SCHEME & SYLLABUS

M.Sc.(Hons.)Physics

(Choice Based Credit System)

Department of Physical Sciences

University Institute of Sciences and Humanities

(UISH)

Sant Baba Bhag Singh University

2020

ABOUT THE DEPARTMENT

The Physical Sciences expands the knowledge of the universe and underlines new technologies, which benefit our society. In keeping with the heritage of imparting quality education, teaching and research are the prime motive of the Department of Physical Sciences. Department of Physical Sciences is dynamic and progressive in its development of new course initiatives. The faculty is well placed to contribute substantially to the goal of SBBSU and becoming a research oriented organization. The teaching is by way of interactive sessions between students and teachers. Our courses ensure a coherent degree structure while encouraging interdisciplinary approach.

SALIENT FEATURES OF THE DEPARTMENT

- The department is blessed to have specialized faculty in various fields of Physical Sciences viz. Chemistry, Physics, Mathematics.

- The Department has well equipped laboratories with a number of instruments and facilities like, UV- Visible Spectrophotometer, High Speed Centrifuge, Muffle furnance, Digital water bath, Polarimeter , Turbiditimeter, AbbsRefractrometer, Digital weighing balance, Magnetic plate with stirrer, pH meter, Conductometer, Flame Photometer, colorimeter and a double distillation plant, Spring balance , Sodium Lamp Transformer , Young's modulus,Ultrasonic interferometer , Rheostat , Maxwell needle apparatus kit , Magnetic field of solenoid , Ballistic Galvanometer , Deflection and vibration Magnetometer , Electron spin resonance

- The Department keeps its students abreast of latest advancements in technology through ultra-modern computer facilities, e-learning, virtual labs, SWAYAM Courses as per UGC guidelines.

- The department updates curricula on a regular basis to ensure that the students keep up with the changing trends of education and research globally. The syllabi of courses are designed to equip students to qualify exams such as GATE, UGC- NET / SLET, etc.

- Student centric, ICT enabled and interactive teaching.
- Students and teachers participation in International, National, State and Regional seminars and conferences.
- Curricular and the co-curricular activities are well balanced in the Teaching Learning environment to provide holistic education to the students.
- Flexiblility in course curriculum as per the needs of students & PG Programmes with Project as research component.
- The outcome based teaching model of faculty comprising of theoretical work, regular academic activities such as research projects, seminars, resource learning and hands-on laboratory work.
- Along with Industry aligned academia, expert interaction, industry exposure and highly dynamic learning environment is the key features of the department.

MSc.(HONS.) PHYSICS (MASTER OF SCIENCE HONOURS IN PHYSICS)

MSc. (Hons.) Physics or **Master of Science Honours Physics** is a postgraduate Physics program. The course helps to train the innovative minds in the latest developments in Physics as applicable in the field of modern inventions and discoveries. The course includes Mathematical Physics, Classical Mechanics, Quantum Mechanics, Electronic Devices, Statistical Mechanics, Electrodynamics and Plasma Physics, Atomic and Molecular Physics, Condensed Matter, Nuclear and Particle Physics. The duration of the course is two years and it is career orienting in nature.

VISION

To aspire, achieve and sustain for excellence in academics and research through scientific knowledge so as to provide solutions to global environmental issues and transform graduates into responsible citizens and competent professionals.

MISSION

- Holistic development of learner through academic excellence, employability, acquisition of analytical skills and higher research.
- To explore and advance new frontiers in physical sciences and integration with interdisciplinary sciences through visionary research for the benefit of society.
- To impart academic environment to seed skills and to promote creativity and to provide a student-centered and professions-oriented higher education.

ELIGIBILITY CRITERIA

B.Sc (N.M) with atleast 50% marks in aggregate with physics or equivalent as one course subject.

DURATION

2 Years

CAREER PATHWAYS

- The Degree serves as a basis for further higher studies in this field such as Ph.D. and M.Phil. Degree in Physics, the successful completion of which makes one eligible for the post of Assistant Professor in any university/college.
- After completing the degree course they can pursue careers in a range of sectors such as IT and consultancy, the environmental industry, financial services, and the legal sector, transport and utilities.
- They can become a school teacher on private basis after it and lecturer after completing a Master’s degree plus NET exam permanently.

PROGRAMME EDUCATIONAL OBJECTIVE (PEO)

PEO1: Students will have knowledge of fundamental laws and principle in a variety of areas of Physics along with their applications.

PEO2: Develop research skills which might include advance laboratory techniques, numerical techniques, computer algebra, computer interfacing.

PEO3: Become effective researcher who will be able to provide the summation of scientific literature on a given topic.

PEO4: To create a sense of ethical responsibilities among students.

PEO5: To make the students to accept the challenges in physics and can effectively disseminate the physics knowledge to coming generations.

PEO6: Design solutions for advanced scientific problems and design system components or processes.

PROGRAMME OUTCOMES (PO)

PO1: Eligible for competetive examinations such as NET,SLET, GATE, for research and employment in Government and private organizations.

PO2: Demonstrate the physics knowledge for sustainable development.

PO3: Demonstrate the ability to plan, undertake, and report on a programme of original work; including the planning and execution of experiments, the analysis and interpretation of experimental results.

PO4: Develop communication skills, both written and oral, for specialized and non-specialized audiences.

PO5: To suggest advanced ideas and working techniques required in emergent area of Physics.

PO6: To develop resources with specialization in theoretical and experimental techniques in Physics required for career in academia and industry.

PROGRAMME SPECIFIC OUTCOMES (PSO)

PSO1: Explain and apply principles of physics for understanding the scientific aspects in classical domain.

PSO2: Explain and apply mathematical techniques for illustrating and deeper understanding of physical systems.

PSO3: Learn and apply statistical methods for portraying the classical and quantum particles in various physical systems.

PSO4: Learn and apply inter-disciplinary concepts and computational skills for interpreting and describing the different phenomenon in physics.

PSO5: Learn and apply advanced experimental/theoretical methods for measurement, observation, and fundamental understanding of physical phenomenon/system.

PSO6: Provide exposure in research in various specialization of Physics like (Solid State Physics/Nuclear Physics/Particle Physics/Radiation Physics etc).

ABOUT THE CHOICE BASED CREDIT SYSTE (CBCS)

The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill based courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. The basic idea is to look into the needs of the students so as to keep up-to-date with development of higher education in India and abroad. CBCS aims to redefine the curriculum keeping pace with the liberalization and globalization in education. CBCS allows students an easy mode of mobility to various educational institutions spread across the world along withthe facility of transfer of credits earned by students.

1. **Curriculum Structure: MSc. (Hons.) Physics** degree programme will have a curriculum with Syllabi consisting of following type of courses:
   - I. **Ability Enhancement Courses (AEC):** The Ability Enhancement Courses (AEC) may be of two kinds: Ability Enhancement Compulsory Courses (AECC) and Skill Enhancement Courses (SEC). AECC courses are the courses based upon the content that leads to Knowledge enhancement; these are mandatory for all disciplines.
     SEC courses are value-based and/or skill-based and are aimed at providing hands-on-training, competencies, skills,etc.
   - II. **CoreCourses(CR):**Acourse,whichshouldcompulsorilybystudiedbya candidate as a core requirement is termed as a Core course.These courses are employability enhancement courses relevant to the chosen program of study.
   - III. **Elective Courses:** Elective course is generally a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/subject of study or with provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the

candidate's proficiency/skill. Accordingly, elective course may be categorizes as:

A. Discipline Specific Elective (DSE) Course: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective.
B. Project (I): An elective course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member is called dissertation/project.

