IKGPTU/PS/1039A
25/04/18

I.K. Gujral Punjab Technical University, Kapurthala

Department of Physical Sciences

Minutes of Meeting

A meeting of members of Board of Studies (BoS), Physical Sciences (Material Science/Nano Science and Technology) was held on 23.04.2018 in the Department of Physical Sciences, I K Gujral Punjab Technical University, Kapurthala.

The following were present in the meeting:

1. Dr. Amit Sarin (Chairperson)
2. Dr. Kanchan L. Singh, Member
3. Dr. Hitesh Sharma, Member
4. Dr. Maninder Kaur, Member
5. Dr. A. S. Bhuttar, (Chairperson, ECE, IKGPTU main campus) as Special invitee
6. Dr. Gazal Sharma (Food Science, IKGPTU main campus) as Special invitee
7. Dr. Jagmeet Bawa (IKGPTU main campus) as Special invitee
8. Dr Priyanka Mahajan (IKGPTU main campus) as Special invitee
9. Dr. Gaurav Bhragava (Chemistry, IKGPTU main campus) as Special invitee
10. Dr. Chander Parkash (Chemistry, IKGPTU main campus) as Special invitee
11. Dr. Varinderjit Singh, Member (Special invitee)
12. Dr. Harkirat Singh, Member (Special invitee)
13. Dr. Neetika Sharma, Member (Special invitee)
14. S. Navdeepak Sandhu, Member

The following members could not attend the meeting:

1. Dr. Davinder Mehta, Member
2. Dr. Ravi Kumar, Member
3. Dr. Rakesh Dogra, Member
4. Dr. Arvind Kumar, Member
5. Dr. Ranjan Kumar, Member
6. Dr. R. K. Bedi, Member
7. Dr. Harpreet Kaur Grewal, Member
8. Dr. B D Gupta, Member
9. Dr. Rajiv Malhotra, Member
10. Dr. P. Arumugam, Member

The Board of Studies discussed on all the agenda points and following recommendations were made:

Agenda item 1 To consider the Revision of scheme and syllabus for M.Tech. (Nano Science

implemented in the revised M.Tech. (Nano Science and Technology). All members approved the Program Educational objectives (PEO), Program outcome (PO), Program specific outcomes and Course outcomes(CO) of course subjects for M.Tech. (Nano Science and Technology). The scheme and course syllabus of all core and elective subjects were also approved. The copy of the approved scheme and syllabus with PO and COs is enclosed as **Annexure A.**

Agenda item 2: To approve the program objectives and course outcomes of M.Sc. (Physics) 2016 batch and Engineering Physics (Batch-2011) as per NAAC requirements

All BoS members approved the educational objectives of the old M.Sc.(Physics) 2016 batch and Engineering Physics (Batch-2011) as per NAAC requirements. The copy of the revised scheme and syllabus with PO and COs of M.Sc.(Physics) 2016 batch is enclosed as **Annexure B** and Engineering Physics (Batch-2011) as **Annexure C**.

Dr. Amit Sarin
Chairperson- BoS, Physical Sciences

Dean Academics

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Annexure-B

M.Sc. Physics

Course Structure and Syllabus
(Based on Choice Based Credit System)
2016-17

DEPARTMENT OF PHYSICAL SCIENCES

VISION

To be a knowledge nerve centre in Physical Sciences, Pure and Applied Research and industry requirements for creating sustainable infrastructure and enhancing quality of life

MISSION

1. To offer globally-relevant, industry-linked, research-focused, technology-enabled seamless education at the graduate, postgraduate and research levels in various areas of Physical sciences keeping in mind that the manpower so spawned is excellent in quality, is relevant to the global scientific and technological needs, is motivated to give its best and is committed to the growth of the Nation;
2. To develop and conduct continuing education programmes for Science graduates with a view to update their fundamental knowledge base and problem-solving capabilities in the various areas of core specialization of the University;
3. To develop comprehensive linkages with premier academic and research institutions within the country and abroad for mutual benefit;

M.Sc. (Physics) Program

Duration: 2 Years (Semester System)

This M.Sc. (Physics) Program includes various core, electives, and other interdisciplinary courses. The diverse lab experiments allow students to understand the fundamental aspects of the subject. A choice of advanced elective courses offers a glimpse in the frontier areas of research and allow students to work on one-year research project as an integral part of their M.Sc. programme. The programme also provide adequate exposure to the students for pursuing higher education in the field of technology (M. Tech.), Physics (M.Phil./Ph.D.) and other job opportunities in academia and industry.

Eligibility:

Pass B.Sc. with 50% marks having Physics as one of the subject. A relaxation of 5% is given in case of candidates belonging to SC/ST category.

PROGRAM EDUCATIONAL OBJECTIVES: The Program Educational Objectives are the knowledge skills and attitudes which the students have at the time of post-graduation. At the end of the program, the student will be able to:

PEO1	Apply the scientific knowledge of Physics, Mathematics, Chemistry, and Physics specialization for deeper understanding of the nature.
PEO2	Identify, formulate, research literature, and analyze advanced scientific problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PEO3	Design solutions for advanced scientific problems and design system components or processes.
PEO4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PEO5	Create, select, and apply appropriate techniques, resources, and modern scientific and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PEO6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional scientific practice.
PEO7	Communicate effectively on complex Scientific activities with the Scientific/engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PEO8	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of scientific and technological change.

PROGRAM OUTCOMES: At the end of the program, the student will be able to:

PO1	Apply principles of basic science concepts in understanding, analysis and prediction of physical systems.
PO2	To introduce interdisciplinary subjects/concepts/ideas for interdisciplinary application of Physics concepts.
PO3	To introduce advanced ideas and techniques required in emergent area of Physics.
PO4	To develop human resource with specialization in theoretical and experimental techniques required for career in academia and industry.
PO5	Engage in lifelong learning and adapt to changing professional and societal needs.

PROGRAM SPECIFIC OUTCOMES: At the end of the program, the student will be able to:

PSO1	Understand and apply principles of physics for understanding the scientific phenomenon in classical domain.
PSO2	Understand and apply mathematical techniques for describing and deeper understanding of physical systems.
PSO3	Understand and apply statistical methods for describing the classical and quantum particles in various physical systems and processes.
PSO4	Understand and apply inter-disciplinary concepts and computational skills for understanding and describing the natural phenomenon.
PSO5	Understand and apply principles of Quantum mechanics for understanding the physical systems in quantum realm.
PSO6	Provide exposure in various specialization of Physics (Solid State Physics/Nuclear Physics/Particle Physics).
PSO7	Provide exposure to advanced experimental/theoretical methods for measurement, observation, and fundamental understanding of physical phenomenon/systems.
PSO8	Engage in research and life-long learning to adapt to changing environment.

SEMESTER FIRST

Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Credits
		L	T	P	Internal	External		

PHS411	Mathematical Physics-I	**3**	**1**	**-**	**30**	**70**	**100**	**4**
PHS412	Classical Mechanics	**3**	**1**	**-**	**30**	**70**	**100**	**4**
PHS413	Quantum Mechanics-I	**3**	**1**	**-**	**30**	**70**	**100**	**4**
PHS414	Statistical Mechanics	**3**	**1**	**-**	**30**	**70**	**100**	**4**
PHS415	Atomic and Molecular Physics	**3**	**1**	**-**	**30**	**70**	**100**	**4**
PHS416	Physics Lab-I	**-**	**-**	**3**	**25**	**50**	**75**	**3**
TOTAL		**15**	**5**	**3**	**175**	**400**	**575**	**23**

SEMESTER SECOND

Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Credits
		L	T	P	Internal	External		
PHS421	Mathematical Physics-II	**3**	**1**	**-**	**30**	**70**	**100**	**4**
PHS422	Nuclear Physics	**3**	**1**	**-**	**30**	**70**	**100**	**4**
PHS423	Quantum Mechanics-II	**3**	**1**	**-**	**30**	**70**	**100**	**4**
PHS424	Computational Physics	**3**	**1**	**-**	**30**	**70**	**100**	**4**
PHS425	Condensed matter Physics-I	**3**	**1**	**-**	**30**	**70**	**100**	**4**
PHS426	Physics Lab-II	**-**	**-**	**3**	**25**	**50**	**75**	**3**
PHS427	Computational Lab	**-**	**-**	**3**	**25**	**50**	**75**	**3**
	TOTAL	**15**	**5**	**6**	**200**	**450**	**650**	**26**

L: Lectures T: Tutorial P: Practical

SEMESTER THIRD

Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Credits
		L	T	P	Internal	External		
PHS531	Condensed Matter Physics-II	3	1	-	30	70	100	4
PHS532	Classical Electrodynamics	3	1	-	30	70	100	4
PHS533	Particle Physics	3	1	-	30	70	100	4
PHS534	Electronics	3	1	-	30	70	100	4
PHS535 PHS536 PHS537 PHS538	Elective Subject-I	3	1	-	30	70	100	4
PHS539	Seminar	-	-	-	Satisfactory/Unsatisfactory			2
PHS540	Physics Lab-III	-	-	3	25	50	75	3
TOTAL		15	5	3	175	400	575	23

SEMESTER FOURTH

Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Credits
		L	T	P	Internal	External		
PHS541 PHS542	Elective Subject-II	3	1	-	30	70	100	4
PHS543 PHS544	Elective Subject-III	3	1	-	30	70	100	4
PHS545	M.Sc. Research Project	12			Satisfactory/Unsatisfactory			12
TOTAL		15	5	3	60	140	200	20

Elective Subjects:

S.No.	Name of the Subject	Code
1	Fibre optics and non-linear optics	PHS535
2	Plasma Physics	PHS536
3	Nonlinear Dynamics	PHS537
4	Structures, Spectra and Properties of Biomolecules	PHS538
5	Experimental techniques in Nuclear and Particle Physics	PHS541
6	Physics of Nanomaterials	PHS542
7	Environmental Physics	PHS543
8	Science of Renewable source of Energy	PHS544

Examination and Evaluation

S. No.		Weightage	Remarks
1.	Mid term/sessional Tests	25%	Best of two mid semester test will be considered for evaluation.
2	Attendance/Seminar/ Assignments	5%	
3	End semester examination	70%	Conduct and checking of the answer sheets will at the Department level in case of University teaching Department or Autonomous institutions. For other colleges examination will be conducted at the university level.
4	Total	100%	Marks may be rounded off to nearest integer.
Practical			
1	Daily evaluation of practical record/Viva Voice/Attendance etc.	50%	Internal evaluation
2	Final Practical Performance + Viva Voice	50%	External evaluation
3	Total	100%	Marks may be rounded off to nearest integer.

PHS411	MATHEMATICAL PHYSICS-I	L-3, T-1, P-0	4 Credits

Pre-requisite: None			
Course Objectives: The objective of the course on **Mathematical Physics-I** is to equip the M.Sc. students with the mathematical techniques that he/she needs for understanding theoretical treatment in different courses taught in this class and for developing a strong background if he/she chooses to pursue research in physics as a career.			
Course Outcomes: At the end of the course, the student will be able to			

CO1	Formulate and express a physical law in terms of tensors and simplify it by use of coordinate transforms.
CO2	Understand the use of complex variables for solving definite integral.
CO3	Solve partial differential equations using boundary value problems.
CO4	Understand the integral equations to solve the physics problems.
CO5	Use statistical methods to analysis the experimental data.

