and its application.	10
IV	**Integral Transforms:** Laplace Transform, First and second shifting theorems, Inverse LT by partial fractions, LT of derivative and integral of a function, Solution of initial value problems by using LT Fourier Transform, Fourier Cosine Transform, Fourier Sine Transform, two dimensional and three-dimensional Fourier transform, Fourier Transform of delta and Gaussian function	15

Suggested Readings:

1. Kreyszig, E. "Advanced Engineering Mathematics" John Wiley & Sons.

2. Rajput, B.S., "Mathematical Physics" Pragati Prakashan, Meerut.

3. Das,H.K., "Mathematical Physics"

Suggestive digital platforms web

links-

1. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx
2. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
3. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd

Suggested Continuous Evaluation Methods:

Continuous Internal Evaluation (CIE) of 25 marks shall be based on Class tests, assignments, presentations, etc. as per revised NEP guidelines.

Programme/Class: **Master of Science/M.Sc**	Year: 4	Semester: 7
Subject: **PHYSICS**		
Course Code: **0720102**	Course Title: **Classical Mechanics**	

Course outcomes:

After completing this course students will be able to understand.

- Fundamental concepts of dynamics of the system of particles, related conservation theorems, equations of motion for mechanical systems using the Lagrangian and Hamiltonian formulation. The main course outcomes are as follows:
- The mechanics of dynamical systems using Lagrange's equations of motion for conservative and non-conservative systems through Lagrangian formulation.
- The variational principle and its application to solve mechanical problems using Lagrangian formulation.
- The problem of two bodies moving under the influence of a mutual central force motion.
- The theory of small oscillations applied in many physical applications.

Credits: 4	Core Compulsory / Elective: Core compulsory
Max. Marks: 75 + 25	Min. Passing Marks: 40

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	**Preliminaries:** Newtonian mechanics of a particle, Mechanics of a system of particles, Constraints; their classification, D'Alembert's principle, Virtual work, generalized coordinates and derivation of Lagrange's equations, Velocity-dependent potentials and the Dissipation function, Applications of Lagrangian formulation, Generalized velocity, momentum and energy, Cyclic coordinates, Symmetries of space and time with conservation laws.	15
II	**Variational Principles and Hamilton Formalism:** Hamilton's principle, some techniques of the calculus of variations, Derivation of Lagrange's equation from Hamilton's principle, advantages of variational principle formulation, Principle of least action, Legendre transformations and Hamilton equations of motion, Cyclic coordinates and conservation theorems, Canonical transformation generating functions. Properties, Poisson bracket, Poisson theorem, Relation of Poisson brackets, Hamilton Jacobi method.	15

III	**Two Body Central Force Problem:** Reduction to the equivalent one-body problem, Motion in a central force field, The Virial theorem, The inverse square law of force, The motion in central force in the Kepler problem.	15
IV	**Rigid Body Dynamics and Small oscillations:** Rotational motion, Moment of Inertia, Euler's theorem, Euler's Angles, Symmetric top, Concept of small oscillations, Expression of kinetic energy and potential energy for the problem of small oscillations, Frequencies of free vibration, and Normal coordinates.	15

Suggested Readings:

1. Goldstein, H., "Classical Mechanics"
2. Rana, N.C. & Joag P.S., "Classical Mechanics"
3. Sommerfield A., "Physics"
4. Perceival & Richards D., "Introduction to Dynamics"

Suggestive digital platforms web links-

1. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx
2. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
3. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd

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Programme/Class: **Master of Science/M.Sc**	Year: 4	Semester: 7
Subject: **PHYSICS**		
Course Code: 0720103	Course Title: **Quantum Mechanics I**	

Course Outcomes:

After completing this course students will be able to understand

- The physical and mathematical basis of quantum mechanics for non-relativistic systems.
- The mathematical tools needed to develop the formal theory of quantum mechanics.
- The measurement process in quantum mechanics.
- The connection between measurement of results and the uncertainty relation.
- The application of wave function theory in quantum mechanics.
- The applicability of angular momenta in several branches of physics.
- The profound strength of approximate methods in problems like Stark effect, Zeeman effect, etc.

Credits: 4	Core Compulsory / Elective: Core compulsory
Max. Marks: 75 + 25	Min. Passing Marks: 40

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	**Fundamental Concepts:** Schrodinger equations : Time dependent and time independent, Operators, Probability density, Expectation values. Principle of Superposition, Motion of wave packets, Eigen values and eigen vectors, Bound and continuum states, Postulates of Quantum mechanics, Coordinate and momentum representation, Hermitian operators, Degeneracy, Orthonormality and Completeness, Unitary Operators, Change of basis, Infinitesimal and finite unitary transformations, Commutator Algebra, Uncertainty relation between two operators, Free particle radial wave function, Spherical well, Cylindrical well, Charge particle in a magnetic field and Hydrogen atom.	20
II	**Representation and Transformations:** Hilbert Spaces. Vector and Bases. Dirac notation. Matrix representations of Kets, Bras and Operators, Matrix representation of Eigen value problem, Linear harmonic oscillator in matrix formulation, Space and time displacements, Rotation generators, Symmetry and conservation laws. Symmetric and anti-symmetric wave-functions and Pauli Exclusion Principle.	12
III	**Approximate Methods:** Time independent first and second order perturbation theory for non-degenerate and degenerate levels, Variational method. and its application for Helium atom, WKB Approximation. Application of electric field (Stark effect), normal and anomalous Zeeman Effect.	14

IV	**Theory of Angular momentum:** Commutation relations involving angular momentum operators, the eigenvalue spectrum. Infinitesimal and finite rotations, Matrix representation of J, Addition of angular momentum, Clebsch- Gordon coefficients, Spin angular momentum, Spin wave functions, Pauli matrices, Precession of an electron in magnetic field, Addition of spin and orbital angular momentum.	14

Suggested Readings:

1. Liboff, R.L., "Introductory Quantum Mechanics".
2. Tyagi, I.S., "Principle of Quantum Mechanics".
3. Khare, S.P., "Quantum Mechanics and Atomic Physics".
4. Schiff, L.I., "Quantum Mechanics".
5. Zettili, N., "Quantum Mechanics: Concepts and Applications".
6. Griffiths, D.J., "Introduction to Quantum Mechanics".

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3. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd

Suggested Continuous Evaluation Methods: Continuous Internal Evaluation (CIE) of 25 marks shall be based on Class tests, assignments, presentations, etc. as per revised NEP guidelines.

Programme/Class: **Master of Science/M.Sc**	Year: 4	Semester: 7
Subject: **PHYSICS**		
Course Code: 0720104	Course Title: **Semiconductor Physics and Devices**	

Course Outcomes:

After completing this course, students will be able to understand

- The conduction mechanism of elemental and compound semiconductors for designing the electronic components and circuits.
- Basic phenomenon of semiconductors, it can be used for the fabrication of modern devices.
- Having the knowledge of semiconductors, junction diodes, transistor biasing, feedback in amplifiers & Operational amplifier, students may perform better in competitive exams as well as may understand semiconductor and microelectronic Industries and find job opportunities in communication and telecommunication sectors also.