2. NOMENCLATURE USED:

CR: Core Course
AEC: Ability Enhancement Core Course
SEC: Skill Enhancement Core Course
DSE: Discipline Specific Elective

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			Nanomaterial C. PHY617 Non Linear fiber optics		
23	SEC	PHY629	**Skill Enhancement Course** Project Part I	III	59
24	CR	PHY602	Particle Physics	IV	61
25	DSE	PHY604/ PHY606	**Discipline Specific Elective** Reactor Physics/ Radiation Physics	IV	63 65
26	DSE	PHY	**Discipline Specific Elective** **(Choose any two)** A. PHY608 Physics of Materials B. PHY610 Geophysics C. PHY612 Nano Technology D. PHY614 Spintronics E. PHY616 Solar cells and Applications F. PHY618 Science of Renewable Energy Source G. PHY620 Plasma Physics	IV	67-79
27	SEC	PHY630	**Skill Enhancement Course** Project Part II	IV	81
28	AEC	BOT001	**Ability Enhancement Course** Natural Hazards and Disaster Management	IV	82

Core Course

Ability Enhancement Courses

Sr. No.	Subject Code	Subject	Semester	Page No
1.	PHY507	Computational Techniques	I	20
2.	PHY501	Computational lab	I	25
3.	PHY540	Research Methodology &Intellectual Property Rights	II	40
4.	BOT001	Natural Hazards and Disaster Management	IV	82

Discipline Specific Elective Courses

Sr. No.	Subject Code	Subject	Semester	Page No
1	PHY613 PHY615 PHY617	**Choose any one** Experimental Techniques/ Physics of Nanomaterial/ Non Linear Fiber Optics	III	52-56
2	PHY604 PHY606	**Choose any one** Reactor Physics/ Radiation Physics	IV	63-65
3	PHY608 PHY610 PHY612 PHY614 PHY616 PHY618 PHY620	**Choose any two** Physics of Materials/ Geophysics/ Nano Technology/ Spintronics/ Solar Cell and its application/ Science of Renewable Sources / Plasma Physics	IV	67-79

Skill Enhancement Courses

Sr. No.	Subject Code	Subject	Semester
1	CHM520/ MAT520	**Choose any one** Medicinal Chemistry/ MATLAB Theory	II
2	MAT522	MATLAB Practical	II
3	PHY629	Project Part I	IV
4	PHY630	Project Part II	IV

Scheme for M.Sc.(Hons.) Physics

Semester-I

I. Theory Subjects

S.No.	Type of Course	Subject Code	Subject Name	Contact Hours (L:T:P)	Credits (L:T:P)	Total Contact Hours	Total Credits Hours
1	CR	PHY501	Electronics	4:0:0	4:0:0	4	4
2	CR	PHY503	Mathematical Physics	4:0:0	4:0:0	4	4
3	CR	PHY505	Classical Mechanics	4:0:0	4:0:0	4	4
4	AEC	PHY507	Computational Techniques	4:0:0	4:0:0	4	4
5	CR	PHY513	Quantum Mechanics-I	4:0:0	4:0:0	4	4

II. Practical Subjects

1	CR	PHY509	Electronics Lab	0:0:4	0:0:2	4	2
2	AEC	PHY511	Computer Lab	0:0:4	0:0:2	4	2
					Total	**28**	**24**

Total Contact Hours: 28
Total Credit Hours: 24

CR: Core Course
AEC: Ability Enhancement Course

Scheme for M.Sc.(Hons.) Physics

Semester II

I. Theory Subjects

S.No.	Type of Course	Subject Code	Subject Name	Contact Hours (L:T:P)	Credits (L:T:P)	Total Contact Hours	Total Credits Hours
1	**CR**	PHY502	Quantum Mechanics-II	4:0:0	4:0:0	4	4
2	**CR**	PHY504	Electrodynamics-I	4:0:0	4:0:0	4	4
3	**CR**	PHY506	Condensed Matter Physics-I	4:0:0	4:0:0	4	4
4	**CR**	PHY508	Atomic & Molecular Spectroscopy	4:0:0	4:0:0	4	4
5	**SEC**	CHM520 MAT520	**Choose any one**: Medicinal Chemistry/ MATLAB Theory	4:0:0/2:0:0	4:0:0/2:0:0	4/2	4/2
6	**AEC**	PHY540	Research Methodology&Intellectual Property Rights	2:0:0	2:0:0	2	2

II. Practical Subjects

1	**CR**	PHY510	Condensed Matter Physics Lab	0:0:4	0:0:2	4	2
2	**CR**	PHY512	Spectroscopy Lab	0:0:4	0:0:2	4	2
3	**SEC**	MAT522	MATLAB Practical	0:0:4	0:0:2	4	2
					Total	**30/32**	**26**

Total Contact Hours: 30/32
Total Credit Hours:26

CR: Core Course
AEC: Ability Enhancement Course
SEC: Skill Enhancement Course

Scheme for M.Sc.(Hons.) Physics

Semester III

I. Theory Subjects

S.No.	Type of Course	Subject Code	Subject Name	Contact Hours (L:T:P)	Credits (L:T:P)	Total Contact Hours	Total Credits Hours
1	**CR**	PHY601	Statistical Physics	4:0:0	4:0:0	4	4
2	**CR**	PHY603	Electrodynamics-II	4:0:0	4:0:0	4	4
3	**CR**	PHY605	Condensed Matter Physics-II	4:0:0	4:0:0	4	4
4	**CR**	PHY607	Nuclear Physics	4:0:0	4:0:0	4	4
5	**DSE**	PHY613/ PHY615/ PHY617	**Choose any one:** Experimental Techniques/ Physics of Nanomaterials/ Non Linear Fiber Optics	4:0:0	4:0:0	4	4

II. Project

1	**SEC**	PHY629	Project Part I	0:0:8	0:0:4	8	4

III. Practical Subjects

1	**CR**	PHY611	Nuclear Physics Lab	0:0:4	0:0:2	4	2
					Total	32	26

Total Contact Hours: 32
Total Credit Hours: 26

CR: Core Course
DSE: Discipline Specific Elective Course
SEC: Skill Enhancement Course

Scheme for M.Sc.(Hons.) Physics

Semester IV

I. Theory Subjects

S.No.	Type of Course	Subject Code	Subject Name	Contact Hours (L:T:P)	Credits (L:T:P)	Total Contact Hours	Total Credits Hours
1	**CR**	PHY602	Particle Physics	4:0:0	4:0:0	4	4
2	**DSE**	PHY604//PHY606	**<u>Choose any one:</u>** Reactor Physics/ Radiation Physics	4:0:0	4:0:0	4	4
3	**DSE**	PHY608/ PHY610/ PHY612/ PHY614/ PHY616/ PHY618/ PHY620/	**<u>Choose any two:</u>** Physics of Materials/ Geophysics/ Nano Technology/ Spintronics/ Solar cells and its application/ Science of renewable sources/ Plasma Physics	4:0:0	4:0:0	4	4
4	**AEC**	BOT001	Natural Hazards and Disaster Management	3:0:0	3:0:0	3	3

II- Project

1	**SEC**	PHY630	Project Part II	0:0:8	0:0:4	8	4
					Total	27	23

Total Contact Hours: 27

Total Credit Hours: 23

CR: Core Course
AEC: Ability Enhancement Course
DSE: Discipline Specific Elective Course
SEC: Skill Enhancement Course

Summarized Report of Course Scheme for M.Sc.(Hons.) Physics									
SEM	L	T	P	Contact hrs./week	Credits hrs./week	CR	AEC	DSE	SEC
I	20	0	08	28	24	18	06	0	0
II	22/18	0	08/12	30/32	26	20	02	0	04
III	20	0	12	32	26	18	0	04	04
IV	19	0	08	27	23	04	3	12	04
Total	81/77	0	36/40	119/117	99	60	11	16	12

SEMESTER I

Course Code	**PHY501**
Course Title	**Electronics**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objectives	The aim of the subject is to enhance the knowledge of students about various electronic circuits, electronic devices and its applications.
Course Outcome (CO)	**Students will able:** CO1: To get to known about the working of various electronic devices. CO2: To gain basic knowledge of OPAMP and their applications in different areas. CO3: To understand the basics of digital electronics. CO4: To analyze various combinational and sequential circuits.