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

1. **Vector fields and Tensors:** Scalar and Vector fields, Scalar and Vector products: Curl, Divergent and Introduction to tensors and definitions, contraction, direct product. Quotient rule, Levi-Civita symbol, Non-Cartesian tensors, metric tensor, Covariant differentiation.

2. **Complex Variables**: Introduction, Cauchy-Riemann conditions, Cauchy's Integral formula, Laurent expansion, singularities, calculus of residues, evaluation of definite integrals, Dispersion relation.

3. **Differential Equations:** Partial differential equations of theoretical physics, boundary value problems, Neumann & Dirichlet Boundary conditions, separation of variables, singular points, series solutions, second solution.

4. **Integral Equations:** Definitions and classifications, integral transforms and generating functions. Neumann series, Separable Kernels, Hilbert-Schmidt theory. Green's functions in one dimension.

5. **Numerical Techniques:** Roots of functions, Interpolation, Extrapolation, Differentiation, integration by trapezoid and Simpson's rule, RungeKutta method and finite difference method.

6. **Elementary Statistics:** Introduction to probability theory, random variables, Binomial, Poisson and Normal distribution

Text Books:

1. Mathematical Methods for Physicists: G. Arfken and H.J. Weber (Academic Press, SanDiego) 7th edition, 2012.

Reference Books:

1. Mathematical Physics : *P.K. Chattopadhyay (Wiley Eastern, New Delhi), 2004*.
2. Mathematical Physics *: A.K. Ghatak, I.C. Goyal and S.J. Chua (MacMillan, India, Delhi),1986.*
3. Mathematical Methods in the Physical Sciences – *M.L. Boas (Wiley, New York) 3rd edition,2007.*
4. Special Functions : *E.D. Rainville (MacMillan, New York), 1960.*
5. Mathematical Methods for Physics and Engineering: *K.F.Riley, M.P.Hobson and S.J. Bence (Cambridge University Press, Cambridge) 3rd ed., 2006.*

PHS412	**CLASSICAL MECHANICS**	**L-3, T-1, P-0**	**4 Credits**

Pre-requisite: None

Course Objectives: The aim and objective of the course on **Classical Mechanics** is to train the students of M.Sc. students in the Lagrangian and Hamiltonian formalisms so that they can use these in the modern branches of physics such as Quantum Mechanics, Quantum Field Theory, Condensed Matter Physics, Astrophysics, etc.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand the necessity of Action, Lagrangian, and Hamiltonian formalism.
CO2	Describe the motion of a mechanical system using Lagrange-Hamilton formalism.
CO3	Use d'Alambert principle and calculus of variations to derive the Lagrange equations of motion.
CO4	Understand essential features of a classical problem (like motion under central force, periodic motions), use them to set up and solve the appropriate physics problems.
CO5	Understand the theory of rigid body motion which is important in several areas of physics e.g., molecular spectra, acoustics, vibrations of atoms in solids, coupled mechanical oscillators, electrical circuits, etc..

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	3	3	3	1	2	2	3
CO2	3	3	3	3	2	2	2	3
CO3	3	3	3	3	2	2	2	3
CO4	3	3	3	3	2	2	2	3
CO5	3	3	3	3	1	2	1	3

Detailed Syllabus:

1. **Lagrangian Formulation:** Mechanics of a system of particles; constraints of motion, generalized coordinates, d'Alembert Principle and Lagrange's velocity-dependent forces and the dissipation function, Applications of Lagrangian formulation.
(Lectures 7)
2. **Hamilton's Principles:** Calculus of variations, Hamilton's principle, Lagrange's equation from Hamilton's principle, extension to nonholonomic systems, advantages of variational principle formulation, symmetry properties of space and time and conservation theorems.
(Lectures 7)
3. **Hamilton's Equations:** Legendre Transformation, Hamilton's equations of motion, Cyclic coordinates, Hamilton's equations from variational principle, Principle of least action.
(Lectures 7)
4. **Canonical Transformation and Hamilton-Jacobi Theory:** Canonical transformation and its examples, Poisson's brackets, Equations of motion, Angular momentum, Poisson's Bracket relations, infinitesimal canonical transformation, Conservation Theorems. Hamilton- Jacobi equations for principal and characteristic functions, Action-angle variables for systems with one-degree of freedom. *(Lectures 10)*

5. **Rigid Body Motion:** Independent co-ordinates of rigid body, orthogonal transformations, Eulerian Angles and Euler's theorem, infinitesimal rotation, Rate of change of a vector, Coriolis force, angular momentum and kinetic energy of a rigid body, the inertia tensor, principal axis transformation, Euler equations of motion, Torque free motion of rigid body, motion of a symmetrical top. *(Lectures 10)*

TUTORIALS: Relevant problems given at the end of each chapter in different books.

Text Books:

1. Classical Mechanics*: H. Goldstein, C.Poole and J.Safko (Pearson Education Asia, New Delhi),* 3rd ed 2002.
2. Classical Mechanics of Particles and Rigid Bodies: *K.C. Gupta (Wiley Eastern, New Delhi), 1988.*

PHS413	**Quantum Mechanics-I**	**L-3, T-1, P-0**	**4 Credits**

Pre-requisite: wave mechanics,

Course Objectives: The aim and objective of the course on **Quantum Mechanics-I** is to introduce the students of M.Sc. class to the formal structure of the subject and to equip them with the techniques of vector spaces, angular momentum, perturbation theory, and scattering theory so that they can use these in various branches of physics as per their requirement.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand the need for quantum mechanical formalism and basic principles.
CO2	Appreciate the importance and implication of vector spaces, dirac ket bra notations, eigen value problems, generalized uncertainty principle in quantum mechanics.
CO3	Better understanding of the mathematical foundations of angular momentum of a system of particles.
CO4	Applications of various approximation methods in solving the Schrodinger equation.
CO5	Apply the perturbation theory to scattering matrix and partial wave analysis.

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2	3	3	3	3	3	2	2
CO2	2	3	3	3	3	3	2	1
CO3	1	3	3	3	3	3	2	3
CO4	-	3	3	3	3	3	3	3
CO5	-	3	3	3	3	3	1	2

Detailed Syllabus:

1. **Linear Vector Space and Matrix Mechanics:** Vector spaces, Schwarz inequality, Orthonormal basis, Operators: Projection operator, Hermitian and Unitary operators, change of basis, Eigenvalue and Eigenvectors of operators, Dirac's bra and ket notation, commutators, Simultaneous eigenvectors, Postulates of quantum mechanics, uncertainty relation, Harmonic oscillator in matrix mechanics, Time development of states and operators, Heisenberg, Schroedinger and Interaction representations, Exchange operator and identical particles, Density Matrix and Mixed Ensemble. *(Lectures 12)*

2. **Angular Momentum:** Angular part of the Schrödinger equation for a spherically symmetric potential, orbital angular momentum operator. Eigen values and eigenvectors of L2 and Lz. Spin angular momentum, General angular momentum, Eigen values and eigenvectors of J2 and Jz. Representation of general angular momentum operator, Addition of angular momenta, C.G. coefficients. *(Lectures 7)*

3. **Stationary State Approximate Methods:** Non-Degenerate and degenerate perturbation theory and its applications, Variational method with applications to the ground states of harmonic oscillator and other sample systems. *(Lectures 7)*

4. **Time Dependent Perturbation:** General expression for the probability of transition from one state to another, constant and harmonic perturbations, Fermi's golden rule and its application to radiative transition in atoms, Selection rules for emission and absorption of light. *(Lectures 7)*

5. **Scattering Theory:** Scattering Cross-section and scattering amplitude, partial wave analysis, Low energy scattering, Green's functions in scattering theory, Born approximation and its application to Yukawa potential and other simple potentials. Optical theorem, Scattering of identical particles. *(Lectures 7)*

Text Books:

1. A Text book of Quantum Mechanics: P.M. Mathews and K. Venkatesan (Tata McGraw Hill, New Delhi) 2nd edition, 2004.
2. Quantum Mechanics: V.K. Thankappan (New Age, New Delhi), 2004.

Reference Books:

1. Quantum Mechanics: M.P. Khanna, (Har Anand, New Delhi), 2006.
2. Modern Quantum Mechanics: J.J. Sakurai (Addison Wesley, Reading), 2004.
3. Quantum Mechanics: J.L. Powell and B. Crasemann (Narosa, New Delhi), 1995.
4. Quantum Physics: S. Gasiorowicz (Wiley, New York), 3rd ed. 2003.

PHS414	**Statistical Mechanics**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisite: None			
Course Objectives: The aim and objective of the course on **Statistical Mechanics** is to equip the M.Sc. student with the techniques of Ensemble theory so that he/she can use these to understand the macroscopic properties of the matter in bulk in terms of its microscopic constituents.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Understand Equations of state and thermodynamic potentials for elementary systems of particles.		
CO2	Learn Modern aspects of equilibrium and non-equilibrium statistical Physics.		
CO3	Describe the features and examples of Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac statistics.		
CO4	Work with various models of phase transitions and thermo-dynamical fluctuations.		
CO5	Describe physical quantities in quantum systems.		

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	3	1	1	2	3	3	3
CO2	1	-	-	-	-	-	2	1
CO3	3	3	2	2	2	2	3	3
CO4	2	3	2	1	2	1	2	3
CO5	2	3	3	2	3	2	3	3

Detailed Syllabus:

1. **The Statistical Basis of Thermodynamics:** The macroscopic and microscopic states, contact between statistics and thermodynamics, classical ideal gas, Gibbs paradox and its solution. *(Lectures 8)*

2. **Ensemble Theory:** Phase space and Liouville's theorem, the microcanonical ensemble theory and its application to ideal gas of monatomic particles; The canonical ensemble and its thermodynamics, partition function, classical ideal gas in canonical ensemble theory, energy fluctuations, equipartition and virial theorems, a system of quantum harmonic oscillators as canonical ensemble, statistics of paramagnetism; The grand canonical ensemble and significance of statistical quantities, classical ideal gas in grand canonical ensemble theory, density and energy fluctuations. *(Lectures 8)*

3. **Quantum Statistics of Ideal Systems:** Quantum states and phase space, an ideal gas in quantum mechanical ensembles, statistics of occupation numbers; Ideal Bose systems: basic concepts and thermodynamic behaviour of an ideal Bose gas, Bose-Einstein condensation, discussion of gas of photons (the radiation fields) and phonons (the Debye field); Ideal Fermi systems: thermodynamic behaviour of an ideal Fermi gas, discussion of heat capacity of a free electron gas at low temperatures, Pauli paramagnetism. *(Lectures 10)*

4. **Elements of Phase Transitions:** Introduction, a dynamical model of phase transitions, Ising model in zeroth approximation. *(Lectures 4)*

5. **Fluctuations:** Thermodynamic fluctuations, random walk and Brownian motion, introduction to nonequilibrium processes, diffusion equation. *(Lectures 3)*

TUTORIALS: Relevant problems given in the end of each chapter in the text book.

