Dear M.Sc Physics students,

Warm welcome to the III Batch of M.Sc students in Physics!

This e-brochure is now updated and contains practical information of the masters' programme in a simple and systematic manner with all required information. The Physics programme with its core-specialization structure offers a wide variety of possibilities, enabling you to pursue your particular ambitions and interests in this fascinating area of science. Courses at different levels of specialization will enable you to deepen your physics knowledge and find out how it is applied in modern research and development.

There are various electives and few courses are on nanosciences and materials science, which are interdisciplinary and has immense applications in all sectors of life. It is at par from the existing syllabi of other universities and NIT's.

Our Laboratories are well- equipped with start of art instruments (including Scanning Electron Microscope) and efforts to make them the best in the region. The laboratories once completely established in all respects shall be made open to the interested students of the country, where they can carry their summer/winter internships also.

We are convinced that we have created a rewarding and challenging post graduate programme in Physics for the first time in the History of NIT Srinagar that keeps its promise which will prepare you for the future. The academic loss if any due to prevailing conditions in Kashmir can be compensated with extra classes. We are less in number but nevertheless academically sound galaxy of eminent faculty having specializations in thrust areas are always available to our students.

We wish you a good start and lots of success!

Dr. M.A.Shah
Programme Director and Coordinator

On July 2017 in NIT Srinagar

Post Graduate Programme

In

Physics

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Syllabus for Credit Based Curriculum

by

Department of Physics

National Institute of Technology

Srinagar

Jammu and Kashmir

July 2017

National Institute of Technology Srinagar: A Brief Profile

The National Institute of Technology, Srinagar (NIT), one of the leading institutes in north of the country, was established in 1960. In 2004, it had the unique distinction of becoming an Institute of National Importance under the NIT Act under the auspices of Ministry of Human Resources Development, Govt. of India.

Being fully residential, the campus located on the western bank of the Dal Lake near the famous Hazratbal Shrine, provides comfortable accommodation to all faculty and students. The institute has signed Memorandum of Understanding (MOU) with various national and international academies, professional and research institutes as well as industry to augment the learning process. These ties are a means for our students to gain valuable and relevant knowledge and experience, providing them with the building blocks for a successful future career. Students from all over the country epitomize a healthy amalgamation of different cultures, religions and languages on the campus and present a classical example of a mini cultural India.

The prestigious technical institute has ten departments which cater six postgraduate and ten undergraduate programmes besides offering Ph.D. degree in all Engineering and Science disciplines. Since its inception, the **Department of Physics** is offering the General Physics courses Physics I and Physics II for all branches of B.Tech. students during first and second semesters respectively. In addition, the department offers several electives to various branches. The Department has full-fledged laboratories for research and offers Ph.D./M.Phil. programmes in Solid state physics, Materials science, Nanotechnology, Nuclear physics, Space physics, and in renewable energy sectors. Presently, the department has six faculty members and the faculty has developed research collaborations with several premier institutions across the globe. In order to inculcate the academic culture, the department regularly organizes lecture/quiz competitions and invited talks by the eminent scientists. So far the department has produced maximum M.Phil. and Ph.D. scholars in the Institutes. Unending efforts are being made by the department to develop the well equipped research laboratories to cater the needs of master's programme which is likely to be approved. In this programme, we have offered intrinsically challenging and didactically inspiring courses.

Small but academically sound galaxy of eminent faculty having specializations in thrust areas are actively engaged in research and other academic assignments including teaching to B.Tech students. Dozens of students pursuing Ph.D under their guidance have collaborations with reputed laboratories across the globe. The faculty has always brought laurels to the institute. However, the Institute overall has witnessed a remarkable growth in all sectors under the guidance of our Director Prof. Rajat Gupta, from the last three years and perseverance of the coordinator Dr. Shah M A.

Programme Structure:

Entire two years Masters Programme has been divided into four semesters. In first year (two semesters) all the core courses have been introduced with more information with relevant updated topics with a view to link earlier (B.Sc) programme. In second year, courses have been designed to accommodate more applied subjects (electives) and comprehensive project work in industry or any national laboratory of repute.

Total No of seats: Twenty five (25)

Reservation for open, SC/ST, OBC and PH are as per Govt. of India rules.

Eligibility Criteria:

Students for admission to M.Sc. Programme must satisfy the criteria: Bachelor's degree with at least 60% marks/6.5 CGPA (on 10 point scale) or equivalent, with **Physics** as main and **Mathematics** as a subsidiary subject **OR** with **Physics and Mathematics** among the main subjects. 5% or 0.5 in CGPA on a 10 point scale relaxation may be extended to candidates belonging to SC/ST/OBC/PH candidates.

Admission Procedure:

Interested candidates satisfying the eligibility criteria will have to submit their application form in the prescribed format, which will be made available on the institute web page (www.nitsri.net). Applicant should be a citizen of India. Admission of foreign nationals, if any, shall be governed by the rules stipulated by the Government of India from time to time. Two step processes to admit the students into M.Sc. programme shall be carried as:

(i) Short listing of candidates as per eligibility.

(ii) Performance in written test examination.

The examination pattern (Theory as well as Practical) approved by the senate will be followed for the programme.
Entrance will be conducted by Institute.

Course Monitoring and Course Evaluation

- Academic coordinator for each semester should be notified by the National Institute of Technology/Institution/Dean much before the start of the semester course work.
- Two independent sets of question papers for the end semester examination should be got set by the academic coordinators for all the courses in each semester. This action should be taken by the academic coordinators much before the start of the semester course work.
- The question paper shall be uniformly distributed over the syllabus giving equal weightage to all the units. The students have to do five questions selecting at least one from each unit.However, all the procedures of the institute shall be followed for the course evaluation.

PROGRAMME AT A GLANCE

Name of Degree	Name of Programme	Intake (Full-time)	Year of starting proposed	Duration	Name of Degree & Eligibility for Admission
M.Sc.	APPLIED PHYSICS	25	2014	2 years	Bachelor's degree in Science and Engineering with at least 60% marks/6.5 CGPA (on 10 point scale) or equivalent, with **Physics** as main and **Mathematics** as a subsidiary subject **OR** with **Physics and Mathematics** among the main subjects. For SC/ST candidates 55% marks or CGPA 5.5/10 in aggregate in the qualifying examination.