UNIT-I

Electronic Devices: MOSFET, Charge Coupled(CCDs) devices, Unijunction transistor (UJT), four layer (PNPN) devices, construction and working of PNPN diode, Semiconductor controlled rectifier (SCR) and Thyristor.

UNIT-II

Electronic Circuits: Differential amplifier, Operational amplifier (OP-AMP), OP-AMP as inverting and non-inverting, scalar, summer, integrator, differentiator. Schmitt trigger, Common Mode rejection ratio.

Digital Principles: Binary and Hexadecimal number system, Binary arithmetic, Logic gates, Boolean equation of logic circuits,

UNIT-III

Combinational Circuits: Digital-to-Analog Converter, Ladder type, Analog-to-digital Convertor, Successive Approximation converter.

Combinational Logic: The transistor as a switch, OR, AND and NOT Gates, NOR and NAND gates, Boolean algebra, Demorgan’s theorems, Exclusive OR gate, Adder, Karnaugh maps, Decoder/Demultiplexer, Data selector/multiplexer, Encoder.

UNIT-IV

Sequential Circuits: RS Flip Flops D Flops, JK flip flop, JK Master slave,T flip flop, Registers, Up/Down counters, Shift register, Synchronous and Asynchronous counters, Mod counters, Memory devices:static and dynamic Random Access memories, SRAM and DRAM.

Text and Reference Books:

S.No.	Name	Author(S)	Publisher
1	Electronic Devices and Circuits	Millman and Halkias	Tata McGraw-Hill
2	Solid State Electronic Devices	Ben G Streetman and Banerjee	Prentice-Hall of India
3	Digital Principles and Applications	P. Malvino and D.P.Leach	Tata McGraw-Hill

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Course Code	PHY503
Course Title	**Mathematical Physics**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	The main objective of this course is to familiarize students with a range of mathematical methods that are essential for solving advanced problems in theoretical physics.
Course Outcome (CO)	**Students will able:** CO1: To understand the general coordinate transformations, their relevant transformation equations, basic tensor algebra, covariant- and contra-variant tensors and Fourier series. CO2: To learn various special functions, solve corresponding differential equations and understand about their properties. CO3: To determine accurate and efficient use of complex analysis techniques. CO4: To describe the basics of Group Theory.

UNIT-I

Fourier Transformation: Fourier decomposition, Fourier series and convolution theorem. Fourier transformations and its applications to wave theory.
Coordinate Systems: Curvilinear coordinates, Differential vector operators in curvilinear coordinates, Spherical and cylindrical coordinate systems, General coordinate transformation. Tensors: covariant, contravariant and mixed, Algebraic operations on tensors, Illustrative applications.

UNIT-II

Differential Equations: Second order differential equations, Frobenius method, Wronskian and a second solution, the Sturm Lioville problem, One dimensional Greens function.
Special functions: Gamma function, The exponential integral and related functions, Bessel functions of the first and second kind. Legendre polynomials associated Legendre polynomials and spherical harmonics, Generating functions for Bessel, Legendre and associated Legendre polynomials.

UNIT-III

Complex Analysis: The Cauchy-Riemann conditions, Cauchy integral theorem, Cauchy integral formula. Taylor and Laurent series, singularities and residues, Cauchy residue theorem, Calculation of real integrals.

UNIT-IV

Group Theory: Definition of a group, multiplication table, conjugate elements and classes of groups, direct product, Isomorphism, homeomorphism, permutation group, Definitions of the three dimensional rotation group and SU(2).

Text and Reference Books:

S.No.	**Name**	**Author(S)**	**Publisher**
1	Mathematical Methods for Physicists	George Arfken	New York Academy, 1970.
2	Advanced Mathematical Methods for Engg. and Science Students	George Stephenson and P.M. Radmore	Cambridge Uni Press, 1990
3	Applied Mathematics for Engineers & Physicists	Harvil and Pipes	Prentice Hall

Course Code	**PHY505**

Course Title	**Classical Mechanics**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	This course will impart the knowledge of Classical Mechanics to students.
Course Outcomes (CO)	**Students will able:** CO1: To understand about the mechanics of system of particles, Lagrangian and Hamiltonian formulations in classical mechanics. CO2: To determine distinct problems related with central force including Kepler's laws of motion. CO3: To understand the idea about Euler's equations of motion of rigid body. CO4: To apply the theories and mathematical equations related to Canonical Transformations.

UNIT-I

Lagrangian Mechanics: Newton's laws of motion, mechanics of a system of particles, constraints, D' Alembert's principle and Lagrange equations of motion. Velocity dependent potentials and dissipation function. Some applications of Lagrangian formulation, Hamilton's principle, derivation of Lagrange equations from Hamilton's principle. Conservation theorems and symmetry properties.

UNIT-II

Central Force Problem: Two body central force problem, reduction to equivalent one body problem, the equation of motion and first integrals, the equivalent one dimensional problem, and classification of orbits. The differential equation for the orbit and integrable power-law potential. The Kepler problem. Scattering in a central force.

UNIT-III

Rigid Body Dynamics: The independent coordinates of a rigid body, orthogonal transformation, Euler's angles. Eulers' theorem on the motion of rigid body, finite and infinitesimal rotations, rate of change of a vector, angular momentum and kinetic energy about a point for a rigid body, the inertia tensor and moment of inertia, Eigen values of the moment inertia tensor and the principal axis transformation. Euler's equations of motion, torque free motion of a rigid body.

UNIT-IV

Canonical Transformations: Legendre transformation and Hamilton equations of motion, cyclic coordinates and conservation theorems, derivation of Hamilton's equations from a variational principle, the principle of least action. The equations of canonical transformation, examples of canonical transformations, Poisson brackets. Equations of motion, infinitesimal canonical transformations and conservation theorems in the Poisson bracket formulation.

Text and Reference Books:

S. No.	Name	Author(S)	Publisher
1	Classical Mechanics	Herbert Goldstein	Narosa Pub. House, New Delhi,
2	Mechanics	L. D. Landau and E. M. Lifshitz	Pergamon Press, Oxford, 1982
3	Classical Mechanics	N. C. Rana and P. S. Joag	Tata Mc Graw Hill, New Delhi,

Course Code	**PHY507**
Course Title	**Computational Techniques**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	The objective of the course is to give student knowledge about different analytical method for solving problem, related to theoretical physics.
Course Outcomes(CO)	**Students will able:** CO1: To learn various example for interpolation, least square fitting and cubic splines. CO2: To learn different numerical methods for solving non-linear and linear system of equations. CO3: To solve the problem related to integration and differentiation numerically. CO4: To learn numerical methods to solve differential equations.

UNIT-I

Interpolation: Interpolation, Newton's formula for forward and backward interpolation, divided differences, Symmetry of divided differences, Newton's general interpolation formula, Lagrange's interpolation formula, Cubic splines, Least square approximation, Interpolation in multidimension.

UNIT-II

Numerical Differentiation and Integration: Derivatives using forward and backward difference formula, Numerical integration, general quadrature formula for equidistant ordinates, Simpson, Weddle and Trapezoidal rules, Monte-Carlo Method, Romberg integration, Gauss quadrature formula, multiple integrals.