Text Books :

1. Statistical Mechanics: R.K. Pathria and P.D. Beale (Butterworth-Heinemann, Oxford), 3rd edition, 2011.

Reference Books :

1. Statistical Mechanics*: K. Huang (Wiley Eastern, New Delhi), 1987*.
2. Statistical Mechanics: *B.K. Agarwal and M. Eisner (Wiley Eastern, New Delhi) 2nd edition, 2011*.
3. Elementary Statistical Physics: *C. Kittel (Wiley, New York), 2004.*
4. Statistical Mechanics: *S.K. Sinha (Tata McGraw Hill, New Delhi), 1990.*

PHS415	**Atomic and Molecular Physics**	**L-3, T-1, P-0**	**4 Credits**

Pre-requisite: None

Course Objectives: The aim and objective of the course on **Atomic and Molecular Physics** for the students of M.Sc. Physics is to equip them with the knowledge of Atomic, Rotational, Vibrational, Raman, and Electronic spectra.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand basic elements of atomic and molecular spectroscopy
CO2	Understand classical/Quantum description of electronic, vibrational and rotational spectra
CO3	Correlate spectroscopic information of known and unknown molecules with their physical description
CO4	Understand and use Raman Spectroscopy for analysis of molecules
CO5	Understand Spin Resonance Spectroscopy with focus on NMR for molecular analysis

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	3	3	2	3	2	2	3
CO2	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3
CO4	3	3	3	2	3	3	3	3
CO5	3	3	3	2	3	3	3	3

Detailed Syllabus:

1. **Electronic Spectroscopy of Atoms:** Bohr-Sommerfeld model of atomic structure, Electronic wave function and atomic quantum numbers – hydrogen spectrum – orbital, spin and total angular momentum - fine structure of hydrogen atom – many electron spectrum: Lithium atom spectrum, angular momentum of many electrons – term symbols – the spectrum of helium and alkaline earths – equivalent and non-equivalent electrons –X-ray photoelectron spectroscopy. *(Lectures 8)*
2. **Electronic Spectroscopy of Molecules:** Diatomic molecular spectra: Born-Oppenheimer approximation – vibrational spectra and their progressions – Franck-Condon principle – dissociation energy and their products –rotational fine structure of electronic-vibration transition - molecular orbital theory – the spectrum of molecular hydrogen – change of shape on excitation – chemical analysis by electronic spectroscopy – reemission of energy – fundamentals of UV photoelectron spectroscopy. *(Lectures 9)*
3. **Microwave and Raman Spectroscopy:** Rotation of molecules and their spectra – diatomic molecules – intensity of line spectra – the effect of isotropic substitution – non-rigid rotator and their spectra – polyatomic molecules (linear and symmetric top molecules) – Classical theory of Raman effect - pure rotational Raman spectra (linear and symmetric top molecules). *(Lectures 8)*
4. **Infra-red and Raman Spectroscopy:** The energy of diatomic molecules – Simple Harmonic Oscillator –the Anharmonic oscillator– the diatomic vibrating rotator – vibration-rotation spectrum of carbon monoxide –breakdown of Born-Oppenheimer approximation – the vibrations of polyatomic molecules –influence of rotation on the spectra of polyatomic molecules (linear and symmetric top molecules) – Raman activity of vibrations – vibrational Raman spectra – vibrations of Spherical top molecules. *(Lectures 8)*
5. **Spin Resonance Spectroscopy** Spin and magnetic field interaction – Larmor precession – relaxation time – spin-spin relaxation - spin–lattice relaxation - NMR chemical shift - coupling constants – coupling between nuclei – chemical analysis by NMR – NMR for nuclei other than hydrogen – ESR spectroscopy - fine structure in ESR. *(Lectures 8)*

Text Books:

1. Fundamentals of Molecular Spectroscopy by Colin N. Banwell and Elaine M. McCash (Tata McGraw-Hill Publishing Company limited).

Reference Books:

1. Physical method for Chemists (Second Edition) *by Russell S. Drago (Saunders College Publishing).*
2. Introduction to Atomic Spectra: *H.E. White-Auckland McGraw Hill, 1934.*
3. Spectroscopy Vol. I, II & III: *Walker & Straughen*
4. Introduction to Molecular spectroscopy: *G.M. Barrow-Tokyo McGraw Hill, 1962.*
5. Spectra of diatomic molecules: *Herzberg-New York, 1944.*
6. Molecular spectroscopy: Jeanne L. McHale

PHS416	Physics Lab- I	L-3, T-1, P-0	4 Credits

Pre-requisite: None

Course Objectives: The aim and objective of the laboratory on **Physics Lab** is to expose the students of M.Sc. class to experimental setups in electronics so that they can verify some of the things read in theory here or in earlier classes and develop confidence to handle sophisticated equipment.

Course Outcomes: At the end of the course, the student will

CO1	Acquire hands on experience of handling and building electronics circuits.
CO2	Be familiar with the various components such as resistors, capacitor, inductor, IC chips and how to use these components in circuits.
CO3	Be able to understand the construction, working principles and V-I characteristics of various devices such as PN junction diodes, UJT, TRIAC etc.
CO4	Capable of using components of digital electronics for various applications.
CO5	Able to design and perform scientific experiments as well as accurately record and analyze the results of experiments.

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	2	2	1	2	2	3	3
CO2	1	2	2	1	-	2	2	3
CO3	1	3	3	1	2	3	3	2
CO4	-	3	-	2	1	3	3	2
CO5	2	2	3	3	2	3	3	3

List of experiments:

1. Study the forward and reverse characteristics of a Zener diode.
2. Construction of adder, subtracter, differentiator and itergrator circuits using the given OP-Amp.
3. Study the static and drain characteristics of a JFET
4. Construction of an Astable multivibrator circuit using transistor
5. Construction of a single FET amplifier with common source configuration
6. Construction of an A/D converter circuit and study its performance
7. Construction of an D/A converter circuit and study its performance
8. Construction of a low-pass filter circuit and study its output performance
9. Construction of a high-pass filter circuit and study its output performance
10. Electron Spin Resonance Spectrometer Experiment
11. Four Probe Method- Determination of resistivity of semiconductor at different temperature
12. To study pulse amplitude, Pulse width and Pulse position modulation
13. To study the frequency response of an operational amplifier
14. To study the characteristics of multivibrators- bistable, Astable, monostable
15. To find the wavelength of sodium light using Michelson interferometer.

PHS421	**Mathematical Physics-II**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisite: None			

Course Objectives: The aim and objective of the course on **Mathematical Physics-II** is to equip the M.Sc. Students with the mathematical techniques that he/she needs for understanding theoretical treatment in different courses taught in this class and for developing a strong background if he/she chooses to pursue research in physics as a career.

Course Outcomes: At the end of the course, the student will able to

CO1	Apply of group theory in all the branches of Physics.
CO2	Use Fourier series and transformations as an aid for analyzing experimental data.
CO3	Use integral transform to solve mathematical problems of interest in Physics.
CO4	Understand the applications of Delta and gamma functions in all the branches of Physics.
CO5	Develop mathematical skills to solve quantitative problems in physics.

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	3	1	3	3	1	2	3
CO2	1	3	2	2	2	2	2	3
CO3	1	3	2	2	2	2	2	3
CO4	1	3	2	3	2	-	2	3
CO5	1	3	3	2	2	1	1	3

Detailed syllabus:

1. **Group Theory :**What is a group ? Multiplication table, conjugate elements and classes, subgroups, Isomorphism and Homomorphism, Definition of representation and its properties, Reducible and irreducible representations, Schur's lemmas (only statements), characters of a representation. Example of C4v, Topological groups and Lie groups, three dimensional rotation group, special unitary groups SU(2) and SU(3).

2. **Delta and Gamma Functions :**Dirac delta function, Delta sequences for one dimensional function, properties of delta function, Gamma function, factorial notation and applications, Beta function.

3. **Special Functions :**Bessel functions of first and second kind, Generating function, integral representation and recurrence relations for Bessel's functions of first kind, orthogonality. Legendre functions : generating function, recurrence relations and special properties, orthogonality, various definitions of Legendre polynominals. Associated Legendre functions: recurrence relations, parity and orthogonality, Hermite functions, Laguerre functions.

4. **Fourier Series and Integral Transforms :**Fourier series, Dirichlet conditions. General properties. Advantages and applications, Gibbs phenomenon. Fourier transforms, Development of the Fourier integral, Inversion theorem, Fourier transforms of derivatives; Momentum representation. Laplace transforms, Laplace transforms of derivatives, Properties of Laplace transform, Inverse Laplace transformation.

Text Books :

1. Group Theory for Physicists : *A.W. Joshi (Wiley Eastern, New Delhi) 2011.*
2. Mathematical Methods for Physicists : *G. Arfken and H.J. Weber, (Academic Press, San Diego) 7th edition, 2012.*

Reference Books :

1. Matrices and Tensors in Physics : *A.W. Joshi (Wiley Eastern, New Delhi) 2005.*
2. Numerical Mathematical Analysis, *J.B. Scarborough (Oxford Book Co., Kolkata) 4th edition.*
3. A First Course in Computational Physics: *P.L. Devries (Wiley, New York) 1994.*
4. Mathematical Physics : *P.K. Chatopadhyay (Wiley Eastern, New Delhi) 2011.*
5. Introduction to Mathematical Physics : *C. Harper (Prentice Hall of India, New Delhi) 2006.*

PHS422	Nuclear Physics	L-3, T-1, P-0	4 Credits
Pre-requisite: None			
Course Objectives: The aim and objective of the course on **Nuclear Physics** is to familiarize the students of M.Sc. class to the basic aspects of Nuclear Physics like static properties of nuclei, radioactive decays, nuclear forces, nuclear models, and nuclear reactions so that they are equipped with the techniques used in studying these things.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Understand structure and properties of nuclei, radioactive decay, and different types of nuclear reactions.		
CO2	Understand Quantum behavior of atoms in external electric and magnetic fields.		
CO3	Compare various nuclear models and properties of the nucleus.		
CO4	Understand about nuclear forces and their dependence on various parameters.		
CO5	Describe various types of nuclear reactions and their properties.		

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	2	3	3	3	3	3	3
CO2	1	3	1	3	3	3	3	3
CO3	1	3	1	3	3	3	3	3
CO4	1	3	1	3	3	3	3	3
CO5	1	3	2	3	2	3	3	3

Detailed Syllabus:

1. **Nuclear Models:** Liquid drop model, Binding energy; fission and fusion, Experimental evidence for shell effects, Shell Model, Spin-Orbit coupling, Magic numbers, Application of Shell Model like Angular momenta and parities of nuclear ground states, Collective model-nuclear vibrations spectra and rotational spectra. *(Lectures 8)*

2. **Static properties of nucleus:** Nuclear radii and measurements, nuclear binding energy (review), nuclear moments and systematic, wave-mechanical properties of nuclei, hyperfinestructure, effect of external magnetic field, Nuclear magnetic resonance. *(Lectures 5)*

3. **Nuclear decay:** Review of barrier penetration of alpha decay & Geiger-Nuttal law. Beta decays, Fermi theory, Kurie plots and comparative half-lives, Allowed and forbidden transitions, Experimental evidence for Parity-violation in beta decay, Electron capture probabilities, Double beta decay, Neutrino,detection of neutrinos, measurement of the neutrino helicity. Multipolarity of gamma transitions, internal conversion process, transition rates. *(Lectures 6)*
4. **Nuclear forces:** Evidence for saturation of nuclear density and binding energies (review), types of nuclear potential, Ground and excited states of deuteron, dipole and quadrupole moment of deuteron, n-p scattering at low energies, partial wave analysis, scattering length, spin-dependence of n-p scattering, effective-range theory, coherent and incoherent scattering, central and tensor forces, p-p scattering, exchange forces & single and triplet potentials, meson theory of nuclear forces. *(Lectures 8)*
5. Neutron physics: Neutron production, slowing down power and moderating ratio, neutron detection. *(Lectures 3)*
6. Nuclear reactions: Nuclear reactions and cross-sections, Resonance, Breit–Wigner dispersion formula for l=0 and higher values, compound nucleus, Coulomb excitation,nuclear kinematics and radioactive nuclear beams. *(Lectures 4)*

Text Books :

1.Nuclear Physics : Irving Kaplan (Narosa), 2002.
2.Theory of Nuclear Structure : R.R. Roy and B.P. Nigam (New Age, New Delhi) 2005.