Credits: 4	Core Compulsory / Elective: Core compulsory
Max. Marks: 75 + 25	Min. Passing Marks: 40

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	**Conduction Mechanism in Semiconductors:** Classification of semiconductors -Elemental and compound semiconductors, Direct band and indirect band gap semiconductors, The Fermi Level, Carrier concentrations; electron and hole concentrations at equilibrium, temperature dependence of carrier concentrations, degenerate semiconductors, drift of carriers in electric and magnetic fields; The Hall effect, conductivity and mobility, effect of temperature and doping on mobility,, Diffusion of carriers in semiconductors; generation and recombination, The continuity equation.	10
II	**Junction-diode and Bipolar Junction Transistors:** The Contact Potential and space charge region, Band diagram of P-N junction, Reverse bias breakdown, Zener diode, Tunnel diode. Metal semiconductor junction, Schottky diode. Transistor current components and parameters, Transistor CB, CE, CC configurations, Input output characteristics, Early Effect and base width modulation. Transistor load lines, Transistor as an amplifier, Graphical analysis of the CE configuration. Transistor biasing and thermal stabilization.	15

III	**Field Effect Transistors:** Construction and characteristics of JFET, transfer characteristics, The FET small signal model, Measurement of gm and rd, JFET fixed-bias, Self-bias and voltage divider configurations, JFET source follower (common-Drain configuration), JFET Common–Gate configuration, Depletion and enhancement type MOSFETs. Idea of NMOS, PMOS and CMOS.	15
IV	**Feedback in Amplifiers and Basics of Operational Amplifiers:** Feedback concept, Effect of negative feedback, Voltage-series feedback, Current-series feedback, Voltage-shunt feedback, Current-shunt feedback. Differential amplifier and its configurations, Op-Amp Block diagram, Schematic symbol and terminals of 741, D.C. power supplies for an Op-Amp, Ideal Op-Amp, Equivalent circuit of an Op-Amp, Important characteristics of an ideal Op-Amp, Practical Op-Amp characteristics, Ideal voltage transfer curve, Open loop operation of an Op-Amp. Op-Amp with negative feedback (closed loop configuration), concept of virtual short and virtual ground. Inverting and non-inverting amplifiers.	20

Suggested Readings:

1. Sze, S.M. & Kwok, K. Ng, "Physics of Semiconductor Devices".
2. Streetman, B.G., "Solid State Electronic Devices".
3. Boylestad, R.L. & Nashelsky, L., "Electronic Devices and Circuit Theory".
4. Millman, J. & Halkias, C.C., "Integrated Electronics".
5. Chattopadhyay, D & Rakshit, P. C., "Electronics Fundamental and Application".
6. Kumar, Balbir & Jain, S.B., "Electronic Devices and Circuits".

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Suggested Continuous Evaluation Methods:

Continuous Internal Evaluation (CIE) of 25 marks shall be based on Class tests, assignments, presentations, etc. as per revised NEP guidelines.

Programme/Class: **Master of Science/M.Sc**	Year: 4	Semester: 7
Subject: **PHYSICS**		
Course Code: 0720180	Course Title: **PHYSICS LAB I**	

Course Outcomes:

After completing this course students will be able to understand

- The basic concepts of electronics/nuclear physics through experiments.
- The concepts studied by them in the theory course and correlate with experimental observations.
- The student will gain practical knowledge of designing, assembling, and testing electronics circuits as well as understanding troubleshooting.
- The student would be equipped with an in-depth knowledge of Physics that can be applied in higher studies in every field of Physics.

Credits: 4	Core Compulsory / Elective: Core Compulsory
Max. Marks: 100	Min. Passing Marks: 40

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-18

List of Experiments-

Choose any **six** experiments from the given list.

1. To study the frequency response and to calculate the various parameters such as input Impedance, output impedance, current gain and voltage gain of the emitter follower.
2. To study the Drain characteristics and Mutual characteristics of a N/P channel MOSFET
3. To study the characteristics of a junction field effect transistor and to calculate the various parameters as

   (a) drain dynamic resistance (b) mutual conductance (c) amplification factor
4. To study and compare the following transistor biasing techniques and calculate the Bias voltage and transistor currents in-

   (a) Single battery biasing (b) Two battery biasing (c) Voltage divider bias (d)Collector to base bias
5. To study the forward and reverse bias characteristics of the following diodes-

   (a) Germanium diode (b) Silicon diode (c) Zener diode (d) Light emitting diode
6. To study the characteristics of a P-N junction and determine –

   (a) Reverse saturation current (b) Material constant

   (C) Determination of temperature coefficient of the Junction (d) Junction voltage and energy band gap.
7. To study the diffraction pattern of a semiconductor laser and –

(a) Determine the width of the single slit from the diffraction pattern.

(b) Measure the thickness of the wire/obstacle.

(c) Determine the wavelength of the laser light using diffraction grating.

8. To study the absorption spectrum of iodine vapour and to obtain –

(a) Energy level diagram for iodine molecule

(b) Deducing the electronic excitation energy for iodine molecule

(c) Deducing force constant for iodine molecule

9. To study the characteristics of a LED and –

(a) Determination of Plank`s constant (b) Determine the material constant

(c) Determine the temperature coefficient

10. To study the characteristics of a Photocell and –

(a) Determination of Plank`s constant (b) Determine the material constant

(c) Determine the temperature coefficient

11. To study a single stage R-C coupled amplifier cum feedback amplifier and draw its frequency Response curve and measure –

(a) Voltage/Power gain (b) Variation of gain (c) Input/Output Impedance

(d Phase relationship between input and output waveforms

12. To study a single stage L-C coupled amplifier cum feedback amplifier and draw its frequency response curve and measure –

(a) Voltage/Power gain (b)Variation of gain (c) Input/Output Impedance

(d) Phase relationship between input and output waveforms

13. To study the dielectric constant and determine the Curie temperature of the ferroelectric ceramics.

14. To demonstrate the concept of quantization of energy levels in accordance with the Bohr model of atoms by Frank Hertz experiment.

15. To trace a B-H curve for a ferro-magnetic material using CRO and to find magnetic parameters from The B-H curve

16. To calculate the resistivity of a semiconductor by Four-Probe method at different temperatures.

~~**Suggested Evaluation Methods:**~~

Evaluation of 100 marks shall be based on the experiments performed, viva-voce and lab records as per revised NEP guidelines (60+25+15).

Programme Class: **Master of Science/M.Sc**	Year: 4	Semester: 8
Subject: **PHYSICS**		
Course Code: **0820101**	Course Title: **Statistical Mechanics**	

Course Outcomes:

After completing this course students will be able to understand

- The basic knowledge of statistical mechanics.
- Calculation of statistical quantities of various systems.
- The ensemble theory required for macroscopic properties of the matter in bulk in terms of its constituents.
- The analysis of properties of ideal Bose gas, Bose- Einstein condensation, liquid helium and electron gas.
- Various theories and models of cluster expansion and fluctuations of thermodynamic variables.
- Explanation of theoretical aspects of order-disorder phase transition in various systems.