UNIT-III

Roots of Equation: Approximate values of roots, Bisection Method, Regula-Falsi Method, Newton-Raphson method, Bairstow method.

Simultaneous Linear Algebraic Equations: Solution of Simultaneous Linear equations, Gauss elimination method, Gauss-Jordon method, Matrix inversion, Iterative methods: Jacobi iteration method, Gauss Seidel iteration method.

UNIT-IV

Ordinary Differential Equation: Euler's method, Modified Euler's method, Runge-Kutta Method, system of coupled first order ordinary differential equations.

Partial differential equations: An elementary idea about numerical solution of partial differential equations using finite difference method.

Text and Reference Books:

S. No.	Name	Author(S)	Publisher
1	Programming with Fortran-77	Ram Kumar	Tata McGraw Hill
2	Programming with Fortran-77	R.S. Dhaliwal	Wiley-Eastern Ltd
3	Numerical Methods for Engineers	Steven C Chapra, Raymond P Canale	Tata McGraw-Hill
4	Numerical Mathematical Analysis	Scarbrough James B	Oxford and IBH Publishing Company

Course Code	**PHY513**
Course Title	**Quantum Mechanics–I**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	To connect the historical development of quantum mechanics with previous knowledge and learn the basic properties of quantum world.
Course Outcomes(CO)	**Students will able:** CO1: To apply different types of ket-bra notations, operators and determine commutation relations in quantum mechanics. CO2: To learn the difference about between Schrodinger and Heisenberg picture. CO3: To learn and apply one dimensional system including step potential, potential barrier on quantum mechanics problem and study their energy eigen states. CO4: To describe the orbital angular momentum and spin angular momentum theory and will be able to calculate CG coefficients. .

UNIT-I

Basic Formulation and quantum Kinematics: Stern Gerlach experiment as a tool to introduce quantum ideas, analogy of two level quantum system with polarisation states of light. Complex linear vector spaces, ket space, bra space and inner product, operators and properties of operators. Eigenkets of an observable, eigenkets as base kets, matrix representations. Measurement of observable, compatible vs. incompatible observable, commutators and uncertainty relations. Change of basis and unitary transformations.Diagonalisation of operators, Position, momentum and translation, momentum as a generator of translations, canonical commutation relations. Wave functions as position representation of ket vectors, Momentum operator in position representation, momentum space wave function.

UNIT-II

Quantum Dynamics: Time evolution operator and Schrodinger equation, special role of the Hamiltonian operator, energy eigen kets, time dependence of expectation values, spin precession. Schrodinger vs. Heisenberg picture, unitary operators, state kets and observable in Schrodinger and Heisenberg pictures, Heisenberg equations of motion, Ehrenfest's theorem.

UNIT-III

One Dimensional System: Potential Step, potential barrier, potential well. Scattering vs. Bounds states. Simple harmonic oscillator, energy eigen states, wave functions and coherent states.

UNIT-IV

Spherical Symmetric Systems and Angular momentum: Schrodinger equation for a spherically symmetric potential. Orbital angular momentum commutation relations. Eigen value problem for $L^2$and L_z , spherical harmonics. Three dimensional harmonic oscillator, three dimensional potential well and the hydrogen atom. Angular momentum algebra, commutation relations. Introduction to the concept of representation of the commutation relations in different dimensions. Eigen vectors and eigen functions of $J^2$and J_z. Addition of angular momentum and C.G. coefficients.

Text and Reference Books:

S. No	Name	Author(S)	Publisher
1	Modern Quantum Mechanics	J.J. Sakurai	Pearson Educaton Pvt. Ltd., New Delhi, 2002
2	Quantum Mechanics	L I Schiff	Tokyo Mc Graw Hill, 1968
3	Feynmann lectures in Physics Vol. III	Addison Wesly, 1975	Prentice Hall

Course Code	**PHY509**
Course Title	**Electronics Lab**
Type of course	Practical
L T P	0 0 4
Credits	2
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	The aim of this course is to impart practical knowledge to the students about combining circuit elements, and have an understanding of how it works.
Course Outcomes(CO)	**Students will able:** CO1: To perform the analysis and design of electrical circuits. CO2: To understand the practical concept behind the design of any electrical designs. CO3: To study the output in different operating modes of different semiconductor devices. CO4: To make mini as well as major projects related to electronics. .

1. To Study the DC characteristics and applications of DIAC.
2. To study the DC characteristics and applications of SCR.
3. To study the DC characteristics and applications of TRIAC.
4. Investigation of the DC characteristics and applications of UJT.
5. Investigation of the DC characteristics of MOSFET.
6. Study of bi-stable, mono-stable and astable multivibrators.
7. Study of Op-Amps and their applications such as an amplifier (inverting, non-inverting), scalar, summer, differentiator and integrator.
8. Study of logic gates using discrete elements and universal gates.
9. Study of encoder, decoder circuit.
10. Study of arithmetic logic unit (ALU) circuit.
11. Study of shift registers.
12. Study of half and full adder circuits.
13. Study of A/D and D/A circuits.
14. Study of pulse width and pulse position modulation.
15. Study of microprocessor 8085 for simple programming: addition, subtraction, multiplication and division

Course Code	**PHY511**
Course Title	**Computer Lab**
Type of course	Practical
L T P	0 0 4
Credits	2
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	The aim of the course is to impart the practical knowledge about implementation of different computational methods for solving physics problems.
Course Outcomes(CO)	**Students will able:** CO1: To gain basic knowledge of programming skills of FORTRAN. CO2: To solve problems using the FORTRAN language. CO3: To demonstrate an understanding of applicability of numerical methods for modeling physical system in physics. CO4: To prepare codes of different numerical methods using FORTRAN

1. **Determination of Roots:**
(a) Bisection Method
(b) Newton Raphson Method
(c) Secant Method
2. **Matrix Manipulation:**
(a) Matrix Multiplication
(b) Determinant
(c) Gauss Elimination
(d) Matrix Inversion
(e) Gauss Jordan
3. **Integration:**
(a) Trapezoidal rule
(b) Simpson 1/3 and Simpson 3/8 rules
(c) Gaussian Quadrature
4. **Differential Equations:**
(a) Euler's method
(b) Runge Kutta Method
5. **Interpolation:**
(a) Forward interpolation,
(b) Backward interpolation
(c) Lagrange's interpolation
6. **Applications**:
(a) Chaotic Dynamics, logistic map
(b) One dimensional Schrodinger Equation
(c) Time period calculation for a potential
(d) Luminous intensity of a perfectly black body vs. temperature

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SEMESTER II

Course Code	**PHY502**
Course Title	**Quantum Mechanics-II**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	To connect the historical development of quantum mechanics with previous knowledge and learn the basic properties of quantum world.
Course Outcomes(CO)	**Students will able:** CO1: To study the importance of perturbation theory to explain Stark effect, fine structure of helium atom, Fermi Golden rule and selection rules for absorption and emission of light. CO2: To apply the approximation methods and scattering theories. CO3: To study the importance of relativistic quantum mechanics compared to non-relativistic quantum mechanics. CO4: To distinguish between identical and non-identical particles and can write the symmetric and antisymmetic wavefunctions.

UNIT-I

Perturbation Theory: First and second order perturbation theory for non-degenerate and degenerate systems. Perturbation of an oscillator and anharmonic oscillator, the variation method, First order time dependent perturbation theory, constant perturbation, Calculation of transition probability per unit time for harmonic perturbation, The Helium atom problem, Stark effect.