Reference Books :

1.Basic Ideas and Concepts in Nuclear Physics : K. Hyde (Institute of Physics) 2004.
2.Nuclear physics: Experimental and Theoretical, H.S. Hans (New Academic Science) 2nded (2011).
3.Nuclear Physics and its applications by John Liley
4.Nuclear Physics V. Devnathan

PHS423	Quantum Mechanics–II	L-3, T-1, P-0	4 Credits

Pre-requisite: Preliminary course of Quantum Mechanics

Course Objectives: The aim and objective of the course on **Quantum Mechanics-II** is to introduce the M.Sc. students to the formal structure of the subject and to equip him/her with the techniques of Relativistic quantum mechanics and Quantum field theory so that he/she can use these in various branches of physics as per his/her requirement.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand relativistic effects in quantum mechanics and need for quantum field theory.
CO2	Demonstrate the Lorentz covariant form of Lagrangian and Hamiltonian for scalar, vector fields, electromagnetic fields and their second quantisation.
CO3	Understand the symmetries and the implications of Noether's Theorem in conserved currents and charges.
CO4	Understand the interaction picture, S-matrix, and Wick's Theorem.
CO5	Explain the origin of Feynman diagrams and apply the Feynman rules to derive the amplitudes for elementary processes in QED.

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	1	2	2	2	2	2	3
CO2	1	2	2	2	2	2	3	1
CO3	1	2	3	3	2	1	2	2
CO4	1	3	3	3	2	1	2	3
CO5	1	2	1	3	2	2	3	3

Detailed Syllabus:

1. **Relativistic Quantum Mechanics-I:** Klein-Gordon equation, Dirac equation and its plane wave solutions, significance of negative energy solutions, spin angular momentum of the Dirac particle, the non-relativistic limit of Dirac equation.
(Lectures 12)
2. **Relativistic Quantum Mechanics-II:** Electron in electromagnetic fields, spin magnetic moment, spin-orbit interaction, Dirac equation for a particle in a central field, fine structure of hydrogen atom, Lamb shift.
(Lectures 10)
3. **Quantum Field Theory:** Resume of Lagrangian and Hamiltonian formalism of a classical field, Quantization of real scalar field, complex scalar field, Dirac field and e.m. field, Covariant perturbation theory, Wick's theorem, Scattering matrix.
(Lectures 12)
4. **Feynman diagrams**:Feynman diagrams and their applications, Wick's theorem, Scattering matrix, QED.
(Lectures 8)

Text Books:

1. Text Book of Quantum Mechanics -P.M. Mathews & K. Venkatesan-Tata McGraw Hill 2010
2. Quantum Mechanics – G Aruldhas - Prentice Hall of India 2006
3. Introduction to Quantum Mechanics - David J.Griffiths Pearson Prentice Hall, 2005
4. Quantum Mechanics – A Devanathan - Narosa Publishing-New Delhi
5. Quantum Mechanics – L.I Schiff - McGraw Hill 1968
6. Quantum Mechanics - A.K. Ghatak and S. Loganathan-McMillan India
7. Principles of Quantum Mechanics - R.Shankar, Springer 2005
8. Quantum Mechanics – Satya Prakash- KatharNathRamnath – Meerut

MSPH 424	**Computational Physics**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisite: None			
Course Objectives: The aim and objective of the course on **Computational Physics** is to familiarize the of M.Sc. students with the numerical methods used in computation and programming using any high level language such as Fortran, C++, etc., so that they can use these in solving simple physics problems.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Apply basics knowledge of computational physics in solving the physics problems.		
CO2	Programme with the C++ or any other high level language.		
CO3	Use various numerical methods in solving physics problems.		
CO4	Analyze the outcome of the algorithm/program using graphic plots.		
CO5	Apply physics knowledge in understanding interdisciplinary problem/concepts.		

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	3	1	1	2	3	3	3
CO2	1	-	-	-	-	-	2	1
CO3	3	3	2	2	2	2	3	3
CO4	2	3	2	1	2	1	2	3
CO5	2	3	3	2	3	2	3	3

Detailed Syllabus:

1.Introduction to high level language: Need and advantages of high level language in physics, programming in a suitable high level language (Matlab/Mathematica/Scilab/ Octave), input/output, interactive input, loading and saving data, loops branches and control flow. Matrices and Vectors, Matrix and array operations, eigenvalues and eigen vectors. *(Lectures 12)*

2.Sub programs: Advantages of modular programming, built-in functions, scripts, functions, sharing of variables between modules. *(Lectures 8)*

3.Graphics: 2D plots, style options, axis control, overlay plots, subplot, histogram, 3D plots, mesh and surface plots, contour plots. *(Lectures 8)*

4.Numerical computation: Computer programs for: solving linear system of simultaneous equations, nonlinear algebraic equation, roots of polynomials, curve fitting, polynomial curve fitting, least square curve fitting, interpolation, data analysis and statistics, numerical integration, Monte-Carlo simulation, ordinary differential equation, first order and second order ODEs, event location. *(Lectures 15)*

5. List of experiments:
1.Black body radiation (computation and graphical representation)
2.Reflection and transmission of an electromagnetic wave
3.Statistical distributions at different temperatures
4.Binding energy curve for nuclei using liquid drop model
5.Eigen-value problem: 1-D square potential well
6.Eigen-values and wave-functions of a simple harmonic oscillator
7.Monte-Carlo simulation
8.Linear/Projectile motion (simulation and solutions)

Text Books:

1. Pratap R, "Getting started with MATLAB 7", Oxford Univ. Press, 2006
2. Gilat A, "Matlab: An introduction with applications", Wiley, 2008
3. Eaton J W, Batchman D and Hauberg S "GNU Octave Manual Version 3", Network Theory Ltd.2008
4. Campbell S, Chancelier J P and Nikoukhah R, "Modeling and simulation in Scilab", Springer 2005
5. "Mathematica Information Center ('MathSource')": http://library.wolfram.com/infocenter/ 2009
6. Gerald C F and Wheatley P O, "Applied Numerical Analysis", 7th Ed, Addison Wesley,2003

PHS425	**Condensed Matter Physics-I**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisite: None			

Course Objectives: The aim and objective of the course on **Condensed Matter Physics-I** is to expose the students of M.Sc. class to the topics like elastic constants, lattice vibrations, dielectric properties, energy band theory and transport theory so that they are equipped with the techniques used in investigating these aspects of the matter in condensed phase.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand basic elements of crystal structure of condensed matter.
CO2	Understand accurate description of lattice dynamics and thermal properties of crystalline solids.
CO3	Understand origin of energy bands in solids with focus on semiconductors.
CO4	Describe and understand basics of transport properties across solids.
CO5	Describe and understand magnetic and dielectric behavior of solids.

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	3	3	3	2	1	3	2
CO2	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3

Detailed Syllabus:

1.Elastic constants :
Binding in solids; Stress components, stiffness constant, elastic constants, elastic waves in crystals.

2.Lattice Dynamics and Thermal Properties :
Rigorous treatment of lattice vibrations, normal modes; Density of states, thermodynamic properties of crystal, anharmonic effects, thermal expansion.

3.Energy Band Theory:
Electrons in a periodic potential: Bloch theorem, Nearly free electron model; tight binding method; Semiconductor Crystals, Band theory of pure and doped semiconductors; elementary idea of semiconductor superlattices.

4.Transport Theory:
Electronic transport from classical kinetic theory; Introduction to Boltzmann transport equation; electrical and thermal conductivity of metals; thermoelectric effects; Hall effect and magneto resistance.

5.Dielectric Properties of Materials:
Polarization mechanisms, Dielectric function from oscillator strength, Clausius-Mosotti relation; piezo, pyro- and ferro-electricity.

6.Liquid Crystals :
Thermotropic liquid crystals, Lyotropic liquid crystals, long range order and order parameter, Various phases of liquid crystals, Effects of electric and magnetic field and applications, Physics of liquid crystal devices.

TUTORIALS :Relevant problems given in the books listed below.

Text Books:

1. Introduction to Solid State Physics: *C. Kittel (Wiley, New York), 8th ed. 2005.*
2. Quantum Theory of Solids: *C. Kittel (Wiley, New York) 1987.*

Reference Books:

1. Principles of the Theory of Solids: *J. Ziman (Cambridge University Press) 1972*
2. Solid State Theory: *Walter A. Harrison (Tata McGraw-Hill, New Delhi) 1970.*
3. Liquid Crystals: *S. Chandrasekhar (Cambridge University), 2nd ed. 1992.*

PHS426	Physics Lab-II	L-3, T-1, P-0	4 Credits
Pre-requisite: None			
Course Objectives: The aim and objective of the **Physics LAB -II** is to expose the students of M.Sc. students to experimental techniques in atomic and nuclear physics so that they can verify some of the results obtained in theory and develop confidence to handle sophisticated equipment.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Acquire hands on experience of using particle detectors such as GM counter and a Scintillation counter.		
CO2	handle oscilloscope for visualisation of various input and output signals.		
CO3	Understand the basic of nuclear safely management.		
CO4	Perform scientific experiments as well as accurately record and analyze the results of nuclear experiments.		
CO5	Solve applied nuclear problems with critical thinking and analytical reasoning.		

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	2	1	2	1	3	3	3
CO2	1	1	1	3	1	3	1	3
CO3	1	1	1	3	1	3	1	2
CO4	1	3	3	3	1	3	3	3
CO5	1	3	3	3	1	3	3	3

Detailed Syllabus:

Note: Students are expected to perform atleast 10 experiments out of following list.

1. Determination of e/m of electron by Normal Zeeman Effect using Febry Perot interferometer.
2. To verify the existence of Bohr's energy levels with Frank-Hertz experiments.
3. Determination of Lande's factor of DPPH using Electron-spin resonance (E.S.R.) spectrometer
4. Determination of ionization Potential of Lithium
5. Analysis of pulse height of gamma ray spectra
6. To study the characteristics of G.M. counter
7. To determine the dead time of G.M. counter
8. To study absorption of beta particles is matter
9. To study Gaussian distribution using G.M. counter
10. Source strength of a beta source using G.M counter
11. Determination of Planck's constant using Photocell and interference filters.
12. Recording and calibrating a gamma ray spectrum by scintillation counter
13. Detecting gamma radiation with a scintillation counter
14. To study absorption of gamma radiation by scintillation counter
15. Identifying and determining the activity of weakly radioactive samples

Text Books:

1. Fundamentals of Molecular Spectroscopy by Colin N. Banwell and Elaine M. McCash (Tata McGraw-Hill Publishing Company limited).
2. Physics of Atoms and Molecules by B. H. Bransden and C. J. Joachain.