Course Structure

The Credit structure is as follows:

Core: 56

Electives: 04

Projects: 30

Total Credits: 90

PROGRAMME STRUCTURE

SEMESTER - I Total Credits: 90

S. No.	Course Code	Courses	L	T	P/	Credits	Page No.
1.	PSPHY 101	Mathematical Methods for Physics	3	1	0	4	01
2.	PSPHY 102	Classical Mechanics	3	1	0	4	02
3.	PSPHY 103	Quantum Mechanics	3	1	0	4	03
4.	PSPHY 104	Solid State Physics	3	1	0	4	04
	PSPHY LB1	**Solid State Physics Lab**			4	2	05
	PSPHY LB2	**Advanced Optics Laboratory**			4	2	05
	Total		**15**	**5**	**8**	**20 (Twenty)**	

SEMESTER - II

S. No.	Course Code	Courses	L	T	P/	Credits	
1.	PSPHY 201	Classical Electrodynamics	3	1	0	4	06
2.	PSPHY 202	Electronics	3	1	0	4	07
3.	PSPHY 203	Thermodynamics and Statistical Mechanics	3	1	0	4	08
4.	PSPHY 204	Atomic and Molecular Physics	3	1	0	4	09
	PSPHY LB3	**Electronics and Instrumentation Lab.**			4	2	10
	PSPHY LB4	**Characterization Lab.**			4	2	10
	Total		**15**	**5**	**8**	**20 (Twenty)**	

SEMESTER – III

S. No.	Course Code	Courses	L	T	P/	Credits	
1.	PSPHY 301	Condensed Matter Physics	3	1	0	4	11
2.	PSPHY 302	Nuclear and Particle Physics	3	1	0	4	12
3	PSPHY 303	Computational Methods in Physics	3	1	0	4	13
		Electives: **one elective as per choice.**					
1.	PSPHY EL1	Renewable Sources of Energy	3	1	0	4	14
2.	PSPHY EL2	Nanoscience and Nanotechnology	3	1	0	4	15
3	PSPHY EL3	Atmospheric Physics	3	1	0	4	16
4.	PSPHY EL4	Fiber Optics	3	1	0	4	17
5	PSPHY EL5	Material Science	3	1	0	4	18
6	PSPHY EL6	Semiconductor Physics	3	1	0	4	19
7	PSPHY El 7	Quantum Field Theory	3	1	0	4	20
8.	PSPHY El 8	Group Theory	3	1	0	4	21

9.	PSPHY El 9	Integrated Electronics	3	1	0	4	22
	PSPHYLB5	**Computational Physics Lab.**			4	2	24
	PSPHY LB 6	**Materials Science Lab.**			4	2	24
	Total		**15**	**5**	**8**	**20 (Twenty)**	

SEMESTER – IV

S. No.	**Course Code**	**Courses**	**L**	**T**	**LAB**	**Credits**	
1	PSPHY PR1	Research Methodology	3	1	0	4	26
2	PSPHY PR2	Project/Dissertation and Viva voce			50/6mon	**26**	27
	Total					**30 (Thirty)**	

PSPHY 101 **MATHEMATICAL METHODS FOR PHYSICS** **C L T P**

4 3 1 0

Vector Analysis in Curved Coordinates and Tensors, Orthogonal Coordinates in R3, Differential Vector Operators, Special Coordinate Systems, Circular Cylinder Coordinates, Spherical and Polar Coordinates.

Tensor Analysis, Contraction, Direct Product, Quotient Rule, Pseudotensors, Dual Tensors , General Tensors, Tensor Derivative Operators. Group Theory, Introduction, Generators of Continuous Group, Orbital Angular Momentum, Angular Momentum Couplin, Homogeneous Lorentz Group, Discrete Groups

Matrices, Cayley-Hamilton Theorem , Eigenvalues and eigenvectors. Functions of a Complex Variable,Analytic Properties , Cauchy–Riemann Conditions, Cauchy's Integral Theorem, Cauchy's Integral Formula, taylor series , Laurent Expansion ,Singularities, Mapping, Functions of a Complex Variable, Calculus of Residues and evaluation of integrals.

Applications and Properties of Fourier Series .,Discrete Fourier Transform, Fourier Expansions of Mathieu Functions , Development of the Fourier Integral, Inversion Theorem , Fourier Transform of Derivatives , Convolution Theorem , Momentum Representation

First-Order Differential Equations, Separation of Variables, Singular Points, Series Solutions—Frobenius Method, A Second Solution, Non-homogeneous Equations Eigen function Expansion Bessel Functions, Bessel Functions of the First Kind, Orthogonality, Neumann Functions ,Modified Bessel Functions, Legendre Generating Function, Recurrence Relations, Orthogonality, Associated Legendre Functions ,Spherical Harmonics, Orbital Angular Momentum Operator, Addition Theorem for Spherical Harmonics, Legendre Functions of the Second Kind ,Hermite Functions, Laguerre Functions,

Text Books

1. L.A. Pipes and L.R. Harvill, Applied Mathematics for Engineers and Physicists, McGraw-Hill (1970).
2. G. B. Arfken and H.J. Weber, Mathematical Methods for Physicists, 5th edition, Academic Press (2001).
3. E. Kreyszig, Advanced Engineering Mathematics, 8th edition, John Wiley & Sons Inc. (1999).

4. W.W Bell: Special functions for scientists and engineers.
5. J. Mathews and R L Walker: Mathematical Methods of Physics.

PSPHY 102 **CLASSICAL MECHANICS** **C L T P**

4 3 1 0

Newtonian mechanics and its limitations. Constrained motion. Constraints and their classification. Principle of virtual work. D' Alembert's principle. Generalized coordinates. Deduction of Lagrange's equations from D' Alembert's Principle. Generalized momenta and energy. Cyclic or ignorable coordinates. Rayleigh' s dissipation function. Integrals of motion. Symmetries of space and time with conservation laws.

Rotating frames. Inertial Forces. Electromagnetic analogy of inertial forces. Terrestrial and astronomical applications of Coriolis force. Foucault's pendulum. Problems.