UNIT-II

Scattering Theory: Born approximation, extend to higher orders, Validity of Born approximation for a square well potential, Optical theorem, Partial wave analysis, unitarity and phase shifts, Determination of phase shift, applications to hard sphere scattering, Low energy scattering in case of bound states, Resonance scattering.

UNIT-III

Relativistic Quantum Mechanics: Klein Gordon equation. Dirac Equation, Lorentz covariance of Dirac equation, Positive and negative energy solutions of Dirac equation, positrons, Properties of gamma matrices, Parity operator and its action on states, Magnetic moments and spin orbit energy.

UNIT-IV

Identical Particles: Brief introduction to identical particles in quantum mechanics (based on Feynmann Vol.III), symmetrisation postulates, Application to 2-electron systems, Pauli exclusion principle, Bose Einstein and Fermi Dirac Statistics.

Text and Reference Books:

S. No.	Name	Author(S)	Publisher
1	Modern Quantum Mechanics	J.J. Sakurai	Pearson Educaton Pvt. Ltd., New Delhi, 2002
2	Quantum Mechanics	L I Schiff-Tokyo	Mc Graw Hill, 1968
3	Feynmann lectures in Physics Vol. III	Feynman	Addison Wesly, 1975

Course Code	PHY504
Course Title	**Electrodynamics-I**
Type of course	Theory
L T P	4 0 0
Credits	4
Course Prerequisite	B.Sc. with physics as one of major subjects
Course Objective	The objectives of the course are to introduce the student to electrodynamics at a theoretically sophisticated level and develop problem solving skills.
Course Outcomes(CO)	**Students will able:** CO1: To explain fundamentals and applications of various laws in electrostatics. CO2: To explain fundamentals and applications of various laws in magnetostatics. CO3: To solve Maxwell equations in free space and for harmonically varying fields. CO4: To solve Electromagnetic wave equations in conducting as well as in non-conducting media and to gain understanding of the phenomenon of reflection, refraction and polarization.

UNIT-I

Electrostatics: Coulomb's law, Gauss's law, Poisson's equation, Laplace equation. Solution of boundary value problem: Green's function, method of images and calculation of Green's function for the image charge problem in the case of a sphere, Laplace equation, uniqueness theorem, Electrostatics of dielectric media, multipole expansion, Boundary value problems in dielectrics, molecular polarisability, electrostatic energy in dielectric media.

UNIT-II

Magnetostatics: Biot and Savart's law, The differential equation of Magnetostatics and Ampere's law, vector potential and magnetic fields of a localised current distribution, Magnetic moment, force and torque on a magnetic dipole in an external field, Magnetic materials, Magnetisation and microscopic equations.

UNIT-III

Time-varying fields: Time varying fields, Maxwell's equations, conservation laws: Faraday's law of induction, Energy in a magnetic field. Maxwell's displacement current, vector and scalar potential, Gauge transformations; Lorentz gauge and Coulomb gauge. Poynting theorem, conservation laws for a system of charged particles and electromagnetic field, continuity equation.

UNIT-IV

Electromagnetic Waves: Plane wave like solutions of the Maxwell equations. Polarisation, linear and circular polarisation. Superposition of waves in one dimension. Group velocity. Illustration of propagation of a pulse in dispersive medium. Reflection and refraction of electromagnetic waves at a plane surface between dielectrics. Polarisation by reflection and total internal reflection. Waves in conductive medium, Simple model for conductivity.

Text and Reference Books:

S. No.	Name	Author(S)	Publisher
1	Classical Electrodynamics	J.D. Jackson	John &Wiley Sons Pvt. Ltd. New York, 2004
2	Introduction to Electrodynamics	D.J. Griffiths	Pearson Education Ltd., New Delhi
3	Classical Electromagnetic Radiation	J.B. Marion	Academic Press, New Delhi, 1995.

Course Code	**PHY506**
Course Title	**Condensed Matter Physics-I**
Type Course	Theory
L T P	4 0 0
Credits	4
Course Prerequisite	B.Sc. with physics as one of major subjects
Course Objective	The main objectives of the course is to provide understanding of the enormously rich behavior of condensed matter systems under a wide variety of conditions.
Course Outcomes(CO)	**Students will able:** CO1: To understand the fundamental of magnetic materials, phenomena of dia, para and ferromagnetism and their properties. CO2: To gain understanding of ferroelectrics materials, transition temperatures and their potential application and the behavior of materials below a certain temperature (superconducting materials). CO3: To describe the detail of existing defects and their role in diffusion process. CO4: To gain understanding of the lattice vibration and concept of phonons in crystal structure. .

UNIT-I

Dia-Para and Ferromagnetism: Classification of magnetic materials, the origin of permanent magnetic dipoles, diamagnetic susceptibility, classical theory of para magnetism, Quantum theory of paramagnetism, Quenching of orbital angular momentum, cooling by adiabatic demagnetization. Paramagnetic susceptibility of conduction electrons. Ferromagnetism, the Weiss molecular field, theinterpretation of the Weiss field. Ferromagnetic domains, Spin waves, quantization of spin waves, Thermal excitations of magnons.

UNIT-II

Antiferro-Ferrimagnetism and Superconductivity: The two sub-lattice model, super exchange interaction, the structure of ferrites,saturation magnetisation, Neel's theory of ferrimagnetism, Curie temperature and susceptibility of ferrimagnets. Superconductivity, zero resistivity, critical temperature, Meissner effect, Type I and Type II superconductors, specific heat and thermal conductivity, BCS theory, Ginzsburg-Landou theory, Josephson effect: dc Josephson effect, ac Josephson effect, macroscopic quantum interference, high temperature superconductivity.

UNIT-III

Defects and Diffusion in Solids: Point defects: Impurities, Vacancies- Schottky and Frankel vacancies, Color centers and coloration of crystals, F-centres, Line defects (dislocations), Edge and screw dislocations, Berger Vector, Planar (stacking) Faults, Grain boundaries, Low angle grain boundaries, the Hydration energy of ions, Activation energy for formation of defects in ionic crystals, Ionic conductivity in pure alkali halides.

UNIT-IV

Lattice Vibrations and Phonons: Vibrations of one dimensional linear monoatomic lattice, Normal modes of vibrations in a finite length of the lattice, The linear diatomic lattice, Excitation of optical branch in ionic crystals – the infra red absorption, Quantization of lattice vibrations – concept of phonons, Phonon momentum, In elastic scattering of photons by phonons, Inelastic scattering of neutrons by phonons.

Text and Reference Books:

S.No.	Name	Author(S)	Publisher
1	An Introduction to Solid State Physics	C. Kittel	Wiely Estem Ltd., New Delhi, 1979
2	Solid State Physics	A.J. Dekkar	Maemillan India Ltd., New Delhi, 2004
3	Principles of Solid State Physics	R.A. Levy	New York Academy, 196

Course Code	**PHY508**
Course Title	**Atomic and Molecular Spectroscopy**
Type of Course	Theory
L T P	4 0 0
Credits	4
Course Prerequisite	B.Sc. with physics as one of major subjects
Course Objectives	To learn the atomic and molecular structure, understand the different Spectroscopic techniques and its application.
Course Outcomes(CO)	**Students will able:** CO1: To describe the atomic spectra of one and two valence electron atoms. CO2: To explain the change in behavior of atoms in external applied electric and magnetic field. CO3: To apply their knowledge of quantum mechanical concepts to describe atomic and molecular spectra in details. CO4: To understand the importance and practical application of spectroscopy in modern research. .

UNIT-I

Spectra of one and two valence electron systems: Magnetic dipole moments; Larmor's theorem; Space quantization of orbital, spin and total angular momenta; Vector model for one and two valence electron atoms; Spin-orbit interaction and fine structure of hydrogen, Lamb shift, Spectroscopic terminology; Spectroscopic notations for L-S and J-J couplings; Spectra of alkali and alkaline earth metals; Interaction energy in L-S and J-J coupling for two electron systems; Selection and Intensity rules for doublets and triplets.