Reference Books:

1. Physical method for Chemists (Second Edition) *by Russell S. Drago (Saunders College Publishing).*
2. Introduction to Atomic Spectra: *H.E. White-Auckland McGraw Hill, 1934.*
3. Spectroscopy Vol. I, II & III: *Walker & Straughen*
4. Introduction to Molecular spectroscopy: *G.M. Barrow-Tokyo McGraw Hill, 1962.*
5. Spectra of diatomic molecules: *Herzberg-New York, 1944.*

PHS427	**Computational Lab**	**L-3, T-1, P-0**	**4 Credits**

Pre-requisite: None

Course Objectives: The aim and objective of the lab on **Computational Physics-II** is to train the students of M.Sc. class in understanding numerical methods, the usage of high level language such as C++ language for simulation of results for different physics problems and graphic analysis of physical data, so that they are well equipped in the use of computer for solving physics related problems.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand and apply basics knowledge of numerical methods in solving the physics problems.
CO2	Write programme with the C++ or any other high level language.
CO3	Learn use of graphical methods in data analysis and solving physics problems.
CO4	Solve physical problem, enabling development of critical thinking and analytical reasoning.
CO5	explore application of computational physics in frontier areas of pure and applied research in physics and allied fields.

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	2	1	3	3	1	3	3
CO2	2	2	1	3	3	2	3	3
CO3	2	2	2	3	3	1	2	3
CO4	1	3	2	2	3	2	3	2
CO5	1	2	1	3	3	2	2	3

Detailed Syllabus:

1. Black body radiation (computation and graphical representation)
2. Reflection and transmission of an electromagnetic wave
3. Statistical distributions at different temperatures
4. Binding energy curve for nuclei using liquid drop model
5. Eigen-value problem: 1-D square potential well
6. Eigen-values and wave-functions of a simple harmonic oscillator
7. Monte-Carlo simulation
8. Linear/Projectile motion (simulation and solutions)

Text Books:

1. Pratap R, "Getting started with MATLAB 7", Oxford Univ. Press, 2006
2. Gilat A, "Matlab: An introduction with applications", Wiley, 2008
3. Eaton J W, Batchman D and Hauberg S "GNU Octave Manual Version 3", Network Theory Ltd.2008
4. Campbell S, Chancelier J P and Nikoukhah R, "Modeling and simulation in Scilab", Springer 2005
5. "Mathematica Information Center ('MathSource')": http://library.wolfram.com/infocenter/ 2009
6. Gerald C F and Wheatley P O, "Applied Numerical Analysis", 7th Ed, Addison Wesley,2003

PHS531	**Condensed Matter Physics-II**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisite: None			
Course Objectives: The aim and objective of the course on **Condensed Matter Physics** is to expose the students of M.Sc. class to the topics like elastic constants, lattice vibrations, dielectric properties, energy band theory and transport theory so that they are equipped with the techniques used in investigating these aspects of the matter in condensed phase.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Understand and describe Optical properties of solids		
CO2	Understand and describe magnetic properties of solids		
CO3	Understand use of NMR methods for describing solids		
CO4	Understand and explain the behavior of superconductors		
CO5	Understand the effect of defects and deformation on the behavior of solids		

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	3	3	3	2	1	3	2
CO2	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3

Detailed Syllabus:

1. **Optical Properties :**Macroscopic theory – generalized susceptibility, Kramers- Kronig relations, Brillouin scattering, Raman effect; interband transitions. *(Lectures 8)*

2. **Magnetism:**Dia- and para-magnetism in materials, Pauli paramagnetism, Exchange interaction. Heisenberg Hamiltonian – mean field theory; Ferro-, ferri-and antiferromagnetism; spin waves, Bloch T3/2 law. *(Lectures 8)*

3. **Principles of Magnetic Resonance:** ESR and NMR – equations of motion, line width, motional narrowing, Knight shift. *(Lectures 8)*

4. **Superconductivity :**Experimental Survey; Basic phenomenology; BCS pairing mechanism and nature of BCS ground state; Flux quantization; Vortex state of a Type II superconductors; Tunneling Experiments; High Tc superconductors. *(Lectures 8)*

5. **Disordered Solids :** Basic concepts in point defects and dislocations; Noncrystalline solids: diffraction pattern, glasses, amorphous semiconductors and ferromagnets, heat capacity and thermal conductivity of amorphous solids, nanostructures – short expose; Quasicrystals. *(Lectures 8)*

Text Books:

1. Introduction to Solid State Physics : *C. Kittel (Wiley, New York) 2005.*
2. Quantum Theory of Solids : *C. Kittel (Wiley, New York) 1987.*

Reference Books:

1. Principles of the Theory of Solids : *J. Ziman (Cambridge University Press) 1972.*
2. Solid State Physics : *H. Ibach and H. Luth (Springer, Berlin), 3rd. ed. 2002.*
3. A Quantum Approach to Solids : *P.L. Taylor (Prentice-Hall, Englewood Cliffs), 1970.*
4. Intermediate Quantum Theory of Solids : *A.O.E. Animalu (East-West Press, New Delhi),1991.*
5. Solid State Physics : *Ashcroft and Mermin (Reinhert& Winston, Berlin), 1976.*

PHS532	Classical Electrodynamics	L-3, T-1, P-0	4 Credits

Pre-requisite: None			
Course Objectives: The **Classical Electrodynamics** course covers Electrostatics and Magnetostatics including Maxwell equations, and their applications to propagation of electromagnetic waves in dielectrics; EM waves in bounded media, waveguides, Radiation from time varying sources.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Understand and apply the laws of electromagnetism and Maxwell's equations in different forms and different media.		
CO2	Solve the electric and magnetic fields problems for different configurations.		
CO3	Provide solution to real life plane wave problems for various boundary conditions.		
CO4	Calculate reflection and transmission of waves at plane interface.		
CO5	Analyze propagation of electromagnetic waves through different waveguides.		

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	3	1	2	1	2	1	2
CO2	3	3	1	2	2	2	2	2
CO3	3	3	1	3	2	1	2	2
CO4	3	3	2	3	2	2	1	2
CO5	3	3	1	3	2	2	2	2

Detailed Syllabus:

1. **Electrostatics:** Laplace and Poisson's equations, Electrostatic potential and energy density of the electromagnetic field, Multipole expansion of the scalar potential of a charge distribution, dipole moment, quadrupole moment, Multipole expansion of the energy of a charge distribution in an external field, Static fields in material media, Polarization vector, macroscopic equations, classification of dielectric media, Molecular polarizability and electrical susceptibility, Clausius-Mossetti relation, Models of Molecular polarizability, energy of charges in dielectric media (Maxwell stress tensor). *(Lectures 10)*
2. **Magnetostatics:** The differential equations of magnetostatics, vector potential, magnetic fields of a localized current distribution, Singularity in dipole field, Fermi-contact term, Force and torque on a localized current distribution. (Magnetic stress tensor) *(Lectures 8)*
3. **Boundary value problems:** Uniqueness theorem, Dirichlet and Neumann Boundary conditions, Earnshaw theorem, Green's (reciprocity) theorem, Formal solution of electrostatic boundary value problem with Green function, Method of images with examples, Magnetostatic boundary value problems. *(Lectures 8)*
4. **Time varying fields and Maxwell equations:** Faraday's law of induction, displacement current, Maxwell equations, scalar and vector potential, Gauge transformation, Lorentz and Coulomb gauges, Hertz potential, General expression for the electromagnetic fields energy, conservation of energy, Poynting Theorem, Conservation of momentum. *(Lectures 8)*
5. **Electromagnetic Waves:** wave equation, plane waves in free space and isotropic dielectrics, polarization, energy transmitted by a plane wave, Poynting theorem for a complex vector field, waves in conducting media, skin depth, Reflection and refraction of e.m. waves at plane interface, Fresnel's amplitude relations, Reflection and Transmission coefficients, polarization by reflection, Brewster's angle, Total internal reflection, Stoke's parameters, EM wave guides, Cavity resonators, Dielectric waveguide, optical fibre waveguide, Waves in rarefied plasma (ionosphere) and cold magneto-plasma, Frequency dispersive characteristics of dielectrics, conductors and plasmas. *(Lectures 8)*
6. **Radiation from Localized Time varying sources:** Solution of the inhomogeneous wave equation in the absence of boundaries, Fields and radiation of a localized oscillating source, electric dipole and electric quadrupole fields, center fed antenna. *(Lectures 4)*

Text Books:

1. Classical Electrodynamics: *S.P. Puri (Narosa Publishing House) 2011.*
2. Classical Electrodynamics*: J.D. Jackson, (New Age, New Delhi) 2009.*
3. Introduction to Electrodynamics: *D.J. Griffiths (Prentice Hall India, New Delhi) 4th ed., 2012.*

Reference Books:

1. Classical Electromagnetic Radiation: *J.B. Marion and M.A. Heald(Saunders College Publishing House) 3rd edition, 1995.*
2. Electromagnetic Fields*, Ronald K. Wangsness (John Wiley and Sons) 2nd edition,1986*.
3. Electromagnetic Field Theory Fundamentals: *Bhag Singh Guru and H.R. Hiziroglu*

PHS533	Particle Physics	L-3, T-1, P-0	4 Credits
Pre-requisite: course on Quantum mechanics and Quantum field Theory			
The aim and objective of the course on **Particle Physics** is to introduce the M.Sc. students to the invariance principles and conservation laws, hadron-hadron interactions, relativistic kinematics, static quark model of hadrons and weak interactions so that they grasp the basics of fundamental particles in proper perspective.			
Course Outcomes: At the end of the course, the student will be able to understand			
CO1	Overview of particle spectrum, their interaction and major historical and latest developments.		
CO2	Various invariance principles and symmetry properties in particle physics.		
CO3	Basic rules of Feynman diagrams and the quark model for hadrons.		
CO4	Properties of neutrons and protons in terms of a simple nonreltivistic quark model.		
CO5	Weak interaction between quarks and how that this is responsible for β decay.		

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2	2	2	3	3	1	2	3
CO2	2	2	2	3	3	1	2	3
CO3	2	2	1	3	3	1	2	3
CO4	1	1	1	3	3	2	3	3
CO5	1	1	2	3	3	2	3	2

Detailed Syllabus:

1. **Introduction:** Fermions and bosons, particles and antiparticles, quarks and leptons, interactions and fields in particle physics, classical and quantum pictures, Yukawa picture, types of interactions - electromagnetic, weak, strong and gravitational, units. *(Lectures 7)*
2. **Invariance Principles and Conservation Laws:** Invariance in classical mechanics and quantum mechanics, Parity, Pion parity, Charge conjugation, Positronium decay, Time reversal invariance, CPT theorem. *(Lectures 7)*
3. **Hadron-Hadron Interactions:** Cross section and decay rates, Pion spin, Isospin, Two nucleon system, Pion-nucleon system, Strangeness and Isospin, G-parity, Total and Elastic cross section, Particle production at high energy. *(Lectures 7)*
4. **Relativistic Kinematics and Phase Space:** Introduction to relativistic kinematics, particle reactions, Lorentz invariant phase space, two-body and three-body phase space, recursion relation, effective mass, dalitz, K-3 p-decay, t-θ puzzle, dalitz plots for dissimilar particles, Breit-Wigner resonance formula, Mandelstem variables. *(Lectures 7)*
5. **Static Quark Model of Hadrons:** The Baryon decuplet, quark spin and color, baryon octer, quark-antiquark combination. *(Lectures 7)*
6. **Weak Interactions:** Classification of weak interactions, Fermi theory, Parity non conservation in ß-decay, experimental determination of parity violation, helicity of neutrino, K-decay, CP violation in K- decay and its experimental determination. *(Lectures 7)*

1.