Central force. Definition and properties of central force. Two-body central force problem. Stability of orbits. Conditions for closure. General analysis of orbits. Kepler's laws. Kepler's equation. Artificial satellites. Rutherford scattering.

Principle of least action. Hamilton's principle. The calculas of variations. Derivation of Hamilton's equations of motion for holonomic systems from Hamilton's principle. Hamilton's principle and characteristic functions.

Canonical Transformations, Generating functions. Poisson brackets, Poisson's Theorem. Invariance of PB under canonical transformations, Angular momentum PBs. Hamilton-Jacobi equation. Connection with Classical Mechanics canonical transformation. Problems. Small oscillations, Normal modes and coordinates. Problems.

Text Books

1. H. Goldstein, C. Poole and J. Safko, Classical Mechanics, 3nd edition, Addison & Wesley(2000).
2. L.D. Landau and E.M. Lifshitz, Mechanics, Buttorworth-Heinemann (1976).
3. W. Greiner, Classical Mechanics – Point particles and Relativity, Springer-Verlag (1989).
4. N.C Rana and P.S Joag, Classical Mechanics.
5. John R Taylor, Classical Mechanics, University Science Books 2012

PSPHY 103 **QUANTUM MECHANICS** **C L T P**

4 3 1 0

Basic postulates of quantum mechanics. Linear operators Hermitian operators. Orthogonality of Eigen functions of a Hermitian operator. Completeness of Eigen functions. Commuting operators and their Eigen functions. Dirac's bra and ket notation. Representation of operators as matrices. Change of basis. Unitary transformation and its significance. Equations of motion. Schrodinger picture and Heisenberg picture. Interpretation of the wave function. Schwartz Inequality and Uncertainty Principle. Classical limit of the Schrodinger equation. operator methods in Q Mechanics, Double Stren-Gerlach experiment for spin half system.

Generalized orbital angular momentum. Operators for J, Spin angular momentum. Total angular momentum operator. The Eigenvalues of I and I. Pauli spin matrices. Commutation relations. Eigen values and Eigen functions of Pauli matrices. Spin functions for two spin -112 particles. Addition of angular momenta. Clebsch Gordan Coefficients. Physical meaning of identity. Symmetric and anti-symmetric wave functions. Construction from unsymmetrized functions. The Pauli Exclusion Principle.

Time independent perturbation theory. Perturbation of non-degenerate states. First order perturbation. Second order perturbation. Perturbation of an oscillator. Perturbation of degenerate states. Removal of degeneracy. First order Stark effect in hydrogen atom. Time dependent perturbation theory. Transition probability. The variation method with simple applications. Green's functions incoming and outgoing solutions.

Text Books

1. P.M. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, Tata McGraw-Hill (1977).
2. J.L. Powell and B. Crasemann, Quantum Mechanics, Narosa Publishing House (1993).
3. J.J. Sakurai, Modern Quantum Mechanics, Addison-Wesley (1999).
4. E. Merzbacher: Quantum Mechanics.
5. Cohen and Tanandji: Quantum Mechanics.

PSPHY 104 **SOLID STATE PHYSICS** **C L T P**

4 3 1 0

The Solid State, Periodicity in Crystals, Bravais lattices- Primitive vectors, Primitive unit cells, Conventional unit cells, Wigner Seitz Cell, Number of Lattice points per unit cell. Classifications of two and three dimensional Bravias lattices, Miller indices, Lattice planes and Interplanner spacing, Directions and atomic packing, Common crystal structures.

X-Rays and their generation, X-Ray diffraction, Bragg's law (SS), Laue's method, powder crystal method, rotating crystal method, The reciprocal lattice, Some properties of reciprocal lattice. Crystal Imperfections, Burgers vector and Burgers circuit, Presence of dislocation, Dislocation motion, Energy of a dislocation, Slip planes and slip directions, Dislocation reactions and surface imperfections.

Classical free electron theory of Metals, Drawbacks of classical theory, Relaxation time, Collision time and Mean free path, Quantum theory of Free electrons, Quantum states and degeneracy, The Density of energy states and Fermi energy, Fermi Dirac Statistics, Heat Capacity of electron Gas, Effect of temperature of Fermi Distribution Function. Band theory of Solids, Bloch's theorem, Kronig- Penney Model, Brillouin zones, Symmetry properties of energy function, Effective mass of an electron, Tight binding electron model, Energy band structure in conductors, semiconductors, insulators.

Semiconducting Materials, Conduction in semiconductor, Charge densities in a semiconductor, powerless diffusion and drift of carries, PN junction, space charge and electric field distribution at junctions forward and reverse biased conditions, carrier in junctions minority and majority carrier currents, Space charge capacitances Zener and avalanche breakdowns, Schottky barrier, zener diodes, varactor diode, tunnel diode, photodiode LED, SCR.

Text Books

1. Charles Kittel, Introduction to Solid State Physics, Wiley Eastern, 5th edition (1983).
2. M.A. Wahab: Fundamentals of Solid State Physics, Naroosa New Delhi (2015)
3. O. Pillay: Solid State Physics, New Age International New Delhi (2011).
4. M Ali Omar: Elements of Solid State Physics, Pearson, New Delhi
5. Ashcroft & Mermin, Solid State Physics, Naroosa New Delhi.

LABORATORIES Ist SEM

PSPHY LB1 **SOLID STATE PHYSICS LAB** **C L T P**
2 0 0 4

1. To determine the band gap of given semiconductor crystal using four probe method.
2. To determine the Hall coefficient for given semiconductor and study its field dependence.
3. Study of frequency dependence of dielectric constant for a given sample.
4. To study hysteresis of ferromagnetic material.
5. To Study the Thermo luminescence of F-Centers in Alkali Halides Crystals.
6. To study the morphology of a sample using SEM and to study elemental analysis by EDX method.
7. To measure the frequency dependence of dielectric constant of a ferroelectric material ($BaTiO_3$) using an 'Impedance meter'.
8. Measurement of resistivity of very low to highly resistive samples by four probe method at different temperatures.
9. To study the superconducting transition of YBCO superconductor.
10. Measurement of Magnetoresistance of Semiconductors.