UNIT-II

Breadth of spectral line and effects of external fields: The Doppler effect; Natural breadth from classical theory; natural breadth and quantum mechanics; External effects like collision damping, asymmetry and pressure shift and stark broadening; The Zeeman Effect for two electron systems; Intensity rules for the Zeeman effect;The calculations of Zeeman patterns; Paschen-Back effect; LS coupling and Paschen –Back effect; Lande's factor in LS coupling; Stark effect.

UNIT-III

Microwave and Infra-Red Spectroscopy: Types of molecules, Rotational spectra of diatomic molecules as a rigid and non-rigid rotator, Intensity of rotational lines, Effect of isotopic substitution, Microwave spectrum of polyatomic molecules, Microwave oven, The vibrating diatomic molecule as a simple harmonic and anharmonic oscillator, Diatomic vibrating rotator, The vibration-rotation spectrum of carbon monoxide, The interaction of rotation and vibrations, Outline of technique and instrumentation, Fourier transform spectroscopy.

UNIT-IV

Raman and Electronic Spectroscopy: Quantum and classical theories of Raman Effect, Pure rotational Raman spectra for linear and polyatomic molecules, Vibrational Raman spectra, Structure determination from Raman and infra-red spectroscopy, Electronic structure of diatomic molecule, Electronic spectra of diatomic molecules, Born Oppenheimer approximation-The Franck-Condon principle, Dissociation and pre-dissociation energy, The Fortrat diagram, example of spectrum of molecular hydrogen.

Text and Reference Books:

S.No.	**Name**	**Author(S)**	**Publisher**
1	Fundamentals of Molecular spectroscopy	C.N. Banwell and Elaine M. McCash	Tata Mc Graw Hill, 1986
2	Spectroscopy Vol. I, II & III	Walker & Straughe	Springer

Course Code	**CHM520**
Course Title	**Medicinal Chemistry**
Type of Course	Theory
L T P	4 0 0
Credits	4
Course Prerequisite	B.Sc. with physics as one of major subjects
Course Objectives	This course will equip students with the necessary medicinal chemistry knowledge concerning the fundamentals in the basic areas of pharmaceutical sciences.
Course outcomes (CO)	**Students will able:** CO1: To focus on the application of chemistry to clinical medicine. CO2: To gain a broad and fundamental understanding of chemistry while developing particular expertise in medical applications. CO3: To gain knowledge with reference to working of various diagnostic tools, medical imaging techniques, therapeutic technique and radiation safety practices. CO4: To understand relevant chemical reactions/synthetic pathways for selected drugs.

UNIT-I

Basic considerations: Proximity effects and molecular adaptation. Introduction and historical prospective, chemical and biological catalysis, remarkable properties of enzymes like catalytic power, specificity and regulation. Nomenclature and classification, extraction and purification. Fischer's lock and key and koshland's induced fit hypothesis, concept and identification of active site by the use of inhibitors, affinity labelling and enzyme modification by site-directed mutagenesis. Enzyme kinetics, Michaelis-menten and lineweaver-Burk plots, reversible and irreversible inhibition. Mechanism of Enzyme Action Transition-state theory, orientation and steric effect, acid-base catalysis, covalent catalysis, strain or distortion. Examples of some typical enzyme mechanisms for chymotrypsin, ribonucleases, lysozyme and carboxypeptidase A.

UNIT-II

Nucleophilic reactions: Nucleophilic displacement on a phosphorus atom, multiple displacement reaction and the coupling of ATP cleavage to endergonic processes. Transfer of sulphates, addition and elimination reactions, enolic intermediates in isomerization reactions, β-cleavage and condensation, some isomerisation and rearrangement reactions. Enzyme catalyzed carboxylation and decarboxylation.

UNIT-III

Cofactors: Cofactors as derived from vitamins, coenzymes, prosthetic groups, apoenzymes. Structure and biological function of coenzyme A, thiamine pyrophosphate, pyridoxal phosphate, NAD+, NADP+, FMN, FAD, LIPOIC ACID, vitamin B12. Mechanisms of reactions catalysed by the above cofactors.

UNIT-IV

Development of new drugs: procedures followed in drug design, concepts of lead compound and lead modification, concepts of prodrugs and soft drugs, structure-activity relationship (SAP), factors affecting bioactivity, resonance, inductive effect, isosterism, bio-isosterism, spatial considerations. Theories of drug activity: occupancy theory, rate theory, induced fit theory. Quantitative structure activity relationship. History and development of QSAR. Concepts of drug receptors. Elementary treatment of drug receptors interactions. Physico-chemical parameters: lipophilicity, partition coefficient, electronic ionization constants, steric, Shelton and surface activity parameters and redox potentials. LD-50, ED-50 (Mathematical equations excluded)

Text and Reference Books:

S.No.	**Name**	**Author(S)**	**Publisher**
1	Principles of Biochemistry	WH-Freeman	Lehninger, 5th edition
2	The organic chemistry of drug design and drug action	R. B.Silverman,	Academic press 2nd edition, 2004.
3	An introduction to drug design	S. S. Pandeya and , J.R.Dimmock	New Age International.

Course Code	**PHY520**
Course Title	**MATLAB**
Type of Course	Theory
L T P	2 0 0
Credits	2
Course Prerequisite	B.Sc. with physics as one of major subjects
Course Objectives	The objective of this course is to teach the basics of MATLAB. For the purpose of learning programming skill Numerical problems with quantum mechanics are included.
Course outcomes (CO)	**Students will able:** CO1: To understand the main features of the MATLAB development environment. CO2: To design simple algorithms to solve problems. CO3: To learn the basics of graphics and data analysis in MATLAB. CO4: To learn basics of plotting functions in MATLAB.

UNIT-I

Basic Operations of Matlab: The Desktop Layout, Syntax, and Operations, Variable names, Operator and delimiter symbolic, Multiple operations, Displaying content of multi-element variables, Importing and Exporting Information, Command Line Import, Import Functions, M-file Scripts, Export Functions.

UNIT-II

Computing and Programming: Computational Procedures: Special Built-in Constants and Functions, Computing with matrices and vectors, Simultaneous linear equations, Eigenvectors and Eigenvalues Programming: Using the Editor, Types and Structures of M-files, Passing variables by name and value, Function evaluation and function handles, Flow control: if, else, and elseif, for, while, switch and case, break, return, nested loops, Sorting and Searching.

UNIT-III

Graphics and Data Analysis: Graphics and Data Visualization, Two dimensional plotting, Sub plotting Patching and Filling, Three dimensional plotting, The Handle Graphics system, saving and exporting graphics.

UNIT-IV

Basic Plotting functions: Creating a plot, multiple data set in one graph, specifying line styles and colors, plotting line and markers, imaginary and complex data, Adding plots to an existing graph, Figure windows, multiple plot in one figure, controlling the axes, axes label and titles, saving figures.

Text and Reference Books:

S.No.	Name	Authors	Publisher
1	MATLAB Programming for Engineers, 4th Edition	S. Chapman	Cengage Learning, Engineering, 1120 Birchmount Rd, Toronto, ON, M1K5G4, Canada. 2008.
2	Advanced engineering mathematics with MATLAB	A.H. Register	Boca Raton, FL: CRC Press, 2003
3	Practical MATALB applications for engineers	M. Kalechman	Boca Raton, FL: CRC Press, 2009.