Text Books:

1. Introduction to High Energy Physics : D.H. Perkins (Cambridge University Press), 42000.

Reference Books:

1. Elementary Particles : I.S. Hughes (Cambridge University Press), 3rd ed. 1991.
2. Introduction to Quarks and Partons : F.E. COse (Academic Press, London), 1979.
3. Introduction to Particle Physics : M.P. Khanna (Prentice Hall of India, New Delhi), 2004.

PHS534	Electronics	L-3, T-1, P-0	4 Credits

Pre-requisite: Basic knowledge about electronics

Course Objectives: The aim and objective of the course on **Electronics** is to introduce the students of M.Sc. class to the formal structure of the subject and to equip them with the knowledge of semiconductor physics, basic circuit analysis, first-order nonlinear circuits, OPAMP based analog circuits and introduction to digital electronics so that they can use these in various branches of physics as per their requirement.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand working of Different Semiconductor devices (Construction, Working Principles and V-I characteristics) and their applications.
CO2	Learn about the construction and working of Thyristors and various applications of Thyristors.
CO3	Understand Analog and Digital Instruments and their applications.
CO4	Enable them for using Boolean algebra and Karnaugh maps.
CO5	Introduce them to the Sequential and Integrated circuits.

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	2	2	2	3	1	3	3
CO2	2	2	1	1	1	1	3	2
CO3	-	1	1	1	-	2	3	3
CO4	-	3	-	-	-	-	3	2
CO5	-	2	2	2	1	3	3	1

Detailed Syllabus:

1. **Analog and Digital Instruments:** Introduction-Basic Emitter Follower Voltmeter; FET Input Voltmeter; Voltage Follower Voltmeter; Amplifier Type OP AMP Voltmeter; Voltage to Current Converter; Current Measurement with Analog Electronic Instrument; Time Base; Basic Digital Frequency Meter System; Reciprocal Counting Technique; Digital Voltmeter System; Digital LCR Measurements. *(Lectures 8)*
2. **UJTs and Thyristors:** Operational Principle of UJT: UJT Relaxation Oscillator circuit; PNPN Diode: Characteristics- As a Relaxation Oscillator-Rate Effect; SCR: V-I Characteristics – Gate Triggering Characteristics; DIAC and TRIAC; Thyristors: Basic Parameters- As Current Controllable Devices- Thyristors in Series and in Parallel; Applications of Thyristors-As a Pulse Generator, BistableMultivibrator, Half and Full Wave Controlled Rectifier, TRIAC based AC power control, SCR based Crowbar Protection; Gate Turn-Off Thyristors; Programmable UJT. *(Lectures 10)*
3. **Digital Integrated Circuits:** 7400 TTL; TTL Parameters; TTL-MOSFET's; CMOS FET's;Three State TTL Devices; External drive for TTL Loads; TTL Driving External Loads; 74C00 CMOS; CMOS Characteristics; TTL to CMOS Interface; CMOS to TTL interface; Current Tracers. *(Lectures 7)*
4. **Integrated Circuits as Analog System Building Blocks:** Electronic Analog Computation; Active Filters: Butterworth Filter-Practical Realization-High Pass Filter-Band Pass Filter-Band Reject Filter; Delay Equalizer; Switched Capacitor Filters; Comparators; Sample and Hold Circuits; Waveform Generators: Square Wave Generator Pulse Generator-Triangle wave Generator-Sawtooth Generator; Regenerative Comparator: Schmitt Trigger.
5. **Integrated Circuits as Digital System Building Blocks**: Binary Adders: Half Adder-Parallel Operation-Full Adder-MSI Adder-Serial Operation; Decoder/Demultiplexer: BCD to Decimal Decoder-4-to-16 line Demultiplexer; Data Selector/Multiplexer:16-to-1 Multiplexer; Encoder; ROM:Code Converters-Programming the ROM-Applications; RAM:Linear Selection-Coincident Selection-Basic RAM ElementsBipolar RAM-Static and Dynamic MOS RAM; Digital to Analog Converters: Ladder Type D/A Converter-Multiplying D/A Converter; Analog to Digital Converters: Successive Approximation A/D Converter. *(Lectures 8)*

Text Books:

1. Text Book of Electronics: *S. Chattopadhyay,* New Central Book Agency P.Ltd., Kolkata, 2006.
2. Digital Principles and Applications: *A.P. Malvino and D.P. Leach,* Tata McGraw-Hill, Publishing Co., New Delhi.

Reference Books:

1. Electronics Principles and Applications: *A.B. Bhattacharya*, New Central Book Agency P.Ltd., Kolkata, 2007.
2. Integrated Electronics Analog and Digital Circuits and Systems: *J. Millman, C.C Halkins and C. Parikh*, 2nd Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2010.

Elective Subject -I

PHS535	**Fibre Optics and Non-linear optics**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisite: None			
Course Objectives: Course Objectives: The aim and objective of the course on **Fibre Optics and Nonlinear Optics** is to expose the M.Sc. students to the basics of the challenging research field of optical fibres and their use in nonlinear optics.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Understand the structure of optical fiber and describe properties of optical fibers.		
CO2	Understand and compare the various processes of fibers fabrication		
CO3	Understand the principles of fiber optics communication in different media		
CO4	Analyze the electro-optic and acousto-optic effects in fibers		
CO5	Understand non-linear effects in optical fibers.		

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	-	2	-	2	-	1	2	3
CO2	-	2	-	2	-	-	1	3
CO3	-	1	-	2	-	-	1	3
CO4	-	2	-	2	-	-	1	3
CO5	-	2	-	2	-	-	1	3

Detailed Syllabus:

1. **Optical fibre and its properties:** Introduction, basic fibre construction, propagation of light, modes and the fibre, refractive index profile, types of fibre, dispersion, data rate and band width, attenuation, leaky modes, bending losses, cut-off wavelength, mode field diameter, other fibre types. *(Lectures 7)*

2. **Fiber fabrication and cable design:** Fibre fabrication, mass production of fiber, comparison of the processes, fiber drawing process, coatings, cable design requirements, typical cable design, testing. *(Lectures 5)*

3. **Optics of anisotropic media:** Introduction, the dielectric tensor, stored electromagnetic energy in anisotropic media, propagation of monochromatic plane waves in anisotropic media, directions of D for a given wave vector, angular relationships between D, E, H, k and Poynting vector S, the indicatrix, uniaxial crystals, index surfaces, other surfaces related to the uniaxial indicatrix, Huygenian constructions, retardation, biaxial crystals, intensity through polarizer/waveplate/ polarizer combinations. *(Lectures 10)*

4. **Electro-optic and acousto-otpic effects and modulation of light beams**: Introduction to the electro-optic effects, linear electro-optic effect, quadratic electro-optic effects, longitudinal electro-optic modulation, transverse electro optic modulation, electro optic amplitude modulation, electro-optic phase modulation, high frequency wave guide, electro-optic modulator, strain optic tensor, calculation of LM for a logitudinal acoustic wave in isotropic medium, Raman-Nath diffraction, Raman-Nath acousto-optic modulator. *(Lectures 10)*

5. **Non-linear optics/processes**: Introduction, anharmonic potentials and nonlinear polarization, non-linear susceptibilities and mixing coefficients, parametric and other nonlinear processes, macroscopic and microscopic susceptibilities. *(Lectures 8)*

Text Books:

1. The Elements of Fibre Optics: *S.L.Wymer and Meardon (Regents/Prentice Hall), 1993.*

Reference Books:

1. Lasers and Electro-Optics: *C.C. Davis (Cambridge University Press), 1996.*
2. Optical Electronics: *Gathak & Thyagarajan (Cambridge Univ. Press), 1989.*
3. The Elements of Non-linear Optics: *P.N. Butcher & D. Cotter (Cambridge University Press), 1991.*

Elective Subject -I

PHS536	**Plasma Physics**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisite: Course on Electrodynamics			
Course Objectives: The aim and objective of the course on **Plasma Physics** is to expose the M.Sc. students to the basics of the challenging research field Plasma physics.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Understand the origin of plasma, conditions of plasma formation and properties of plasma.		
CO2	Distinguish between the single particle approach, fluid approach and kinetic statistical approach to describe different plasma phenomena.		
CO3	Classify propagation of electrostatic and electromagnetic waves in magnetized and non-magnetized plasmas		
CO4	Describe the basic transport phenomena such as plasma resistivity, diffusion and mobility for both magnetized and non-magnetized plasmas.		
CO5	Formulate the conditions for describing a plasma to be in a state of thermodynamic equilibrium, or non-equilibrium, and analyze the stability of this equilibrium.		

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	-	2	2	3	3	1	-
CO2	3	3	3	3	3	3	1	-
CO3	3	3	3	3	3	3	2	-
CO4	3	3	3	3	3	3	1	1
CO5	3	3	3	3	3	3	2	1

Detailed Syllabus:

1. **Introduction:** Plasma State, elementary concepts and definitions of temperature and other parameters, occurrence and importance of plasma for various applications, Production of Plasma in the laboratory, Physics of glow discharge, electron emission, ionization, breakdown of gases, Paschen's laws and different regimes of E/p in a discharge, Townsend discharge and the evolution of discharge. *(Lectures 8)*

2. **Plasma diagnostics:** Probes, energy analyzers, magnetic probes and optical diagnostics, preliminary concepts. *(Lectures 5)*

3. **Single particle orbit theory:** Drifts of charged particles under the effect of different combinations of electric and magnetic fields, Crossed electric and magnetic fields, Homogenous electric and magnetic fields, spatially varying electric and magnetic fields, time varying electric and magnetic fields, particle motion in large amplitude waves. *(Lectures 8)*

4. **Fluid description of plasmas:** distribution functions and Liouville's equation, macroscopic parameters of plasma, two and one fluid equations for plasma, MHD approximations commonly used in one fluid equations and simplified one fluid and MHD equations. dielectric constant of field free plasma, plasma oscillations, space charge waves of warm plasma, dielectric constant of a cold magnetized plasma, ion- acoustic waves, Alfven waves, Magnetosonic waves. *(Lectures 10)*

5. **Stability of fluid plasma:** The equilibrium of plasma, plasma instabilities, stability analysis, two stream instability, instability of Alfven waves, plasma supported against gravity by magnetic field, energy principle. microscopic equations for my body system: Statistical equations for many body systems, Vlasov equation and its properties, drift kinetic equation and its properties. *(Lectures 7)*

Text Books:

1. Introduction to Plasma Physics, *F.F. Chen*

Reference Books:

1. Principles of Plasma Physics, *Krall and Trievelpice*
2. Introduction to Plasma Theory, *D.R. Nicholson*
3. The Plasma State, *J.L. Shohet*
4. Introduction to Plasma Physics, *M. Uman*
5. Principles of Plasma Diagnostic, *I.H. Hutchinson*