Credits: 4	Core Compulsory / Elective: Core compulsory
Max. Marks: 75 + 25	Min. Passing Marks: 40
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0	

Unit	Topics	No. of Lectures
I	**Ensembles and Statistics of Ideal Gas System:** Scope and objectives of statistical mechanics. Analysis of phase space, phase points, □ - space and □ - space, concept of ensemble, density of phase points, Microstates and Macrostates, Number of accessible microstates. Detailed analysis of micro-canonical, canonical and grand canonical ensembles. Partition function formulation. Partition function of microcanonical, canonical and grand canonical ensembles. The entropy of an ideal gas using microcanonical ensemble, Gibbs paradox, Sackur-Tetrode equation	15

II	**Quantum Statistical Mechanics:** Transition from classical statistical mechanics to quantum statistical mechanics. Postulates of quantum statistical mechanics, Density matrix, Indistinguishability and quantum statistics, identical particles and symmetry of wave functions. Basic postulate and particle distribution function of Bose Einstein statistics. Energy, number of particles and pressure of B.E. gas. Bose Einstein Condensation, Thermal properties of B.E. gas, Transition in liquid ^{4}He, Superfluidity in ^{4}He. Basic postulate and particle distribution function of Fermi Dirac statistics. Energy, number of particles, temperature and pressure of F.D. gas. Properties of ideal electron gas. Thermionic Emission	20
III	**Statistical models for order-disorder phase transition:** Cluster expansion for a classical gas, virial equation of state, first and second order phase transition, Ising model, mean-field and Heigenburg theories of Ising model, Exact solutions in one-dimension, Landau theory of phase transition, Landau theory of liquid He-II, critical exponents.	15
IV	**Fluctuations:** Introduction to non-equilibrium process, mean square deviation, Energy and density fluctuations, one dimensional random walk, Random walk and Brownian motion, Langevin theory of Brownian motion and relation with diffusion equation, The Fokker-Plank equation	10

Suggested Readings:

1. Reif, F., "Statistical and Thermal Physics".

2. Huang, K., "Statistical Mechanics".

3. Pathria, R.K., "Statistical Mechanics".

4. Kubo, R., "Statistical Mechanics".

5. Landau & Lifshitz, "Statistical Physics".

6. Agarwal, B.K. & Eisner, M., "Statistical Mechanics".

7. Gopal, E.S.R., "Statistical Mechanics and properties of matter, theory and application"

Suggestive digital platforms web links-

1. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx
2. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
3. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd

Suggested Continuous Evaluation Methods:

Continuous Internal Evaluation (CIE) of 25 marks shall be based on Class tests, assignments, presentations, etc. as per revised NEP guidelines.

Programme/Class: **Master of Science/M.Sc**		Year: 4	Semester: 8
Subject: **PHYSICS**			
Course Code: **0820102**	Course Title: **Electrodynamics Physics**		

Course Outcomes:

After completing this course students will be able

- Basics of electrostatics, magnetostatics and electromagnetism.
- Concepts of field produced by stationary charged distribution in free space ,metals and dielectrics.
- About the field produced by steady currents in free space and matter and different behavior of materials in magnetic field .
- Basic idea of time varying fields and fundamental equations of electromagnetism.
- The computational skills in solving basic problems of electromagnetism.
- Basic concepts in electromagnetic wave propagation in different media and at interfaces.

Credits: 4	Core Compulsory / Elective: Core compulsory
Max. Marks: 75 + 25	Min. Passing Marks: 40

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	**Electrostatics:** Gauss' Law and its applications, divergence and Curl of E, Electrostatics of Conductors, Solution of electrostatic problems: Laplace's and Poisson's Equations, Methods of images, point charge near an infinite conducting plane, Point charge near a grounded conducting sphere, Electrostatic of Dielectrics: Dielectrics and Polarization, Field of polarized object, Electric field inside dielectrics, Electric displacement, Linear dielectrics.	15
II	**Magnetostatics:** Magnetic field of a Steady currents; Biot-Savart Law, Ampere's Law and elementary applications, Divergence and curl of B, Magnetic vector potential, Magnetostatic fields in Matter, Magnetization, field of a magnetized object, magnetic field inside matter, linear and nonlinear magnetic media; Ferromagnetism: Hysteresis loop.	15

III	**Time Varying Fields:** Faraday's laws of electromagnetic induction (Integral and Differential form), Maxwell's displacement current, Maxwell's equations in free space and dielectrics, Boundary conditions, Poynting theorem, Lienard Wiechert potentials due to a point charge, Field of a point charge in motion, Power radiated by accelerated charges.	15
IV	**Plane Electromagnetic Wave:** Electromagnetic waves in free space, dielectrics and conductors, Reflection and Refraction of EM Waves at an interface between dielectrics (normal and oblique incidence), transmission, absorption, Fresnel's relation of polarization by reflection and total internal reflection, Reflection from conducting surface.	15

Suggested Readings:

1. Jackson, J.D., "Classical Electrodynamics".
2. Reitz, J.R., Milford, F.J. & Christy, R.W., "Foundations of Electromagnetic Theory".
3. Griffiths, David J., "Introduction to Electrodynamics".
4. Verma, H.C., "Classical Electrodynamics".

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1. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx
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Suggested Continuous Evaluation Methods:

Continuous Internal Evaluation (CIE) of 25 marks shall be based on Class tests, assignments, presentations, etc. as per revised NEP guidelines.

Programme/Class: **Master of Science/M.Sc**	Year: 4	Semester: 8
Subject: **PHYSICS**		
Course Code: **0820103**	Course Title: **Atomic and Molecular Physics**	

Course Outcomes:

After completing this course, students will be able to understand

- Concepts of atomic spectra of Hydrogen atoms and similar valence electron atoms.
- Interpretation of atomic spectra for many electron atoms.
- Change in behavior of atoms in external applied electric and magnetic field and corresponding changes in observed spectra.
- The rotational, vibrational, electronic and Raman spectra of molecules.
- Different characterization techniques like IR/FTIR, Raman, etc.
- Nuclear Magnetic Resonance (NMR) for structure elucidation of synthesized materials.

The knowledge of various material characterization techniques can impart skills to enhance direct/indirect employability.

Credits: 4	Core Compulsory / Elective: Core compulsory
Max. Marks: 75 + 25	Min. Passing Marks: 40

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	**Atomic Physics -I:** Introduction to Atomic spectra, Quantum states of an electron in Hydrogen atom. Relativistic corrections for energy levels of hydrogen atom. Concept of spin and fine structure of hydrogen atom. Singlet and triplet States of Helium. Broad features of spectra of alkali elements. Fine structure in Alkali Spectra.	15
II	**Atomic Physics - II:** Many electron atoms: Central field approximation, atomic wave function, Hartree and Hartree–Fock approximations, Results of Hartree's theory, Spectroscopic Terms: LS coupling, Lande Interval rule, determination of spectral terms for atoms; with two or more Non-equivalent optical electrons, and two or more equivalent optical electrons. Breit's scheme. JJ coupling for many electron atoms. Atom in external field, Zeeman, Paschen-Bach & Stark effects.	15
III	**Molecular Physics:** Born-Oppenheimer approximation, Classification of Molecules, Types of Molecular Spectra and Molecular Energy States: Pure Rotational Spectra, Vibrational-Rotational Spectra, Raman Scattering, Classical and Quantum theory of Raman effect. Selection rules, Isotope effect, Formation of electronic spectra, fine structure of electronic bands. Intensity distribution in electronic bands: Franck-Condon principle. Explanation of intensity distribution in absorption and emission bands from Franck-Condon principle.	20