Course Code	**PHY522**
Course Title	**MATLAB Practical**
Type of Course	Theory
L T P	0 0 4
Credits	2
Course Prerequisite	B.Sc. with physics as one of major subjects
Course Objectives	The objective of this course is to teach the basics of MATLAB. For the purpose of learning programming skill Numerical problems in quantum mechanics.
Course outcomes (CO)	**Students will able:** CO1: To design simple algorithms to solve problems. CO2: To write simple programs in MATLAB for solving scientific and mathematical problems. CO3: To carry out simple numerical computations and analyses using MATLAB. CO4: To write basic mathematical, quantum mechanical problems in MATLAB.

Working with the various practical examples:

1. Addition of numbers
2. Division of matrices
3. Finding inverse of matrices
4. Generate random numbers
5. Writing differential operators as matrix
6. Construction of wavepacket
7. Eigen functions and energy eigen values of free particle
8. Eigen functions and eigen energies of one-dimensional Schrödinger equation for arbitrary potentials
9. Probability density for particle in double well potential
10. Time dependent Schrodinger equation in one dimension: Reflection at a potential cliff
11. Time dependent Schrodinger equation in two-dimensions: Reflection at a potential barrier.

Text and Reference Books:

S.No.	Name	Authors	Publisher
1	MATLAB Programming for Engineers, 4th Edition	S. Chapman	Cengage Learning, Engineering, Canada. 2008.
2	Advanced engineering mathematics with MATLAB	A.H. Register	Boca Raton, FL: CRC Press, 2003
3	Practical MATALB applications for engineers	M. Kalechman	Boca Raton, FL: CRC Press, 2009.

Course Code	**PHY540**
Course Title	**Research Methodology &Intellectual Property Rights**
Type of course	Theory
L T P	2 0 0
Credits	2
Course prerequisite	B. Sc. Medical or Non-medical
Course Objective	To acquaint the students about the research& different types of property rights that a person possesses.
Course outcomes (CO)	**Students will able:** CO1: To identify a research problem. CO2: To understand importance of educational research, interpret the results and report writing. CO3: To describe the role of Intellectual Property Rights (IPR) in research and development. CO4: To understand the different types and laws of Intellectual Property Rights (IPR).

UNITI

Research Methodology: Types and method of research, Research process; criteria of good research. Defining and formulating the research problem, selecting the problem, necessity of defining the problem, importance of literature review in defining a problem, Meaning of research design; need for research design; important concepts related to research design; different research designs. Writing research proposal: Characteristics of a proposal; content and organization of a proposal.

UNIT II

Interpretation and report writing: Meaning of interpretation; technique of interpretation; precautions in interpretation; significance of report writing; layout of research report; types of reports; Organization and writing of research paper, Presentation of research work-oral, poster and writing of research paper; Precautions for writing research report, Application and uses of common softwares in chemistry and physics.

UNIT III

IPR: Introduction and the need for intellectual property right (IPR) - Kinds of Intellectual Property Rights: Copyright, protection under copyright law, rights, transfer of copyright, infringement,

Trademarks its objectives, types, rights, protection of goodwill, infringement, passing off, Defenses, Domain name, trade secrets. Design, Geographical Indication.

Introduction to the leading International Instruments concerning Intellectual Property Rights: the Berne Convention, Universal Copyright Convention, The Paris Convention, Patent Co-operation Treaty, TRIPS, The World Intellectual Property Organization (WIPO) and the UNESCO. Infringement. IPR in Pharmaceuticals and drug designing

UNIT IV

Ethical issues: Citation and acknowledgement, Reproducibility, Review of published research in the relevant field, plagiarism.

Patent and Patents Writing, Patent Act 1970 and its amendments. Procedure of obtaining patents, Chemical safety and ethical handling of chemicals. Safety rules of laboratory acquaintance of experimental set up, importance of safety and security of data.

Industrial Designs its objectives, rights, registration, infringements, and Defenses of Design, Need for Protection of Industrial Designs, The Designs Act, 2000

Text and Reference books:

S.No.	**Name/Title**	**Author**	**Publisher**
1	Research Methodology: Methods & Techniques (Rev. Ed.)	C.R. Kothari	New Age International. New Delhi
2	An Introduction to Research Methodology	B.L. Garg, R. Karadia, R., F. Agarwal, F. and U.K. Agarwal	RBSA Publishers
3	Qualitative Inquiry and Research Design: Choosing Among Five Approaches	John W. Creswell	SAGE Publication
4	Principles of Intellectual Property	N.S. Gopalakrishnan, and T.G. Agitha	Eastern Book Company
5	Law relating to patents, trade marks, copyright designs and geographical indications	B.L.Wadehra	Universal Law Publishing
6	An Introduction to Intellectual Property Rights	Venkataraman M	Affliated East-West Press

Course Code	**PHY510**
Course Title	**Condensed Matter Lab-I**
Type of course	Practical
L T P	0 0 4
Credits	2
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	The course is to impart practical knowledge to the students about the measurement of different physical properties (electric, magnetic, dielectrics etc.) using different methods.
Course Outcomes (CO)	**Students will able:** CO1: To study the band gap, magneto resistance, resistivity and charge carrier concentration in semiconductors. CO2: To know how to determine the crystal structure, lattice parameter and crystallite size? CO3: To understand measurement and analysis of various types of transport. CO4: To explain optical characterization of solid, magnetic and dielectric behavior of solids.

1. To determine Hall coefficient by Hall Effect.
2. To determine the band gap of a semiconductor using p-n junction diode..
3. To determine the magnetic susceptibility of a material using Quink's method.
4. To determine the g-factor using ESR spectrometer.
5. To determine the energy gap and resistivity of the semiconductor using four probe method.
6. To trace hysteresis loop and calculate retentivity, coercivity and saturation magnetization.
7. To determine dielectric constant.
8. To study the series and parallel characteristics of a photovoltaic cell.
9. To study the spectral characteristics of a photovoltaic cell.

Course Code	**PHY512**
Course Title	**Atomic and molecular spectroscopy lab**
Type of course	Practical
L T P	0 0 4
Credits	2
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	The purpose of this lab is to understand of atomic structure and its relation to the production of light.
Course Outcomes (CO)	**Students will able:** CO1: To study the spectroscopic behavior of materials. CO2: To understand nature of atomic energy levels. CO3: To gain understanding of the wave nature of light along with the measurement of the wavelength of the light. CO4: To learn the impact of the external magnetic field on the atomic energy levels.

1. To find the wavelength of monochromatic light using Fabry Perot interferometer.
2. To find the wavelength of sodium light using Michelson interferometer.
3. To calibrate the constant deviation spectrometer with white light and to find the wavelength of unknown monochromatic light.
4. To find the grating element of the given grating using He-Ne laser light.
5. To find the wavelength of He-Ne laser using Vernier calipers.
6. To verify the existence of Bohr's energy levels with Frank-Hertz experiment.
7. To determine the charge to mass ratio (e/m) of an electron with normal Zeeman Effect.
8. To determine the velocity of ultrasonic waves in a liquid using ultrasonic interferometer.

SEMESTER III

Course Code	**PHY601**
Course Title	**Statistical Mechanics**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	The objective of this course is the evaluation of the laws of classical thermodynamics for macroscopic systems using the properties of its atomic particles.
Course Outcomes (CO)	**Students will able:** CO1: To identify the link between statistics and thermodynamics, classical and quantum statistics and its applications. CO2: To describe the fundamentals of classical statistical mechanics and learn about phase space, various ensembles and their application in some cases. CO3: To learn about the quantum mechanical theory of statistics and its application in various important cases of Bosons and Fermions. CO4: To understand the behaviour of ideal Bose and Fermi gases.