PSPHY LB2 **ADVANCED OPTICS LAB** **C L T P**
2 0 0 4

1. Determination of line width of a laser using monochromator.
2. Diffraction of light due to a straight edge
3. Thickness of the enamel coating on a wire - by diffraction.
4. Production and analysis of linearly, circularly and elliptically polarized light
5. Measurement of screw parameters using a laser beam.
6. Using Michelson's interferometer for the determination of thickness of film and its refractive index.
7. Measurement of coherence length of laser using Michelson interferometer.
8. Construction and reconstruction of an object using holography.
9. Diffraction of light by straight edge.
10. Mach-Zehnder Interferometer using a He-Ne laser.

PSPHY 201 **CLASSICAL ELECTRODYNAMICS** **C L T P**

4 3 1 0

Coulomb's Law, Electric Field, Gauss's Law, Differential Form of Gauss's Law , Surface Distributions of Charges and Dipoles and Discontinuities in the Electric Field and Potential, Poisson and Laplace Equations, Green's Theorem, Uniqueness of the Solution with Dirichlet or Neumann Boundary Conditions, Formal Solution of Electrostatic Boundary-Value Problem with Green Function, Electrostatic Potential Energy and Energy Density

Faraday's Law, Quasi-Static Fields , Introduction and Definitions, Biot and Savart Law ,Differential Equations ofMagnetostatics and Ampere's Law ,Vector Potential ,Vector Potential and Magnetic Induction for a Circular Current Loop ,Magnetic Fields of a Localized Current Distribution, Magnetic Moment, Force and Torque on and Energy of a Localized Current Distribution in an External Magnetic Induction , Macroscopic Equations, Boundary Conditions on B and H, Methods of Solving Boundary-Value Problems in Magnetostatic , Uniformly Magnetized Sphere , Magnetized Sphere in an External Field , Faraday's Law of Induction, Energy in the Magnetic Field , Energy and Self- and Mutual Inductances, Eddy Currents; Magnetic Diffusion.

Method of Images, Point Charge in the Presence of a Grounded Conducting Sphere , Point Charge Near a Conducting Sphere at Fixed Potential, Laplace Equation in Rectangular Coordinates, Multipoles, Electrostatics of Macroscopic Media, Dielectrics , Multipole Expansion, Multipole Expansion of the Energy of a Charge Distribution in an External Field Boundary-Value Problems with Dielectrics , Molecular Polarizability and Electric Susceptibility , Models for Electric Polarizability , Electrostatic Energy in Dielectric Media,
Macroscopic Electromagnetism, Conservation Laws, Maxwell's Displacement Current; Maxwell Equations ,Vector and Scalar Potentials, Gauge Transformations, Lorenz Gauge, Coulomb Gauge, Green Functions for the Wave Equation ,Retarded Solutions for the Fields: Jefimenko's Generalizations of the Coulomb and Biot-Savart Law ; . Derivation of the Equations of Macroscopic ElectromagnetismPoynting's Theorem and Conservation of Energy and Momentum for a System of Charged Particles and Plane Electromagnetic Waves and Wave Propagation ,Plane Waves in a Nonconducting Medium , Linear and Circular Polarization , Reflection and Refraction of Electromagnetic Waves at a Plane ,

Text Books

1. J.D. Jackson, Classical Electrodynamics, John Wiley & Sons, 2nd edition (1990).
2. D. J. Griffiths, Introduction to Electrodynamics, Pearson Prentice Hall, 3rd edition (1999).
3. J.R. Reitz., F.J. Milford and R.W. Christy, Foundations of Electromagnetic Theory, 3rd edition, Narosa Publishing House (1979).
4. L.C Landau and E.M. Lifshitz Classical theory of fields.
5. Panofsky and Phillips: Classical Electrodynamics.

PSPHY 202 **ELECTRONICS (Solid State)** **C L T P**

4 3 1 0

Classification of semiconductors, Charge Carriers in semiconductors, Carrier concentration, Drift of carriers in electric and magnetic fields, Excess carriers in semiconductors, Photoluminescence, Electroluminescence, Photoconductive devices, Diffusion of carriers, Diffusion and recombination.

The p-n junction, Capacitance of a p-n junction, The P-n junction diode, Rectifying diodes, Light emitting junction diodes, tunnel diode, Schottky barrier diode Microwave diodes: varactor diode, p-i-n diode. Photo diodes. The transistors, The Junction FET, The MOSFET, Operation of BJT, BJT Characteristics, enhancement and depletion modes of operation – basic idea of charge coupled devices.

Logic gates – half adder, full adder – comparators, decoders, multiplexers, demultiplexers – design of combinational circuits – sequential circuits – *Flip-flops:* RS flip-flop, JK flip-flop, JK master-slave flip-flops, T flip-flop, D flip-flop – synchronous and asynchronous counters, registers – A/D and D/A conversion – characteristics.

Text Books

1. Ben G Streetman and Sanjay Banerjee, Solid State Electronic Devices, PHI, New Delhi (2002).
2. Linda Edward Shea, Solid State Electronics PHI, New Delhi (1997)
3. J. Milman and C.C. Halkias, Electronic Devices and Circuits, McGraw-Hill (1981).
4. R. L. Boylsted and L. Nashelsky, Electronic Device and Circuits, Pearson Education (2003).
5. A.P. Malvino, Electronics: Principles and Applications, Tata McGraw-Hill (1991).

PSPHY 203 **THERMODYNAMICS AND STATISTICAL MECHANICS** **C L T P**
4 3 1 0

Review of thermodynamic concepts required for Statistical Mechanics, the macroscopic and the microscopic states, specification of states of a thermodynamic system, the principle of maximum entropy, thermodynamic potentials, contact between statistical mechanics and thermodynamics, Euler's equation and the Gibbs-Duhem relation, the Legendre transformation, classical ideal gas, entropy of mixing and Gibb's paradox.

Micro-canonical ensemble, phase space, trajectories and density of states, Liouville's theorem, canonical and grand canonical ensembles; partition function, calculation of statistical quantities, Energy and density fluctuations. Systems in contact with heat reservoir, expression of entropy, Canonical partition function, Helmholtz free energy, systems in contact with a particle reservoir, chemical potential, grand canonical partition function, fluctuation of particle number, Chemical potential of ideal gas.