IV	**SpectroscopicTechniques:** Infrared/FTIR Spectroscopy, General description and working of dispersive and FTIR instrument. Interpretation of FTIR spectra. Raman spectroscopy. Nuclear Magnetic Resonance, Chemical Shift, NMR Spectrometer. NMR spectrum analysis.	10

Suggested Readings:

1. White, H.E., "Introduction to atomic spectra".
2. Herzberg, "Spectra of diatomic molecules".
3. Weissbluth, M., "Atoms and Molecules".
4. Slater, "Quantum theory of Atomic Structure, Vol. I".
5. Slater, "Quantum theory of Molecules and Solids".
6. Banwell, C.B., "Fundamentals of Molecular Spectroscopy".
7. Barrow, G.M., "Introduction to Molecular Spectroscopy".
8. Brown, J.M., "Molecular Spectroscopy".
9. Larkin, Peter J., "Infrared and Raman Spectroscopy: Principles and Special Interpretation".
10. Ghatak, Ajoy & Thyagarajan, K., "Lasers: Fundamentals and Applications".

Suggestive digital platforms web links-

1. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx
2. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
3. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd

Suggested Continuous Evaluation Methods:

Continuous Internal Evaluation (CIE) of 25 marks shall be based on Class tests, assignments, presentations, etc. as per revised NEP guidelines.

Programme/Class: **Master of Science/M.Sc**	Year: 4	Semester: 8
Subject: **PHYSICS**		
Course Code: **0820104**	Course Title: **Nuclear and Particle Physics**	

Course outcomes:

After completing this course students will be able to understand

- Basics of nuclear Physics and Fermi theory of allowed β decay .
- The different aspects of nuclear physics. For example i.e Interaction and Detection of Nuclear Radiation wit matter
- Nuclear Models magic numbers and General idea of elementary partcles.
- General introduction of nucleus with modern technology may help to persue research in nuclear physics

Credits: 4	Core Compulsory / Elective: Core compulsory
Max. Marks: 75 + 25	Min. Passing Marks: 40

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0

Unit	Topics	No. of Lectures
I	**General Introduction:** Scattering of α particles, Mirror nuclei, μ meson atoms consideration, Idea of protonic charged nuclear dimensions. Nuclear mass, Nuclear angular momentum and magnetic moment, electric quadrupole moment, Parity quantum number, Statistics of nuclear particles, Isobaric spin concept, Electron capture. Partial wave analysis of n-p scattering, phase shift, single and triplet potentials	15
II	**General β decay DISINTEGRATION:** Fermi theory of allowed β decay. Non conservation of parity and Wu's experiment. Internal conversion.	05
III	**Interaction and Detection of Nuclear Radiation with matter Chemical and Biological effects of radiation:** Interaction of charged particles with matter, Stopping power of heavy charged particles, Range and straggling of electrons. Introduction of Ionization chamber, Proportional counter ,G.M. counter ,scintillation counter . Radiation monitoring and Dosimeters, Physical effects of radiation, Chemical effects of radiation. Effects of radiation on water and aqueous solutions, Penetration and ionizing power of nuclear radiations in the human body.	20

IV	**Nuclear Models:** Single particle. Individual particle model, predictions of shell model and magic numbers.	10
V	**Nuclear elementary particles:** General idea of elementary particles, Conservation laws, CP and CPT invariance, introductions of hadrons, Quarks, leptons and mesons Gell-Mann Okubu mass formula, Formation of stars, Chandrashekhar limit, neutron rich matter and supernova explosion	10

Suggested Readings:

1. Srivastava, B.B., "Fundamentals of Nuclear Physics".
2. Ghoshal. S.N., "Nuclear Physics" S. Chand Publications.
3. Tayal. D.C., "Nuclear Physics" Himalaya Publications.

Suggestive digital platforms web links-

1. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx
2. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
3. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd

Suggested Continuous Evaluation Methods:
Continuous Internal Evaluation (CIE) of 25 marks shall be based on Class tests, assignments, presentations, etc. as per revised NEP guidelines.

Programme/Class: **Master of Science/M.Sc**	Year: 4	Semester: 8
Subject: **PHYSICS**		
Course Code: **0820180**	Course Title: **PHYSICS LAB II**	

Course Outcomes:

After completing this course students will be able to learn.

- The basic concepts of electronics through experiments.
- The concepts studied by them in the theory course and correlation with experimental observations.
- The practical knowledge of designing, assembling and testing electronic circuits as well as understanding troubleshooting.

In-depth knowledge of Physics can be applied in higher studies and help to perform better.

Credits: 4	Core Compulsory / Elective: Core Compulsory
Max. Marks: 100	Min. Passing Marks: 40

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-18

List of Experiments- Choose another **six** experiments from the given list.

1. To study the frequency response and to calculate the various parameters such as input Impedance, output impedance current gain and voltage gain of the emitter follower.
2. To study the Drain characteristics and Mutual characteristics of a N/P channel MOSFET
3. To study the characteristics of a junction field effect transistor and to calculate the various parameters as

   (a) drain dynamic resistance (b) mutual conductance (c) amplification factor

4. To study and compare the following transistor biasing techniques and calculate the Bias voltage and transistor currents in-

   (a) Single battery biasing (a) Two battery biasing (c) Voltage divider bias (d) Collector to base bias

5. To study the forward and reverse bias characteristics of the following diodes-

   (a) Germanium diode (b) Silicon diode (c) Zener diode (d) Light emitting diode

6. To study the characteristics of a P-N junction and determine –

   (a) Reverse saturation current (b) Material constant (c) Determination of temperature coefficient of the Junction (d) Junction voltage and energy band gap.

7. To study the diffraction pattern of a semiconductor laser and –

   (a) Determine the width of the single slit from the diffraction pattern.

(b) Measure the thickness of the wire/obstacle.
(c) Determine the wavelength of the laser light using diffraction grating.

8. To study the absorption spectrum of iodine vapour and to obtain –

   (b) Energy level diagram for iodine molecule

   (c) Deducing the electronic excitation energy for iodine molecule

   (d) Deducing force constant for iodine molecule

9. To study the characteristics of a LED and –

   (e) Determination of Plank's constant (b) Determine the material constant

   (c) Determine the temperature coefficient

10. To study the characteristics of a Photocell and –

   (a) Determination of Plank's constant (b) Determine the material constant

   (c) Determine the temperature coefficient

11. To study a single stage R-C coupled amplifier cum feedback amplifier and draw its frequency Response curve and measure –

(a) Voltage/Power gain (b) Variation of gain (c) Input/Output Impedance (d Phase relationship between input and output waveforms

12. To study a single stage L-C coupled amplifier cum feedback amplifier and draw its frequency response curve and measure –

(a) Voltage/Power gain (b)Variation of gain (c) Input/Output Impedance

(d) Phase relationship between input and output waveforms

13. To study the dielectric constant and determine the Curie temperature of the ferroelectric ceramics.

14. To demonstrate the concept of quantization of energy levels in accordance with the Bohr model of atoms by Frank Hertz experiment.