Elective Subject -I

PHS537	**Nonlinear Dynamics**	**L-3, T-1, P-0**	**4 Credits**

Pre-requisite: None

Course Objectives: The aim and objective of the course on **Nonlinear Dynamics** is to familiarize the M.Sc. students with the basics of the recently emerging research field of dynamics of nonlinear Hamiltonian systems.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand basic knowledge of nonlinear dynamics and phenomenology of chaos
CO2	Apply the tools of dynamical systems theory in context to models
CO3	Learn skills by solving problems on solving nonlinear problems using numerical methods.
CO4	Understand Hamilton approach for describing various physical system
CO5	Quantify classical chaos and Quantum chaos

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2	3	3	3	3	2	3	1
CO2	-	3	3	3	3	2	3	1
CO3	1	3	3	3	3	1	3	1
CO4	3	3	3	3	3	1	3	2
CO5	3	3	3	3	3	2	3	2

Detailed Syllabus:

1. **Phenomenology of Chaos**: Linear and nonlinear systems, A nonlinear electrical system, Biological population growth model, Lorenz model; determinism, unpredictability and divergence of trajectories, Feigenbaum numbers and size scaling, self similarity, models and universality of chaos. *(Lectures 8)*

2. **Dynamics in State Space:** State space, autonomous and nonautonomous systems, dissipative systems, one dimensional state space, Linearization near fixed points, two dimensional state space, dissipation and divergence theorem. Limit cycles and their stability, Bifurcation theory, Heuristics, Routes to chaos. Three-dimensional dynamical systems, fixed points and limit cycles in three dimensions, Lyapunov exponents and chaos. Three dimensional iterated maps, U-sequence. *(Lectures 10)*

3. **Hamiltonian System**: Non-integrable systems, KAM theorem and period doubling, standard map. Applications of Hamiltonian Dynamics, chaos and stochasticity. *(Lectures 8)*

4. **Quantifying Chaos**: Time series, Lyapunov exponents. Invariant measure, Kolmogorov - Sinai entropy. Fractal dimension, Statistical mechanics and thermodynamic formalism. *(Lectures 7)*

5. **Quantum Chaos**: Quantum Mechanical analogies of chaotic behaviour, Distribution of energy eigenvalue spacing, chaos and semi-classical approach to quantum mechanics. *(Lectures 7)*

Text Books:

1. Chaos and Non Linear Dynamics: R.C. Hilborn (Oxford Univ. Press), 2001.

Reference Books:

1. Chaos in Dynamical Systems: E. Ott (Cambridge Univ. Press), 2002.
2. Applied Nonlinear Dynamics: A.H. Nayfeh and B. Balachandran (Wiley), 1995.
3. Chaos in Classical and Quantum Mechanics: M.C. Gutzwiller (Springer-Verlag), 1990.

Elective Subject -I

PHS538	**Structures, Spectra and Properties of Biomolecules**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisite: None			
Course Objectives: The aim and objective of the course on **Structures, Spectra and properties of Biomolecules** is to familiarize the M.Sc. students with the basics of the recently emerging research field of dynamics of Structures, Spectra and properties of Biomolecules.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Describe various structural and chemical bonding aspects of Biomolecules.		
CO2	Understand structure and theoretical techniques and their application to Biomolecules.		
CO3	Understand use of various spectroscopic techniques and their application to the Biomolecules.		
CO4	Understand the structure-Function relationship and modeling of biomolecules.		
CO5	Outline and correlate for providing solution to interdisciplinary problem		

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	3	3	3	3	2	3	2
CO2	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	2	3	2

Detailed Syllabus:

1. **Structure Aspects of Biomolecule:** Conformational Principles, Conformation and Configuration Isomers and Derivatives, Structure of Polynucleotides, Structure of Polypeptides, Primary, Secondary, Tertiary and Quaternary Structure of Proteins, Structure of Polysaccharides. *(Lectures10)*

2. **Theoretical Techniques and Their Application to Biomolecules:** Hard Sphere Approximation, Ramachandran Plot, Potential Energy Surface, Outline of Molecular Mechanics Method, Brief ideas about Semi-empirical and Ab initio Quantum Theoretical Methods, Molecular Charge Distribution, Molecular Electrostatic Potential and Field and their uses. *(Lectures 10)*

3. **Spectroscopic Techniques and their Application to Biomolecules:** Use of NMR in Elucidation of Molecular Structure, Absorption and Fluorescence Spectroscopy, Circular Dichroism, Laser Raman Spectroscopy, IR spectroscopy, Photoacoustic Spectroscopy, Photo-biological Aspects of Nucleic Acids. *(Lectures 10)*

4. **Structure-Function Relationship and Modeling:** Molecular Recognition, Hydrogen Bonding, Lipophilic Pockets on Receptors, Drugs and Their Principles of Action, Lock and Key Model and Induced fit Model. *(Lectures 10)*

Text Books:

1. *Srinivasan & Pattabhi:* Structure Aspects of Biomolecules.

Reference Books:

1. *Govil & Hosur*: Conformations of Biological Molecules
2. *Price:* Basic Molecular Biology
3. *Pullman:* Quantum Mechanics of Molecular Conformations
4. *Lehninger:* Biochemistry
5. Mehler&Cordes: Biological Chemistry
6. *Smith and Hanawait:* molecular Photobiology, Inactivation and Recovery

PHS539	Seminar	L-0, T-2, P-0	2 Credits
Pre-requisite: Knowledge of specific branch of physics			
Course Objectives: The aim of the **seminar** is to expose the students to preliminaries and methodology of research in Theoretical Physics and Experimental Physics.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Explain the significance and value of problem in physics.		
CO2	Design and carry out scientific experiments as well as accurately record the data of experiments.		
CO3	Critically analyse the experimental strategies, and decide which one is most appropriate for answering specific questions.		
CO4	Communicate the scientific knowledge in the context of a topic related to Physics, in oral, written and electronic formats.		
CO5	Explore new areas of research in physics and allied fields of science and technology.		

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	3	3	3	3	3	3	3
CO2	3	2	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3
CO4	2	3	2	3	3	3	3	3
CO5	2	3	3	3	3	3	3	3

Guidelines for the seminar:

The aim of Seminar in M.Sc. 3th semesters is to expose some of the students to preliminaries and methodology of research and as such it may consist of review of some research papers, development of a laboratory experiment, fabrication of a device, working out some problem, analysis of data, etc. related to research Project work which can be in Experimental Physics or Theoretical Physics in the thrust as well as non-thrust research areas of the department.

A student opting for this course will be attached to one teacher of the department in the start of the 3rd semester. These seminars are aimed to develop in-depth subject knowledge and skill. Besides subject expertise, they help train students in the presentation and communication skill.

PHS540	**Physics Lab-III**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisite: None			
Course Objectives: The aim and objective of the courses on **Physics Lab-III** is to train the students of M.Sc. class to advanced experimental techniques in condensed matter physics so that they can investigate various relevant aspects and are confident to handle sophisticated equipment and analyze the data.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Measure conductivity, resistivity and thermo-dynamical properties of solids.		
CO2	Measure magnetic properties and magnetic behavior of magnetic materials.		
CO3	Describe the lattice dynamics of simple lattice structures in terms of dispersion relations.		
CO4	Design and carry out scientific experiments as well as accurately record and analyze the results of experiments.		
CO5	Solve problem with critical thinking and analytical reasoning.		

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	3	-	3	3	2	2	3
CO2	3	3	-	3	3	3	2	3
CO3	3	3	2	3	3	2	2	3
CO4	3	3	2	3	3	3	2	3
CO5	3	3	2	3	3	3	2	3

Detailed Syllabus:

Note: Students are expected to perform atleast ten experiments out of following list.

1. To study temperature dependence of conductivity of a given semiconductor crystal using four probe method.
2. Temperature dependence of a ceramic capacitor-verification of curie-weiss law for the electrical susceptibility of a ferroelectric material.
3. To determine charge carrier density and Hall coefficient by Hall effect.
4. To determine energy gap and resistivity of the semiconductor using four probe method.
5. To determine magnetic susceptibility of material using Quink 's tube method.
6. To determine energy gap and resistivity of the semiconductor using four probe method.
7. To trace hysteresis loop and calculate retentivity, coercivity and saturation magnetization.
8. To study the series and parallel characteristics of photovoltaic cell
9. To study the spectral characteristics of photovoltaic cell.
10. To determine the g-factor using ESR spectrometer.

Text Books:

1. Introduction to Solid State Physics: *C. Kittel (Wiley, New York), 8th ed. 2005.*
2. Quantum Theory of Solids: *C. Kittel (Wiley, New York) 1987.*

Reference Books:

1. Principles of the Theory of Solids: *J. Ziman (Cambridge University Press) 1972*
2. Solid State Theory: *Walter A. Harrison (Tata McGraw-Hill, New Delhi) 1970.*
3. Liquid Crystals: *S. Chandrasekhar (Cambridge University), 2nd ed. 1992.*

Elective Subject -II

PHS541	**Experimental Techniques in Nuclear and Particle Physics**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisite: Course on Nuclear and Particle Physics			
Course Objectives: The aim and objective of the course on **Experimental Techniques in Nuclear and Particle Physics** is to expose the students of M.Sc. students to experimental aspects of different equipment and methods used in the fields of nuclear physics and particle physics.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Understand various experimental techniques for describing interaction of radiations with matter.		
CO2	Use various statistical methods for experimental data.		
CO3	Knowledge about the different types of the radiation detectors and their applications.		
CO4	Introduced to neutron physics, methods to detector slow and fast neutrons.		
CO5	Equipped with the basic knowledge about the experimental methods used in the various laboratories across the world.		

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	2	1	2	3	3	3	3
CO2	1	3	3	2	1	3	3	3
CO3	1	1	1	3	1	3	3	3
CO4	1	3	1	3	3	3	3	3
CO5	1	3	1	3	1	3	3	3

Detailed Syllabus:

1. **Detection of radiations:** Interaction of gamma-rays, electrons, heavy charged particles, neutrons, neutrinos and other particles with matter. General properties of Radiation detectors, energy resolution, detection efficiency and dead time. Statistics and treatment of experimental data. Gas-filled detectors, Proportional counters, space charge effects, energy resolution, time characteristics of signal pulse, position-sensitive proportional counters, Multiwire proportional chambers, Drift chamber, Time projection chamber. Organic and inorganic scintillators and their characteristics, light collection and coupling to photomultiplier tubes and photodiodes, description of electron and gamma ray spectrum from detector, Cherenkov detector. Semiconductor detectors, Ge and Si(Li) detectors, Charge production and collection processes, semiconductor detectors in X- and gamma-ray spectroscopy, Pulse height spectrum, Compton-suppressed, Semiconductor detectors for charged particle spectroscopy and particle identification. *(Lectures 18)*

2. **Electromagnetic and Hadron calorimeters:** Motion of charged particles in magnetic field, Magnetic dipole and quadrupole lenses, beta ray spectrometer. Detection of fast and slow neutrons - nuclear reactions for neutron detection. General background and detector shielding. *(Lectures 10)*

3. **Experimental methods**: Detector systems for heavy-ion reactions : Large gamma and charge particle detector arrays, multiplicity filters, electron spectrometer, heavy-ion reaction analysers, nuclear lifetime measurements (DSAM and RDM techniques), production of radioactive ion beams. Detector systems for high energy experiments :Collider physics (brief account), Particle Accelerators (brief account), Secondary beams, Beam transport, Modern Hybrid experiments- CMS and ALICE. *(Lectures 15)*

Text Books:

1. Techniques in Nuclear and particle Experiments by W.R. Leo (Springer), 1994.

Reference Books:

1. Radiation detection and measurement by Glenn F. Knoll (Wiley), 2010.
2. Introduction to Experimental Particle Physics by Richard Fernow (Cambridge University Press), 2001.
3. Detectors for particle radiation by Konrad Kleinknecht (Cambridge University Press), 1999.