Density matrix, statistics of ensembles, statistics of indistinguishable particles, Maxwell-Boltzmann, Fermi-Dirac and Bose Einstein statistics, properties of ideal Bose and Fermi gases, Bose-Einstein condensation. Real gases, Mayer's cluster expansion for a classical gas, Virial equation of state, Ising model, mean-field theories of the Ising model in two and one dimensions.

Landau theory of phase transition, critical indices, scale transformation and dimensional analysis. Correlation of space time dependent fluctuations, fluctuations and transport phenomena, Brownian motion, Langevin theory, Fluctuation dissipationtheorem, The Fokker Planck equation

Text Books

1. F. Reif, Fundamentals of Statistical and Thermal Physics, International Students edition, Tata McGraw-Hill (1988).
2. K. Haung, Statistical Mechanics, Wiley Eastern (1991).
3. F.W. Sears and G.L. Salinger, Thermodynamics, Kinetic Theory and Statistical Thermodynamics, 3rd edition, Narosa Publishing House (1998).
4. H.B Callen: Thermodynamics and an introduction to thermostatics.
5. R. Kubo: Statistical Mechanics.

PSPHY 204 **ATOMIC AND MOLECULAR PHYSICS** **C L T P**

4 3 1 0

Solution of' Schrödinger's equation for Coulomb field, quantum numbers n, l, m, Comparison with Bhor's model, the hydrogen spectrum Problems. The hydrogen atom Fine structure: Electron Spin, Stern-Gerlach experiment, the interaction terms, relativistic correction, spin-orbit interaction, vector model, spectroscopic terms and selection rules, lamb shift, summary of the hydrogen spectrum, Problems.

The Helium Atom, Approximation Models, Symmetry of the Wave Function ,Electrostatic interaction and exchange degeneracy ground and excited states of helium, Electron spin functions and Pauli's exclusion principle, Energy Levels of the Helium Atom, Helium Spectrum, Problems.

The LS-coupling approximation, allowed term in LS coupling, Fine structure in LS coupling, J-J Coupling. Problems, Hyperfine Structures. Interaction with External Field: Zeeman, Paschen-Back and Stark effects, Problems.

Covalent ionic and Vander Waal's interaction. Rotational, Vibrational, Rotational-Vibrational and electronic spectra of di-atomic molecules, selection rules, Frank-Condon principle. Raman effect and Raman spectra.

Text Books

1. C.N. Banwell, Fundamentals of Molecular Spectroscopy, 4th edition, McGraw-Hill, New York (2004).
2. Manas chanda, Atomic Structure and Chemical Bond, Tata McGraw-Hill, New Delhi (2003).
3. Arthur Beiser, Concepts of Modern Physics, 6th edition, Tata McGraw-Hill, New Delhi (2003).
4. G. Aruldhas, Molecular Structure and Spectroscopy, Prientice Hall of India, NewDelhi (2002).
5. B.H Bransden and C.J Joachain: Physics of atoms and Molecules.

LABORATORIES II SEM

PSPHY LB3 **<u>ELECTRONICS AND INSTRUMENTATION LAB</u>** **C L T P**
2 0 0 4

1. To study the gain characteristics of a double stage RC coupled BJT amplifier.
2. To study the drain, transfer characteristics of a JFET.
3. To study the input and output characteristics of a differential amplifier.
4. To study MOSFET as output power amplifier.
5. Design and performance study of inverting, non-inverting and unity gain, differentiator, integrator amplifier using op-amp.
6. Design and performance study of Schmidt trigger circuit.
7. Design and performance study of astable multivibrator and mono-stable multivibrator.
8. Design and performance study of active filters (Low pass, high pass, band pass, band reject).
9. Combinational circuits: Adders, multipliers, magnitude comparators.
10. Sequential circuits: Flip flops, counters, shift registers. (Ripple counter with D type flip-flops; J-K flip flop and its application to counting).

PHY LB4 **<u>CHARACTERIZATION LAB</u>** **C L T P**
2 0 0 4

1. Structural determination of powdered crystalline materials by XRD.
2. Surface morphology of the materials by SEM.
3. Characterization of semiconductors: Determination of number of charge carriers, mobility.
4. Study of Dielectric Constant and Measure Curie temperature of Ferroelectric Ceramics.
5. Apparatus for Measurement of Susceptibility of Paramagnetic Substance in the form of Solution by Quincy's Tube Method.
6. Mossbauer Spectrometer.
7. Ultrasonic testing apparatus.
8. Experimental methods for gamma-ray (G.M. Counter).
9. Determination of the g of DPPH by Electron Spin Resonance Spectrometer (ESR).
10. Determination of band gap of semiconducting materials by UV- Visible spectrometer.

PHY 301 **CONDENSED MATTER PHYSICS** **C L T P**

4 3 1 0

Symmetry Elements, Combination of Symmetry elements (Point Groups) Concepts of point groups, Crystal Symmetry, Space groups, Symmetry and Degeneracy, Crystal field spiliting, Kramers Degenracy, Quasicrystals, General idea, approximation translational and rotational symmetry of two dimensional.

The Boltzmann transport equation, relaxation time, Electrical conductivity of metals, impurity scattering, ideal resistance, thermoelectric effects, thermal conductivity. Electronic properties in a magnetic field, Classical theory of magneto resistance, Hall effect and magnetic resistance, k space analysis of electrons motion in a uniform magnetic theory, Energy levels and density of states in a magnetic field, Quantum hall effect

The dielectric function, the dielectric function for harmonic function, Dielectric losses of electrons, K K Relations, Interaction of phonones and electrons with photons, Interband transition, Direct and indirect transition. Skin effect and anomalous skin effect.

History, general properties, measurements, critical field, temperature, current, Meissner effect, type-I and type-II superconductors (SS). London equation, penetration depth, optical properties, Cooper pair, BCS theory (Qualitative), coherence length, electron-phonon interaction, flux quantization, Josephsonjunction, high Tc superconductors.