15. To trace a B-H curve for a ferro-magnetic material using CRO and to find magnetic parameters from the B-H curve

16. To calculate the resistivity of a semiconductor by Four-Probe method at different temperatures.

Suggested Continuous Evaluation Methods:

. Evaluation of 100 marks shall be based on the experiments performed, viva-voce and lab records as per revised NEP guidelines (60+25+15).

Programme /Class: **MASTER OF SCIENCE(M.Sc.)**	Year:5	Semester:9
Subject: **PHYSICS**		
Course Code: **092010I**	Course Title: **Op-Amp Applications & Digital Electronics**	

Course outcomes:

After completing this course ,students will be able to understand

- Design of various types of electronic circuits built around OP-Amp and study them experimentally.
- Operational amplifier based circuit analysis.
- Various steps of combinational logic circuit design.
- Working of Clocks and Sequential Logic Circuits:
- The concept of data storage and transfer.
- The basics of microprocessor 8085 and writing simple assembly language programs.

Credits:4	Core Compulsory/Elective: Core compulsory
Max. Marks: 75+25	Min.PassingMarks:40

TotalNo.ofLectures-Tutorials-Practical(inhoursperweek):L-T-P:4-0-0

Unit	Topics	No.of Lectures
I	**Applications of Operational Amplifier:** Linear OP-Amp Circuits: Closed loop Inverting and Non-Inverting amplifier, voltage follower, Summing and Difference amplifier, Adder and Subtractor, Controlled Sources: Voltage Controlled Voltage Source, Voltage Controlled Current Source, Current Controlled Voltage Source, Current Controlled Current Source. Non-Linear OP-Amp Circuits: Rectifiers, Clippers, Clampers, Comparators and Schmitt Triggers, Integrator and Differentiator Active Filter and Oscillators: Low Pass, High Pass, Band Pass, Band Rejection Filters (with special reference to Butterworth filters), Wein Bridge and Phase Shift Oscillators.	15
II	**Logic Gates, IC Logic Families and Combinational Logic Circuits: Logic Gates:** symbols, truth tables and timing diagrams **IC Logic Families:** Characteristic Parameters, TT Land MOS Logic Families **Boolean Algebra:** Describing logic circuits algebraically, Implementing logic circuits for Boolean equations, Boolean Theorems, De Morgan's theorems, Universality of NAND and NOR gates. SOP and POS forms of Boolean equations, minterm and maxterm notations, converting a truth table to aPOS and SOP equation. Simplifying Boolean equations: Algebraic simplification, Karnaugh Map (K-Map) up to four variables. K-Map simplification method for Boolean equations: Pair, Quad, Octet. Implementing Don't Care conditions. Arithmetic Circuits: HalfAdder ,FullAdder, Half Subtractor, Full Subtractor, Data Processing Circuits: Multiplexer, Demultiplexer, Encoders and Decoders.	15

III	**Clocks and Sequential Logic Circuits:** Clock Waveform, 555 Timer IC and its application as astable and mono stable multivibrator **Flip Flops:** NOR gate latch and NAND gate latch, Level Clocked and Edge-triggered, Flip-Flops,R-SFlip-Flop,D-FlipFlop,J-KFlip-Flop,T-FlipFlop,ExcitationTableofFlip- Flops, Flip-Flop timing considerations, Master/Slave Flip-Flops. **Counters:** Asynchronous (Ripple) counters, Up and Down Counter, Asynchronous counter with Mod Number<2N, Synchronous counter, Synchronous counter design. **Register:** Serial-in-serial out, Serial-in-parallel out, Parallel-in-serial out, Parallel-in parallel out, Shift Register, Shift Register counter (Ring Counter and Johnson Counter).	15
IV	**Analog/Digital Interfacing Memories and Microprocessor:** **Digital to Analog conversion:** DAC specifications, Binary Weighted Register DAC, R/2R Ladder DAC. **Analog to Digital Conversion:** ADC specifications, Counter Type ADC, Successive Approximation ADC, Dual Slope ADC and Flash ADC. Basic Terms and Idea of Memory Devices. **Microprocessor-8085:** Architecture and its operations, Memory and I/O interfacing devices, Writing Assembly language Programs (Simple Cases of data transfer and arithmetic operations).	15

Suggested Readings:

1. Gayakwad, R.A.,"Op- Ampand Linear Integrated Circuit".
2. Tocci, RonaldJ., "Digital Systems, Principles and Applications".
3. Malvino ,A.P. & Leach,D.P.,"Digital Principles and Applications".
4. Maini, AnilK.,"Digital Electronics ,Principles and Integrated Circuits".
5. Gaonkar,Ramesh,"MicroprocessorArchitecture,ProgrammingandApplicationswiththe8085".

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1. UttarPradeshHigherEducationDigitalLibrary,http://heecontent.upsdc.gov.in/SearchContent.aspx
2. Swayam Prabha- DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8
3. National ProgrammeonTechnologyEnhancedLearning(NPTEL),https://www.youtube.com/user/nptelhrd

Suggested Continuous Evaluation Methods:

Continuous Internal Evaluation (CIE) of 25 marks shall be based on Class tests, assignments, presentations, etc. as per revised NEP guidelines.

Programme /Class: **MASTER OF SCIENCE(M.Sc.)**	Year:5	Semester: 9
Subject: **PHYSICS**		
Course Code: **0920102**	Course Title: **Condensed Matter Physics**	

Course outcomes:

After completing this course ,students will be able to understand

- The correlation and virtual lattice which is the key of structure property relationship of any solid.
- X-ray diffraction techniques and its applications.
- Various crystal imperfections and their impacton properties of the material.
- Electronic and magnetic properties which may help to design new materials with desired electronic and magnetic properties.
- Basic concept of super conductivity and its application in various fields.

Credits:4	Core Compulsory/Elective: Core compulsory
Max .Marks: 75+25	Min.PassingMarks:40
TotalNo.ofLectures-Tutorials-Practical(inhoursperweek):L-T-P:4-0-0	

Unit	Topics	No.of Lectures
I	**Crystal structure:** Lattice, primitive and non primitive cell, Classification of Bravais lattice, Common crystal structures: NaCl and CsCl Structure, close-packed structure, X-ray diffraction,Reciprocallattice,andBrillouinzone;Pointdefects(Schottky&Frankel Defects) Imperfections, Line defects (Edge & Screw dislocations),	15
II	**Band Theory of solids :** Different types of bonding in solids, covalent, metallic, Vander Waal, hydrogen bonding & ionic bonding, Madelung constant of ionic crystals, cohesive energy. Elastic properties, phonons, lattice specific heat. Free electron theory and electronic specific heat. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power.	15
III	**Electronic and Magnetic Properties of Solids:** Electrons in a periodic lattice: Bloch theorem, The Kronig-Penny Model, Effective mass of an electron, Tight-binding approximation, Cellular and pseudo potential methods, Fermi surface and Brillouin zones. Weiss theory of ferromagnetism, Heisenberg model and molecular field theory, Ferromagnetic domains, The Bloch-wall, Spin waves and Magnons, Curie- Weiss law for susceptibility, Ferri and anti ferro-magnetic order.	20
IV	**Superconductivity:** Review of basic properties, Meissner effect, Type-I and Type-II superconductors, thermodynamics of superconductors, London's phenomenological theory, Flux quantization. Elements of BCS theory.	10

Suggested Readings:

1. Verma&Srivastava,"Crystallography for Solid State Physics".
2. Azaroff,"Introduction to Solids".
3. Pillai,S.O.,"Solid State Physics".
4. Omar,"Elementary Solid-StatePhysics".
5. Aschr off &Mermin,"SolidStatePhysics".
6. Kittel,"Solid State Physics".
7. Chaikin&Lubensky,"Principles of Condensed Matter Physics".