Elective Subject -II

PHS542	**Physics of Nanomaterials**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisite: Condensed matter physics			
Course Objectives: The aim and objective of the course on **Physics of Nano-materials** is to familiarize the students of M.Sc. to the various aspects related to preparation, characterization and study of different properties of the nanomaterials so that they can pursue this emerging research field as career.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Demonstrate techniques of microscopy for investigations on the nanometer and atomic scales		
CO2	Acquire knowledge of basic approaches to synthesize inorganic colloidal nanoparticles and their self-assembly in solution and surfaces		
CO3	Understand and describe the use of unique optical properties of nanoscale metallic structures for analytical and biological applications		
CO4	Understand the physical and chemical properties of carbon nanotubes and nanostructured mesoporous materials.		
CO5	the structure-property relationships in nanomaterials as well as the concepts, not applicable at larger length scales.		

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	-	3	3	3	3	3	3	3
CO2	2	3	3	3	3	3	3	3
CO3	2	3	3	3	3	3	3	3
CO4	-	3	3	3	3	3	3	3
CO5	-	3	3	3	3	3	3	3

Detailed Syllabus:

1. **Introductory Aspects:** Free electron theory and its features, Idea of band structure—metals, insulators and semiconductors. Density of state in one, two and three dimensional bands and its variation with energy, Effect of crystal size on density of states and band gap. Examples of nanomaterials. *(Lectures 8)*

2. **Preparation of Nanomaterials:** Bottom up: Cluster beam evaporation, ion beam deposition, chemical bath deposition with capping techniques and Top down: Ball Milling. *(Lectures 8)*

3. **General Characterization Techniques:** Determination of particle size, study of texture and microstructure, Increase in x-ray diffraction peaks of nanoparticles, shift in photo luminescence peaks, variation in Raman spectra of nanomaterials, photoemission microscopy, scanning force microscopy. *(Lectures 8)*

4. **Quantum Dots:** Electron confinement in infinitely deep square well, confinement in one and two-dimensional wells, idea of quantum well structure, Examples of quantum dots, spectroscopy of quantum dots. *(Lectures 8)*

5. **Other Nanomaterials:** Properties and applications of carbon nanotubes and nanofibres, Nano-sized metal particles, Nanostructured polymers, Nanostructured films and Nano structured semiconductors. *(Lectures 8)*

Books:

1. Nanotechnology-Molecularly Designed Materials: *G.M. Chow & K.E. Gonsalves (American Chemical Society), 1996.*
2. Nanotechnology Molecular Speculations on Global Abundance: *B.C. Crandall (MIT Press), 1996.*
3. Quantum Dot Heterostructures: *D. Bimerg, M. Grundmann and N.N. Ledentsov (Wiley),1998.*
4. Nanoparticles and Nanostructured Films–Preparation, Characterization and Application: *J.H.Fendler (Wiley), 1998.*
5. Nanofabrication and Bio-system: *H.C. Hoch, H.G. Craighead and L. Jelinski (Cambridge Univ. Press), 1996.*
6. Physics of Semiconductor Nanostructures*: K.P. Jain (Narosa), 1997.*
7. Physics of Low-Dimension Semiconductors*: J.H. Davies (Cambridge Univ. Press) 1998.*
8. Advances in Solid State Physics (Vo.41): *B. Kramer (Ed.) (Springer), 2001.*

Elective Subject -III

PHS543	**Environmental Physics**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisite: none			
Course Objectives: The objective of the course on Environmental Physics is to build fundamental understanding of envoronmental physics and related effects.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Understand the essential of the environmental physics		
CO2	Apply the solar and terrestrial radiations to the earth atmosphere system.		
CO3	Describe the factors responsible for envirnmental pollution and degradation.		
CO4	Provide exposure to envoronmental changes and understand the idea of remote sensing.		
CO5	Provide exposure to the studenst about the global and regional environmental changes.		

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	3	3	3	3	3	3	1
CO2	2	3	3	3	3	3	3	1
CO3	2	3	3	3	3	3	3	-
CO4	2	3	3	3	3	3	3	-
CO5	2	3	3	3	3	3	3	1

Detailed Syllabus:

1. **Essentials of Environmental Physics:** Structure and thermodynamics of the atmosphere, Composition of air, Greenhouse effect, Transport of matter, energy and momentum in nature, Stratification and stability of atmosphere, Lass of motion, hydrostatic equilibrium, General circulation of the topics, Elements of weather and climate of India. *(Lectures 10)*

2. **Solar and Terrestrial Radiation :**Physics of radiation, Interaction of light with matter, tayleigh and Mie scattering, Laws of radiation (Kirchoffs law, Planck's law, Beer's law, Wien's displacement law, etc.), Solar and terrestrial spectra, UV radiation, Ozone depletion problem, IR absorption energy balance of the earth atmosphere system *(Lectures 8)*

3. **Environmental Pollution and degradation:** Elementary fluid dynamics, Diffusion, Turbulence and turbulent diffusion, Factors governing air, Water and noise pollution, Air and water quality standards, Waste disposal, Heat island effect, Land and sea breeze, Puffs and plumes, Gaseous and particulate matters, Wet and dry deposition. *(Lectures 8)*

4. **Environmental Changes and remote sensing:** Energy sources and combustion processes, Renewable sources of energy, Solar energy, Wind energy, bioenergy, hydropower, fuel cells, nuclear energy, Forestry and bioenergy. *(Lectures 7)*

5. **Global and Regional Climate:** Elements of weather and climate, Stability and vertical motion of air, Horizontal motion of air and water, Pressure gradient forces, Viscous forces, Reynolds number, Enhanced Greenhouse Effect, Energy balance-a Zero-dimensional Greenhouse model, Global climate models. *(Lectures 10)*

Text and Reference Books

1. Egbert Boeker &Rienk Van Groundelle: Environmental Physics (John Wiley).
2. J. T Hougtion: The Physics of atmosphere (Cambrige University Press, 1977).
3. J Twidell and J Weir: Renewable energy Resources (Elbs, 1988).
4. Sol Wieder: An introduction t solar energy for scientists and Engineers (John Wiley, 1982)
5. R. N. Keshavamurthy and M. Shanker Rao: The Physics of Monsoons (Allied Publishers, 1992).
6. G.J. Haltiner and R.T. Williams: Numerical Weather Prediction (John Wiley, 1980).

Elective Subject -III

PHS544	**Science of Renewable source of Energy**	**L-3, T-1, P-0**	**4 Credits**
Pre-requisite: None			
Course Objectives: The aim and objective of the course on **Science of renewable Energy Sources** is to expose the M.Sc. students to the basics of the alternative energy sources like solar energy, hydrogen energy, etc.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Know the energy demand of world and India.		
CO2	Understand traditional and alternative form of energy.		
CO3	Understand concept of solar energy radiation, making of solar cell and its types.		
CO4	Identify hydrogen as energy source, its storage and transportation methods.		
CO5	Compare wind energy, wave energy and ocean thermal energy conversion.		

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	-	3	-	3	1	2	2	3
CO2	-	2	-	3	1	2	2	3
CO3	-	3	-	3	2	1	3	3
CO4	-	3	-	3	2	1	3	3
CO5	-	3	-	3	1	1	3	3

Detailed Syllabus:

1. **Introduction**: Production and reserves of energy sources in the world and in India, need for alternatives, renewable energy sources. *(Lectures 8)*

2. **Solar Energy**: Thermal applications, solar radiation outside the earth's atmosphere and at the earth's surface, fundamentals of photovoltaic energy conversion. Direct and indirect transition semi-conductors, interrelationship between absorption coefficients and band gap recombination of carriers. Types of solar cells, p-n junction solar cell, Transport equation, current density, open circuit voltage and short circuit current, description and principle of working of single crystal, polycrystalline and amorphous silicon solar cells, conversion efficiency. Elementary ideas of Tandem solar cells, solid-liquid junction solar cells and semiconductor-electrolyte junction solar cells. Principles of photo electrochemical solar cells. Applications. *(Lectures 12)*

3. **Hydrogen Energy**: Environmental considerations, solar hydrogen through photo electrolysis and photocatalytic process, physics of material characteristics for production of solar hydrogen. Storage processes, solid state hydrogen storage materials, structural and electronic properties of storage materials, new storage modes, safety factors, use of hydrogen as fuel; use in vehicles and electric generation, fuel cells, hydride batteries. *(Lectures 10)*

4. **Other sources**: Nature of wind, classification and descriptions of wind machines, power coefficient, energy in the wind, wave energy, ocean thermal energy conversion (OTEC), system designs for OTEC. *(Lectures 8)*

Text Books:

1. Solar Energy: *S.P. Sukhatme (Tata McGraw-Hill, New Delhi), 2008.*

Reference Books:

1. Solar Cell Devices: *Fonash (Academic Press, New York),2010.*
2. Fundamentals of Solar Cells, Photovoltaic Solar Energy: *Fahrenbruch and Bube (Springer, Berlin), 1983.*
3. Photoelectrochemical Solar Cells : *Chandra (New Age,New Delhi).*

PHS545	**Research Project work**	**L-0, T-12, P-0**	**12 Credits**
Pre-requisite: Knowledge of specific branch of physics			
Course Objectives: The aim of the **M.Sc.** Research project work is to expose the students to preliminaries and methodology of research in Theoretical Physics and Experimental Physics. Students get the opportunity to participate in some ongoing research activity and development of a laboratory experiment.			
Course Outcomes: At the end of the course, the student will be able to			
CO1	Explain the significance and value of problem in physics, both scientifically and in the wider community.		
CO2	Design and carry out scientific experiments as well as accurately record the results of experiments.		
CO3	Critically analyse and evaluate experimental strategies, and decide which is most appropriate for answering specific questions.		
CO4	Research and communicate scientific knowledge in the context of a topic related to condensed matter physics/Nuclear/High Energy Physics, in oral, written and electronic formats to both scientists and the public at large.		
CO5	Explore new areas of research in physics and allied fields of science and technology.		

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	3	3	3	3	3	3	3
CO2	3	2	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3
CO4	2	3	2	3	3	3	3	3
CO5	2	3	3	3	3	3	3	3

Guidelines for the Project:

The aim of project work in M.Sc. 4th semesters is to expose the students to preliminaries and methodology of research and as such it may consist of review of some research papers, development of a laboratory experiment, fabrication of a device, working out some problem, participation in some ongoing research activity, analysis of data, etc.. Project work can be in Experimental or Theoretical Physics in the thrust as well as non-thrust research areas of the department.

A student opting for this course will be attached to one teacher of the department before the end of the 3rd semester. A report about the work done in the project (typed on both the sides of the paper and properly bound) will be submitted by a date to be announced by the Head of Department.

Assessment of the work done under the project will be carried out by a committee on the basis of effort put in the execution of the project, interest shown in learning the methodology, report prepared, grasp of the problem assigned and viva-voce/seminar, etc. as per course guidelines.