Electron interaction via lattice, Cooper pairs, BCS theory, Bogoliubov transformation-notion of quasiparticles, Meissner effectDisordered in condensed matter- substitional , positional and tropographical disorder, Short and long range order, Atomic correlation function and structural description of glasses and liquids, Hubbard Model and koudo effect.

Text Books

1. Solid State Theory: M. Sachs.
2. Principles of the theory of solids: J .M Ziman
3. Solid State Physics: Ashcroft & Mermin
4. Solid State Physics: A. J . Dekker, Macmillan, new Ed, 2011

5. Materials science and Engineering by V. Raghavan, Prentice-Hall Pvt. Ltd.

PSPHY 302 **NUCLEAR AND PARTICLE PHYSICS** **C L T P**

4 3 1 0

Basic nuclear properties, Nuclear size and distribution of nucleons, Energies of nucleons in the nucleus, Angular momentum, Parity and symmetry, Magnetic dipole moment and electric quadrupole moment, Energy levels and mirror nuclei. Characteristics of nuclear forces - Range and strength, Simple theory of two nucleon system-deuterons, Spin states of two nucleon system, Effect of Pauli's exclusion principle, Magnetic dipole moment and electric quadrupole moment of deuteron -The tensor forces.

Interaction of charged particles with matter. Stopping power and raige. Detectors for energetic charged particles; Solid State or Semiconductor detector; Bubble chamber; Nuclear emulsions. Composite relations. E rays, Ionization and scattering measurements in nuclear emulsions, Identification of particles. Need for accelerator of charged particles, Classification of types of accelerators, Proton Synchrotron, Betatron; alternating gradient accelerator, Colliding beam accelerator.

Different types of reactions, Quantum mechanical theory, Resonance scattering, Compound nucleous formation, Statistical theory of nuclear reactions and evaporation probability.

Classification and properties of elementary particles, Leptons, Baryons, mesons particles and antiparticles excited states and resonances. Various types of interactions - gravitational, electromagnetic, weak and strong interactions and their mediating quanta, Conservation rules in fundamental interactions. Charge symmetry and charge independence, Parity and charge conjugation, Conservation of parity and its violation in different types of interactions. Strange particles, associated production, strangeness and decay modes of charged Kaons, Isospin and its conservation. Idea of eight fold way and quarks.

Text Books

1. Heral Enge, Introduction to Nuclear Physics, Addison Wesley (1981).
2. D.C. Tayal, Nuclear Physics, 4th edition, Himalaya House, Bombay (1980).
3. W.C. Burcham, Elements of Nuclear Physics, ELBS (1979).
4. Kenneth S. Krane, Introductory Nuclear Physics, John Wiley & Sons, New York (1988).

5. J .S Lilley: Nuclear Physics.

PSPHY 303 **Computational Methods in Physics** **C L T P**

4 3 1 0

1. Introduction to MATLAB and its use for data analysis
   (i) MATLAB and its IDE; variables and arrays; scalar and array operations; built-in MATLAB functions;
   (ii) Working with data sets: file input/output. Data visualisation and plotting in MATLAB;
   (iii) Revision of error analysis: χ^2 analysis, errors on fitting coefficients, propagation of errors; MATLAB functions for error analysis;
   (iv) User-defined functions in MATLAB;
   (v) Comparison of MATLAB with other languages.

Project 1: Analysis of experimental spectrum data.

2. Numerical methods and the solution of ordinary differential equations
   (i) Introduction to numerical computing; errors in numerical methods;
   (ii) Numerical methods for solving ordinary differential equations; Euler's method; higher -order methods; symplectic methods;
   (iii) Implementation of numerical methods in MATLAB programs;
   (iv) The linear driven damped oscillator; phase space; conserved quantities; sources of simulation error;
   (v) Map-based schemes; introduction to nonlinear systems.

Project 2: Numerical integration of the driven damped oscillator.

3. The Monte Carlo method and its application to particle transport
   (i) Introduction to Monte Carlo methods; Monte Carlo integration; classical problems;
   (ii) Pseudorandom and quasirandom sampling; methods of generating samples with given probability density;
   (iii) Introduction to particle transport simulation; cross-sections;
   (iv) Simulation of neutron transport and scattering; nuclear criticality with Monte Carlo;
   (v) Importance sampling and statistical errors; Woodcock tracking;
   (vi) Other applications of Monte Carlo methods.

Project 3: Simulation of the penetration of neutrons through shielding.

Text books: As Suggested By Teacher

ELECTIVES

PSPHY EL 01 **Renewable Sources of Energy** **C L T P**

4 3 1 0

Relevance of renewable energy in relation to depletion of fossil fuels and environmental considerations, Green Energy, Solar Energy, Sun as a source of energy, nature of solar radiation and sun-earth angles, Flat plate collectors, types of FPC, effects of various parameters on the performance of FPC, Overall heat loss coefficient and heat transfer correlations, collector efficiency factor, Solar thermal applications like solar cooker and solar water heaters solar dyers, solar stills, solar cooling. Solar refrigeration and Carnots refrigeration cycle, thermal energy storage, active and passive heating of buildings.

Physics and Materials properties basic to photovoltaic conversion, Optical properties of solids, Direct and indirect transition semiconductors, interrelationship between absorption coeeficient and band gap, recombination of carriers, Types of solar cells, pn junction solar cells, transport equation, current density, open circuit voltage and short circuit current, brief description of single crystal silicon and amorphous silicon solar cells, e.g. tandem solar cells, solid liquid junction solar cells, nature of semiconductor, electrolyte junction, photoelectrochemical solar cells

Solar Hydrogen through photoelectrolysis and photocatalytic process. Physics of material characteristics for production of solar hydrogen, Various factors relevant for safety, use of Hydrogen as fuel, use in vehicular transport, hydrogen for electricity generation, Fuel Cells, Energy Storage, Brief discussion of various storage processes, special feature of solid state hydrogen storage materials, structural and electronic characteristics of storage materials, new storage modes Wind Energy, Energy and power in Wind, Wind Turbines, Aerodynamics of Wind turbines, Environmental impacts, offshore wind energy, economics

Text Books:

1. Twidel and Weir, Renewable Energy, E& F N Spon ltd
2. Godfrey Boyle, Renewable Energy: Power for a sustainable Future, Oxford
3. Duffie, J.A. and W.A. Beckmann. Solar engineering of thermal processes, John Wiley and son's incorporation, New York.
4. Sukhatme S.P. Solar Energy, Principles of thermal collection and storage, Tata McGraw Hill Publishing Company Limited New Delhi, 1997.
5. Garg, H.P and T.C.Kandpal "Laboratory Manual on solar Thermal Experiments " Narosa publishing House , New Delhi.