Suggestive digital platforms weblinks-

- UttarPradeshHigherEducationDigitalLibrary,http://heecontent.upsdc.gov.in/SearchContent.aspx

National Programme Technology Enhanced Learning https://www.youtube.com/user/nptelhrd

Suggested Continuous Evaluation Methods: Continuous Internal Evaluation (CIE) of 25 marks shall be based on Class tests, assignments, presentations, etc. as per revised NEP

Programme /Class: **MASTEROFSCIENCE(M.Sc.)**	Year:5	Semester:9
Subject: **PHYSICS**		
Course Code: **0920103**	Course Title: **Introduction to Nano Science & Technology**	

Course outcomes:

After completing this course, students will be able to understand

- The basics of nanoscience and fundamental concepts behind size reduction in various properties of materials.
- The phenomena of size dependence of physical properties.
- Quantum Confinement in different dimensions.
- The electronic band structure and density of states of different types of nanostructures.

Credits:4	Core Compulsory
Max.Marks: 75+25	Min.PassingMarks:40

TotalNo.ofLectures-Tutorials-Practical(inhoursperweek):L-T-P:4-0-0

Unit	Topics	No.of Lectures
I	**Fundamentals of Nano materials:** History of Nano science & Nanotechnology, Feynman's vision on Nano Science & technology, bulk Vs Nano materials. Central importance of Nano scale morphology-small things making big differences, nanotechnology as nature's technology, clusters and magic numbers. Recent developments in Application of Nano materials and Carbon Nano tubes, challenges and future prospects of Nano materials.	15
II	**Size and shape dependent properties of Nano materials:** Size and shape dependent properties, Melting points and lattice constants, Surface Tension, Surface energy. Mechanical properties, Optical properties Surface Plasmon resonance in metal nanoparticles and quantum size effect in Semiconductors ,Electrical conductivity :Surface scattering, change of electronic structure, Magnetic. properties: Ferroelectrics, dielectrics and super para magnetism.	15
III	**Classification of nano materials:** Classification based on the dimensionality,Zero dimensional nano structures: metal , semiconductor and oxide nano particles. One-dimensional , nano structures. nano wires and nano rods,Two-dimensional nano structures: Thin films, Three dimensional nano materials, Special Nanomaterials: Carbon fullerenes and carbon Nano tubes, From a Graphene Sheet to a Nano tube. Single wall and Multi walled Nano tubes, Zigzag and Armchair Nano tubes, Micro and meso porous materials,	15

IV	**Physics of Nano materials:** Idea of band structure of insulators semi conductors & conductors Group velocity, Concept of Effective mass & and Fermi surfaces, Localized particles Donors, Acceptors and Deep and shallow traps, Mobility, Density of states, variation of density of states with energy and dimensions of the crystal Conductivity in relation to band structure Quantum confinement and its effects in Nanostructures i.e. Quantum well, Quantum wire and Quantum dot.	15

References/compulsory reading

1. CharlesP.Poole.Jr.FrankJ.Owens."IntroductiontoNanotechnology"JohnWiley&SonsInc.
2. PradeepT."AtextbookofNanoscience&Technology"TataMcGraw-HillEducation2012.
3. Wilson .M.,"Nanotechnology: Basic Science and Emerging Technologies"
4. G.CaoandY.Wang,NanostructuresandNanomaterials,2ndEd.,ImperialCollegePress,2004.
5. R.Kelsall,I.Hamleyand M.Geoghegan,NanoscaleScienceandTechnology,Wiley,2005.
6. K.J Klabunde,R.M.Richards, Nanoscale Materialsin Chemistry, 2 ndEd.,Wiley,2009.
7. G.Schmidt, Nanoparticles: from Theoryto applications, Wiley-VCH, 2004

Supplementary/Suggested reading

1. Murty,B.S.,P.Shankar,BaldevRaj,B.B.Rath,andJamesMurday.TextbookofNanoScienceandnanotechnology. Springer Science &Business Media,2013
2. RobertK.IanH.MarkG.NanoscaleScienceandTechnology,JohnWiley&sonsLtd.,2005.

Suggestive digital platforms web links-

1. Uttar Pradesh Highe rEducation Digital Library,http://heecontent.upsdc.gov.in/SearchContent.aspx
2. SwayamPrabha-DTHChannel,https://www.swayamprabha.gov.in/index.php/program/current_he/8
3. NationalProgrammeonTechnologyEnhancedLearning(NPTEL),https://www.youtube.com/user/nptelhrd

Suggested Continuous Evaluation Methods:

Continuous Internal Evaluation (CIE) of 25 marks shall be based on Class tests, assignments, presentations, etc. as per revised NEP guidelines.

Programme/Class: **Master of Science/M.Sc.**		Year: 5	Semester: 9
Subject: **PHYSICS**			Credits: **04**
Course Code: **0920165**	Course Title: **RESEARCH PROJECT**		
Max. Marks: **75+25** (75 for Research Project and 25 for Paper Publication)			

Course Outcomes:

- The students will be able to develop a positive outlook on learning with deepen understanding of subjects.
- Engagement in research projects will improve the critical thinking , problem solving and communication skills in student's.
- Students learn to collect information from reliable sources and carry out research.
- They get the benefit of Research Experience in graduate programs when applying for advanced studies.

Programme /Class: **Master of Science/M.Sc**		Year:5	Semester:9
Subject: **PHYSICS**			
Course Code: **0920180**	Course Title: **ELECTRONICS LAB**		

Course Outcomes:

After completing this course, students will be able to learn

- Basic concepts of electronics through experiments.
- The concepts studied in the theory course and their correlation with experimental aspect.
- Designing, assembling, and testing electronics circuits as well as understanding of troubleshooting

In-depth knowledge of Electronics can be applied in higher studies in every field of Physics.

Credits:4	Core Compulsory/ Elective: Core Compulsory
Max. Marks: 100	Min. Passing Marks: 40
Total No. of Lectures-Tutorials-Practical (in hours per week):L-T-P:0-0-18	

List of Experiments:

Choose any six experiments from the given list.

1. To study the various logic gates, Half Adder, Full Adder, Half Subtractor and Full Subtractor by using digital IC's.
2. To study the performance characteristics of various optical transducers, such as (a) photovoltaic cell (b) photoconductive cells (c) Characteristics of photo diode (d) phototransistors.