PSPHY EL 02 **NANOSCIENCE AND NANOTECHNOLOGY** **C L T P**

4 3 1 0

Top-Down and Bottom-Up approaches of nanomaterial (nanoparticles, nanoclusters and quantum dots) synthesis: Top-down techniques: photolithography, other optical lithography (EUV, X-Ray, LIL), particle-beam lithographies (e-beam, FIB, shadow mask evaporation), probe lithographies, Bottom-up techniques: self-assembly, self-assembled monolayers, directed assembly, layer-by-layer assembly. Pattern replication techniques: soft lithography, nanoimprint lithography. Pattern transfer and enhancement techniques: dry etching, wet etching, pattern growth techniques (polymerization, directed assembly). Combination of Top-Down and Bottom-up techniques: current state-of-the-art.

Characterization Techniques Related to Nanoscience and Nanotechnology: Compositional surface analysis: XPS, SIMS, Contact angles. Microscopies: optical microscopy, fluorescence and confocal microscopy, TEM, SEM, Probe techniques: Scanning tunneling microscopy (STM), Atomic force microscopy (AFM), Scanning Nearfield Optical Microscopy SNOM, Scanning Ion Conducting Microscopy (SICM). Ellipsometry, Neutron Scattering and XRD, Spectroscopic Techniques: UV-visible, FT-IR, Raman, NMR, ESR. Electrochemical Techniques: Voltammetric techniques, AC Impedance Analysis.

Basics of nanoelectronics – Single Electron Transistor – quantum computation – tools of micro-nanofabrication – nanolithography – quantum electronic devices – MEMS and NEMS – dynamics of NEMS – limits of integrated electronics.

Text Books:

1. Jan Korvink and Andreas Greiner, Semiconductors for Micro and Nanotechnology – an Introduction for Engineers, Weinheim Cambridge: Wiley-VCH (2001).
2. M.A. Shah and T Ahmad, Principles of Nanoscience and Nanotechnology, Narosa, New Dehli
3. N John Dinardo and Weinheim Cambridge, Nanoscale Characterisation of Surfaces & Interfaces, 2nd edition, Wiley-VCH (2000).
4. M.S Rao and Singh, Nanotechnology, Wiley (2012)
5. M.A. Shah and K. A. Shah, Nanotechnology-The Science of Small, Wiley, (2013).

PSPHY EL 07 **Quantum Field Theory**
C L T P

4 3 1 0

Klein Gordon, Dirac, Weyl and Majorana Eqns. Plane wave Solutions and observation. Non-relativistic limits of Dirac Eqn. Foly Wouthyer transformation. Canonical quantization of neutral scalar, Charged scalar, spin 1/2 and massive spin-i fields, Pock space and observables. Field commutation, an commutation relations,
Interaction picture. Normal product. Wick's theorem. Feynman propagat
S-matrix. Feynman diagrams for itheory. Quantization of electromagnetic field. Gupta-Bleuler condition. Indefinite metric. Feynman diagrams of QED. Tree level calculations of Moll Bhabha, Compton and Scattering in external field. General Formulation. Conjugate Momentum and Quantization. Neutral Scalar Field. Commutation Relations, Normal Ordering, Bose Symmetry, Fock Space.

The Dirac Equation, Relativistic Covariance. Anti-Commutators. Quantization of the Dirac Field, Electrons and Positrons. Connection between Spin and Statistics. Discrete Symmetries, Parity, Charge Conjugation, Time Reversal, CPT Theorem. Gauge Invariance and Gauge Fixing. Quantization of the Electromagnetic Field, Propagator, Vacuum Fluctuations.

Text Books

1. Bogolinbov & Shirkov : Introduction to Quantized Field Theory.
2. Bjorken & Drell : Quantum Field Theory.
3. Itzyksen & Zuber : Quantum Field Theory (McGraw Hill).
4. Quantum Field Theory, C. Itzykson and J . B. Zuber, McGraw-Hill Book Co (1985).
5. Quantum Field Theory, L. H. Ryder, Cambridge University Press (2008).

PSPHY EL 04 **Materials science** **C L T P**

4 3 1 0

Solar energy materials, luminescent and optoelectronic materials, Polymer, Liquid crystals

and quasi crystals, Ceramics. Composites, Preparation of materials by different techniques: Single crystal growth, zone refining, epitaxial growth. Melt-spinning and quenching methods, sol-gel, polymer processing. Preparation of ceramic materials; Fabrication, control and growth modes of organic and inorganic thin films: different technique of thin film preparations: Basic principles
Point defect, line defect, plane defect, volume defect, dislocation, stacking faults, application, Burger vectors.

X-ray energy level schemes, diagram and non-diagram lines, Absorption of X-rays and theory of filters. X-ray scattering: General description of scattering process, coherent and incoherent scattering, total scattering from a spherically symmetric electron cloud, Quantum mechanical treatment of scattering in outline. Perfect crystal theory: Intensity form a small single crystal, Integrated intensity from a small perfect crystal (no deduction), integrated reflection from Mosaic and powder crystal.

Diffraction techniques: interpretation of x-ray powder diffraction patterns, Identification & quantitative estimation of unknown samples by X-ray powder diffraction technique and fluorescent analysis. Theory and method of particle size analysis. Integral breadth method, Warren-Averbach's Fourier method, profile fitting method, Rietveld Method.

Text Books

1. Materials science and Engineering by V. Raghavan, Prentice-Hall Pvt. Ltd.
2. Thin Solid Films by K. L Chopra.
3. Elements of X-ray diffraction by B. D. Cullity, Addison-Wesley Publishing Co.
4. Elements of crystallography by M. A. Azaroff.
5. Engineering Materials by Kenneth G. Budinski.