3. To study the features of an IC 555 timer and to set up and operate is as a (a) free running multivibrator (b) monostable
4. To study the operational amplifier as-(a) inverting amplifier (b) non-inverting amplifier(c) Voltage follower
5. To study the operational amplifier as-(a) adder or summing amplifier (b) subtractor (C)integrator (d) differentiator
6. To study the active filters of first and second stage using operational amplifier as- (a) As low pass filter (b) High pass filter (c) Band pass filter
7. To study the R-S flip flop circuits by using (a) NOR gates only. (b) a combination of AND and NOR gates.(c) Clocked R-S flip flop (d) T flip flop.
8. To study the digital to analog conversion by using a R-2R ladder circuit.
9. To study the analog to digital conversion by using the IC ADCO808
10. To construct any desired circuit on a digital breadboard using the digital /analog trainer kit
11. To stimulate the given circuit by the computer simulation software LT Spice.

Suggested Continuous Evaluation Methods:

Evaluation of 100 marks shall be based on the experiments performed, viva-voce and lab records as per revised NEP guidelines (60+25+15).

Programme /Class: **MASTER OF SCIENCE(M.Sc.)**	Year: 5	Semester:10
Subject: **PHYSICS**		
Course Code: **01020101**	Course Title: **QUANTUM MECHANICS II**	

Course outcomes:

After completing this course ,students will be able to understand

- The scattering processes in atomic, subatomic, and molecular systems.
- The time-dependent Schrodinger wave approach and its applications in real life, transition probabilities.
- The quantum theory of radiations.
- The relativistic quantum theory.

Credits:4	Core Compulsory/Elective :Core compulsory
Max.Marks: 75+25	Min.PassingMarks:40
TotalNo.ofLectures-Tutorials-Practical(inhoursperweek):L-T-P:4-0-0	

Unit	Topics	No.of Lectures
I	**Scattering Theory:** Laboratory and center-of-mass systems, scattering by potential field, scattering amplitude, differential and total cross sections, partial wave analysis, phase shift, Lippmann-Schwinger equation, and First Born approximation.	15
II	**Time Dependent Perturbation Theory:** First order perturbation, Harmonic Perturbation, Interaction of an atom with an electromagnetic field, Transition probabilities, Fermi Golden rule, Dipole approximation.Einstein`scoefficientsbasedonquantummechanics,Induced and spontaneous emissions of radiations, adiabatic and sudden approximation.	15
III	**Quantum Theory of Radiation:** Classical radiation field, Fourier decomposition and electromagnetic radiation field, dipole approximation, Creation, annihilation and number operators, Photon states, Basic matrix elements for emission and absorption, explanation of stimulated and Spontaneous emission on the bases of quantum mechanics, Plank`s radiation law.	15
Iv	**Relativistic Quantum Theory:** Klein-Gordon equation and its plane wave solution, Probability density in KG theory, Difficulties in KG equation, Dirac equation for a free electron, Dirac matrices and spinors , Plane wave solutions, Charge and current densities, Existence of spin and magnetic moment from Dirac equation of electromagnetic field. Dirac equation for central field with spin orbit interaction. Energy levels of Hydrogen atom from the solution of Dirac equation, covariant form of Dirac equation.	15

Suggested Readings:

1. Khare, S.P., "Quantum Mechanics and Atomic Physics".
2. Schiff, L.I.. "Quantum Mechanics".
3. . Sakurai J.J., "Advanced Quantum Mechanics
4. . Zettili, N., "Quantum Mechanics: Concepts and Applications".
5. Chaddha, G.S., "Quantum Mechanics".

Suggestive digital platforms web links

1. **Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx**
2. **Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8**
3. **.National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd**

Suggested Evaluation Method:

Continuous Internal Evaluation (CIE) of 25 marks shall be based on Class tests, assignments, presentations, etc. as per revised NEP guidelines.

Programme/Class : **MASTER OF SCIENCE (M.Sc.)**	Year : 5	Semester: 10
Subject : **PHYSICS**		
Course Code: **1020102**	Course Title: **Synthesis of Nanomaterials**	

Course Outcome

After completing this courses students will be able to understand

- The differentiation among nanomaterials according to their confinements in 1-D, 2-D and 3-D.
- Different approaches i.e. Top down and Bottom-up approaches of nanomaterials synthesis.
- The synthesis of nanomaterials by sol-gel method, spray pyrolysis ball milling, physical Vapour deposition, sputtering, microwave plasma and a few other processes.
- The role of surfactants in the formation of self-assembled nanostructures.
- The various parameters required for good quality thin film deposition with quantum dots and nanowires morphology.
- Synthesis of single walled and multi walled carbon nano tubes.

Credits:4	Core Compulsory
Max. Marks: 75+25	Min. Passing Marks:40

TotalNo.ofLectures-Tutorials-Practical(inhoursperweek):L-T-P:4-0-0

Unit	Topics	No.of Lectures
I	**Surface science for nano materials:** Key issues in synthesis of Nano materials , surface energy & Surface stress capping agents, Stabilization mechanisms, Steric stabilization and Electro steric stabilization, Critical radius, homogenous and heterogenous nucleation. Subsequent growth of nuclei.	10
II	**Synthesis of nano materials:** Bottom-up and top-down approaches - Synthesis of zero-dimensional nanostructures - colloidal nano synthesis- synthesis of metallic (Au, Ag) nano particles - synthesis of semiconducting nano particles (CdSe, CdS) - synthesis of oxide nano particles - Self Assembly, sol-gel method , Ball milling Synthesis of 1D nanostructures - spontaneous growth - vapor-liquid-sold growth – template based synthesis . Electro spinning , Synthesis of carbon nanotubes, Arc discharge , RF plasma, laser ablation	15
III	**Synthesis of 2D nano structures** – Fundamentals of film growth – Physical Vapour deposition – Sputtering – Chemical vapour deposition – Atomic layer deposition – Self assembly – LangmuirBlodgett films. Inert gas condensation, Ion, Sputtering, , Spray pyrolysis, Ion Implantation, Molecular Beam Epitaxy	15

IV	**Lithography techniques** –Overview of Lithography, Rayleigh criteria for resolution, Photolithography source, Optical Lithography- contact, proximity and projection, resolution limit and limitations. Electron lithography- concept of mask generation, electron optics and resolution.X-raylithography--Proximity and mask, wet chemical ,dry etching, plasma etching and ion milling for material removal.	20

Suggested Readings:

1. Frank J. Owens, Charles P. Poole Jr, The Physics and Chemistry of Nanosolids, John Wiley & Sons, 2008.
2. Dieter Vollath, Nanomaterials: An introduction to Synthesis, Properties, and Applications (second edition), Wiley-VCH, 2013.
3. Edward L. Wolf, Nanophysics and Nanotechnology - An Introduction to Modern Concepts in Nanoscience, Wiley-VCH, 2006.
4. V. I. Klimov (Ed.), Semiconductor and Metal Nanocrystals - Synthesis and Electronic and Optical properties, Marcel Dekker Inc., 2004
5. Guozhong Cao, Nanostructures and Nanomaterials- Synthesis, properties and Applications,Imperial college press, 2004.
6. Challa Kumar (Ed.), Semiconductor Nanomaterials, Wiley-VCH, 2010.
7. Ampere A Tseng (Ed.), Nanofabrication-Fundamentals and Application, World Scientific, 2008.

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3. NationalProgrammeonTechnologyEnhancedLearning(NPTEL),https://www.youtube.com/user/nptelhrd

Suggested Continuous Evaluation Methods:

Continuous Internal Evaluation (CIE) of 25 marks shall be based on Class tests, assignments, presentations, etc. as per revised NEP guidelines.

Programme/Class: **MASTER OF SCIENCE/M.Sc**	Year:5	Semester: 10
Subject: **PHYSICS**		
CourseCode: **1020103**	CourseTitle: **Characterization of Nano materials**	

Course Outcomes:

After completing this course students will be able to understand

- The working and principles of various analytical tools such as XRD, XPS,
- UV-VIS spectroscopy, Raman spectroscopy .
- The principle and working of Electron Microscopic techniques e.g.SEM&TEM,required for the characterization of nanomaterials.
- Scanning Probe Microscopic techniques like AFM & STM .
- The investigation of the thermal and electrical properties by Thermogravimetric (TGA) and two /four probe method can be understood.
- To interpret and analyze the data.

Credits:4	Core Compulsory
Max.Marks: 75+25	Min.Passing Marks:40

Total No.of Lectures-Tutorials-Practical(in hours per week):L-T-P:4-0-0

Unit	Topics	No.of Lectures
I	**X-ray diffraction:** Interaction of x- rays with matter. Fundamentals of x-ray diffraction. X-ray diffraction methods, Powder diffraction method, Single crystal, laue and Rotating crystal method, diffraction under non ideal conditions Derivation of Scherer formula for grain size determination of nano particles. Increase in with of XRD peaks of nanoparticles,X-Ray Photo electron Spectroscopy (XPS)	15
II	**Spectroscopy:** UV-VIS-NIR.spectroscopy. Emission Absorption Spectroscopy,Shift in absorption spectra of nanoparticles and their correlation with energy band gap, shift in photoluminescence peaks. Fluroscence spectroscopy, Basic Principal of Fourier Transform infra red FTIR& Raman spectroscopy	15
III	**Electron microscopy:** Electron & Matter interaction, Scanning Electron Microscope(SEM) with EDX Analysis Transmission Electron Microscope(TEM) with SAED Studies Scanning, Probe microscopy (SPM) ,Scanning Tunnelling Electron Microscopy(STM)and Atomic Force Microscopy (AFM).	15
Iv	**Thermal and electrical characterization techniques** Differential Scanning Calorimetry (DSC). Thermo Gravimetric Analysis (TGA). Differential Thermal Analysis (DTA), Two and Four probe method, Van der Pauw method. Hall probe method. Electrochemical (IV, CV, Impedance, Capacitance) Measurements, BET.Surface area measurement	15

Suggested Readings:

1. CharlesP.Poole.Jr.FrankJ.Owens,"Introduction to Nanotechnology"JohnWiley&SonsInc.
2. PradeepT."A,text,book of Nanoscience & Technology"TataMcGraw-HillEducation2012.
3. Wilson.M.,"Nanotechnology:BasicScienceandEmergingTechnologies"
4. G.CaoandY.Wang,Nanostructures and Nanomaterials, 2nd Ed.,Imperial College Press,2004.
5. R.Kelsall,I.HamleyandM.Geoghegan, Nanoscale Science and Technology,Wiley,2005.
6. K.JK labunde, R.M. Richards, Nanoscale Materials in Chemistry, 2ndEd.,Wiley,2009.
7. G.Schmidt, Nanoparticles: from Theory to applications, Wiley-VCH, 2004

Supplementary/Suggested reading

1. Murty.B.S.,P.Shankar, Baldev Raj, B.B.Rath, and James Murday.Textbook of NanoScience and nanotechnology. Springer Science &Business Media,2013
2. RobertK, IanH,MarkG, Nanoscale Science and Technology,JohnWiley&sonsLtd.,2005.

Suggestive digital platforms web links-

1. UttarPradeshHigherEducationDigitalLibrary,http://heecontent.upsdc.gov.in/SearchContent.aspx
2. SwayamPrabha-DTHChannel,https://www.swayamprabha.gov.in/index.php/program/current_he/8
3. NationalProgrammeonTechnologyEnhancedLearning(NPTEL).https://www.youtube.com/user/nptelhrd

Suggested Continuous Evaluation Methods:

Continuous Internal Evaluation (CIE) of 25 marks shall be based on Class tests, assignments, presentations, etc. as per revised NEP guidelines.

Programme /Class: **Master of Science/M.Sc**	Year:5	Semester:10
Subject: **PHYSICS**		
Course Code: **1020180**	Course Title: **Lab Nano Science**	

Course Outcomes:

At the end of the laboratory course, every student is expected to understand

- Basic concepts of Nano science and Electronics through experiments.
- The concepts studied in the theory course and their correlation with experimental observations.
- Practical knowledge of characterization techniques as well as understanding of Lithography & nano materials synthesis. In-depth knowledge of experimental aspect can be applied in higher studies in every field of physics.

Credits: 4	Core Compulsory/ Elective: Core Compulsory
Max. Marks: 100	Min. Passing Marks: 40

TotalNo.ofLectures-Tutorials-Practical(inhoursperweek):L-T-P:0-0-18

List of Experiments-
Choose any six experiments from the given list.

1. X-ray diffraction-structure evaluation and identification of material with JCPDS data
2. Analysis of given X-ray diffraction pattern of nanocrystalline samples of different crystallite sizes - Strain analysis and particle size determination by XRD and Phase determination by JCPDS.
3. Measurement of resistivity of low and high resistivity semiconductors-four probe method
4. Study of Hall effect and calculation of Hall coefficient of the given semiconductor
5. Measurement of magnetioresistance of semiconductors
6. Determination of thickness of a film by envelope method and calculation of band gap using the given transmittance spectrum of the film.
7. Determination of band gap of a semiconductor nanomaterial using UV-visible absorption spectra
8. Study of optical properties of material by using UV-Vis spectroscopy
9. Preparation of a thin film nanostructured sample by Spin Coating
10. Study of transmission line characteristics and calculate the various parameters like (i) Attenuation coefficient (ii) Phase shift coefficient (ii) Characteristic impedance
11. Study of amplitude modulation and demodulation and calculate the modulation index
12. Study of frequency modulation and demodulation and calculate modulation index

Suggested Evaluation Methods:

Evaluation of 100 marks shall be based on the experiments performed, viva-voce and lab records as per revised NEP guidelines (60+25+15).

Programme/Class: **Master of Science/M.Sc.**		Year: 5	Semester: 10
Subject: **PHYSICS**			Credits: **04**
Course Code: **01020165**	Course Title: **RESEARCH PROJECT**		
Max. Marks: **75+25** (75 for Research Project and 25 for Paper Publication)			

Course Outcomes:

- The students will be able to develop a positive outlook on learning with deepen understanding of subjects.
- Engagement in research projects will improve the critical thinking , problem solving and communication skills in student's.
- Students learn to collect information from reliable sources and carry out research.
- They get the benefit of Research Experience in graduate programs when applying for advanced studies.