LABORATORIES 3rd SEM

PSPHY LB 05	<u>**Computational Physics Lab V**</u>	**C L T P**
		2 0 0 4

1: Programming in C and elementary graphics rendering. Solution of the one-dimensional wave equation with the leapfrog algorithm and visualization.
2: Elements of FORTRAN. Array constructs and operations with arrays.
3: Blurring of an image. Discretized Laplacian. The diffusion equation. Review of the finite and continuum Fourier transform and the fast Fourier transform (FFT).
4: Eigenvectors of the discretized Laplacian. Instability of the algorithm for solving the

diffusion equation. Unblurring the image

5: Solution of the equation for the electrostatic potential in presence of conductors. Relaxation algorithms and their relation with a diffusion process. Critical slowing down. Mention of multiscale methods.

6: Solution of the one-dimensional time-dependent Schr odinger equation by a split operator Formalism and the FFT. Visualization of the evolution. Importance of preserving unitarity.

7: Generation of (pseudo)random numbers. Monte Carlo integration.

8: Monte Carlo simulation of the Ising model. Parallel computing and MPI (message passing interface)

PSPHY LB 06 **Materials Science Laboratory** **C L T P**

2 0 0 4

Materials Science Special Practical Experiments:

1. To study the temperature dependence of Hall coefficient of a given semiconductor.
2. Determination of Band gap of a given semiconductor material by four probe technique.
3. Design/fabrication of a temperature controller and to study the performance of the designed controller using PID Controlled Oven.
4. Determination of Lattice parameters, particles sizes etc. of different powder samples of bulk-/nano-systems (ferrite, α-Fe2O3, γ-Fe_2O_3) using X-ray diffractograms.
5. Determination of Miller indices and lattice parameter of an unknown powder material by x-ray diffraction.
6. Phase identification of an unknown sample by x-ray diffraction.
7. Determination of particle size and lattice strain of an unknown powder specimen applying marq2 software and Scherrer equation.
8. Preparation of nanocrystalline powder specimen by ball milling: analysis of their x-ray spectra and particle size estimation by Scherrer formula.
9. Preparation of nanocrystalline powder specimen by chemical route: analysis of their x-ray spectra and particle size estimation by scherrer formula.
10. Study of porosity and grain size of thin film and powder sample by SEM.

PSPHY PR1 **Scientific Writing and Research Methodology** C LTP
3 1 0 1

Science / Scientific Writing (Theory and Practice): Goals and Objectives. Ethics in writing. Structure of documents. , importance of clear title, abstract or summary. Introduction, Methods, Results, and Discussion. Numbers and statistics, Tables and Figures, Language and grammar. Illustrations and aids. Writing proposals and instructions. Making presentations. Formatting documents. Drafts and revisions. Editing. Writing popular science / journal article,

Introduction to Philosophy of Science: What is science? Scientific reasoning; Scientific Method, Explanation in science; Realism and instrumentalism; Scientific change and scientific revolutions.

Types of research, exploratory, conclusive, modelling and alogrithemic. Research process: Identification of research problems, selection of a problem, formulation of a problem. Data collection: data analysis, interpretation of results, validation of results

Intellectual Property Rights and Associated Issues: Plagiarism, paraphrasing and copy write violation. Consequences of plagiarism. Why not to fudge, tinker, fabricate or falsify data

History of Patenting. Digitalizing Culture, Free Software and Free Culture. Journals and Publishers: Monopolistic practices by Academic Publishers.

Suggested Texts and References:

1. The Craft of Scientific Writing (3rd Edition), Michael Alley, Springer, New York, 1996.
2. Science and Technical Writing – A Manual of Style (2nd Edition), Philip Reubens (General editor), Routledge, New York, 2001.
3. Writing Remedies – Practical Exercises for Technical Writing Edmond H. Weiss, Universities Press (India) Ltd., Hyderabad, 2000.
4. Effective Technical Communication, M. Ashraf Rizvi, Tata Mc Graw Hill, New Delhi, 2007
5. A History of the Sciences, Stephen F. Mason, Collier Books, Macmillan Pub. Co. (1962)
6. A Concise History of Science in India, D. M. Bose, S. N. Sen, B. V. Subbarayappa, INSA (1971)
7. Philosophy of Science – A Very Short Introduction, Samir Okasha, Oxford Univ Press (2002)
8. Great Scientific Experiments – Ron Harre, Oxford University Press (1983)
9. The Story of Physics, Lloyd Motz and Jefferson Hane Weaver, Avon Books (1992)
10. The Cambridge Illustrated History of World Science, Colin A. Ronan, Cambridge-Newnes 11. Encyclopaedia of Classical Indian Sciences, Ed. Helaine Selin and Roddam Narasimha, University Press (2007)
12. Research Methodology: An introduction for science and engineering students, . Stuart Milville & Wayne Goddard, McGraw Hill International.
13. Research Methodology: Methods & Techniques, C.R. Kothari New Age International Publishers, New Delhi.
14. Research Methodology, N. Thanulingon , Himalaya Publishing House, New Delhi
15. Research Methodology, R. Pannerselvam Prentice Hall of India Pvt. Ltd.

PROJECT WORK **PSPHY PR 01** **C L T P**

26 0 0 52

Guidelines for Project in M.Sc. Course:

1. Projects would be allotted to M.Sc. (Previous) students which have to be carried out and completed all Semesters.

2. A list of projects will be finalized and announced by the Department. The students will have an option to select the project in their field of interest.

3. The project will comprise of the following:
    a. Study of background material, Literature review *etc*.
    b. Collection of data, procurement and fabrication of experimental Set up and

writing of computer programs, if needed.

c. Giving a preliminary seminar before the final presentation for the purpose of internal assessment whose weight age would be 25%.
d. Writing a dissertation or project report. This will be submitted by the M.Sc. (Final) students.

4. The Final evaluation of the project work completed will be examined by external and internal examiners appointed by the Board of Studies on the basis of an oral presentation and the submitted Project-Report. The weight age of the final evaluation would be 75%.

Proposed plan and structure

by

Dr.M.A.Shah

Programme Coordinator

Department of Physics

July, 2017