UNIT-I

Classical Stat. Mech. I: Foundation of statistical mechanics; specification of states in a system, contact between statistics and thermodynamics, the classical ideal state, the entropy of mixing Gibbs paradox, The phase space of classical systems, Liouville's theorem and its consequences.

UNIT-II

Classical Stat. Mech. II: The microcanonical ensemble with examples. The canonical ensemble and its thermodynamics, partition function, classical ideal gas in canonical ensemble theory, energy fluctuations in the canonical ensemble. A system of harmonic oscillators. The statistics of paramagnetism. The grand canonononical ensemble, the physical significance of the statistical quantities, examples, fluctuation of energy and density. Cluster expansion of classical gas, the virial equation of state.

UNIT-III

Quantum Stat. Mech.I : Quantum states and phase space, the density matrix, statistics of various ensembles. Example of electrons in a magnetic field, a free particle in a box and a linear harmonic oscillator. Significance of Boltzmann formula in classical and quantum statistical mechanics.

UNIT-IV

Quantum Stat. Mech. II: An ideal gas in quantum mechanical microcanonical ensemble. Statistics of occupation numbers, concepts and thermodynamical behavior of an ideal gas. Bose

Einstein condensation, Discussion of a gas of photons and phonons, Thermodynamical behavior of an ideal Fermi gas, electron gas in metals, Pauli paramagnetism, and statistical equilibrium of white dwarf stars.

Text and Reference Books:

S. No	**Name**	**Author(S)**	**Publisher**
1	Statistical Mechanics	R.K. Patharia	Butten Worth Heinemann, 1996
2	Statistical and Thermal Physics	F. Reif	Mc-Graw Hill, 1965
3	Statistical Mechanics	Kerson Huang	Wiley, 1963

Course Code	**PHY603**
Course Title	**Electrodynamics-II**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	The objectives of the course are (i) to introduce the student to electrodynamics at a theoretically sophisticated level; (ii) develop problem solving skills; (iii) develop the techniques of mathematical physics to solve problems in E&M as well as other areas of physics
Course Outcomes (CO)	**Students will able:** CO1: To understand the concept of different wave guides. CO2: To understand relativistic formulation of electrodynamics. CO3: To study the radiation field systems in electrodynamics. CO4: To learn the concept of field of moving charges.

UNIT-I

Wave Guides: Field at the surface of and within a conductor. Cylindrical cavities and wave-guides, modes in a rectangular wave guide, energy flow and attenuation in wave guides. Perturbation of boundary conditions, resonant cavities, power loss in cavity and quality factor.

UNIT-II

Relativistic formulation of electrodynamics: Special theory or relativity, simultaneity, length, contraction, time dilation and Lorenz's transformations. Structure of space-time, four scalars, four vectors and tensors, relativistic mechanics. Relativistic electrodynamics. Magnetism as a relativistic phenomena and field transformations. Recasting Maxwell equations in the language of special relativity, covariance and manifest covariance, field tensor. Lagrangian formulation for the covariant Maxwell equations.

UNIT-III

Radiation Systems: Fields of radiation of localized oscillating sources, electric dipole fields and radiation, magnetic dipole and electric quadrupole fields, central fed antenna, brief introduction to radiation damping and radiation reaction.

UNIT-IV

Fields of moving charges: Lienard Wiechert potential, field of a moving charge. Radiated power from an accelerated charge at low velocities, Larmour's power formula and its relativistic generalisation ; Angular distribution of radiation emitted by an accelerated charge.

Text and Reference Books:

S. No	Name	Author(S)	Publisher
1	Classical Electrodynamics	J.D. Jackson	Wiley, 1967
2	Electricity and Magnetics	D.J. Griffiths	Prentice hall, 1996
3	Classical Electromagnetic Radiation	J.B. Marian	Academic Press, 1965

Course Code	**PHY605**
Course Title	**Condensed Matter Physics-II**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	The objectives are to provide understanding of the enormously rich behaviour of condensed matter systems under a wide variety of conditions.
Course Outcomes (CO)	**Students will able:** CO1: To explain the thermal properties in solid and the elastic behavior under stress and elastic constants. CO2: To understand the concept of conductivity of metals and luminescence in detail. CO3: To distinguish between plasmons & polaritons and can study the concept of optical properties. CO4: To understand the theory of dielectrics and ferro-electrics.

UNIT-I

Lattice Specific Heat and Elastic Constants: The various theories of lattice specific heat of solids. Einstein model of the Lattice Specific heat. Density of modes of vibration, Debye model of Lattice specific heat, Born cut-off procedure, specific heat of metals, Elastic strain and stress component. Elastic compliance and stiffness constants. Elastic constants of cubic crystals. Elastic waves in cubic crystals.

UNIT-II

Free electron theory: Band theory, Electrical conductivity of metals, Drift velocity and relaxation time, the Boltzmann transport equation. The Sommerfield theory of conductivity, Mean free path in metals, qualitative discussion of the features of the resistivity, Mathiesson's rule Luminescence, excitation and emission, Decay mechanisms, Thallium activated alkali halides. The Sulphide phosphors. Electro Luminescene.

UNIT-III

Plasmons, Polaritons and Opticals Properties: Dielectric function of the electron gas, plasma optics, transverse and longitudinal modes in plasma, plasmons. Electrostatic screening, polaritons and LST relations, Electron- phonon interaction, polarons, Kramer-Kroning relations, Conductivity of collissionless electrons.

UNIT-IV

Dielectrics and Ferro Electrics: Macroscopic field, The local field, Lorentz field. The Claussius-Mossotti relations, Different contribution to polarization: dipolar, electronic and ionic polarizabilities, General properties of ferroelectric materials. The dipole theory of ferroelectricity, objection against dipole theory, Thermodynamics of ferroelectric transitions.

Text and Reference Books:

S. No	Name	Author(S)	Publisher
1	An Introduction to Solid State Physics	C. Kittle-Wiley, 1958	Wiley, 1958
2	Solid State Physics	A.J. Dekker	Prentice Hall, 1965
3	Principles of Solid State Physics	R.A. Levey	Academic Press, 1968

Course Code	**PHY607**
Course Title	**Nuclear Physics**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	The objective of this course is to introduce students to the fundamental principles and concepts governing nuclear and particle physics and have a working knowledge of their application to real-life problems.
Course Outcomes (CO)	**Students will able:** CO1: To understand the role of nuclear forces, strong interactions & nuclear properties. CO2: To get knowledge about the hyperfine structure & nuclear model. CO3: To learn about the radioactive decays like α-particle emission, beta decays , gamma decay, Angular momentum and parity selection rules, Internal conversion, Nuclear isomerism. CO4: To learn about the nuclear reactions and their properties like Compound nuclear-scattering matrix, Resonance scattering.

UNIT-I

Nuclear Interactions and Nuclear Reactions Nuclear Forces: Two nuclear system, deuteron problem, binding energy, nuclear potential well, pp and pn scattering experiments at low energy, meson theory of nuclear forces, e.g. Bartlett, Heisenberg, Majorans forces and potentials, exchanges forces and tensor forces, effective range theory-spin dependence of nuclear forces-Charge independence and charge symmetry of nuclear forces-Isospin formalism- Yukawa interaction.

UNIT-II

Nuclear Models: Liquid drop model, Bohr-Wheeler theory of fission, Experimental evidence for shell effects, Shell Model, Spin-Orbit coupling, Magic-Applications of Shell model like Angular momenta and parities of nuclear ground states, Quantitative discussion and estimates of transition rates-magnetic moments and Schmidt lines, Collective model, Nuclear vibrations spectra and rotational spectra, applications, Nilsson model.

UNIT-III

Nuclear Decay: Beta decay, Fermi theory of beta decay, shape of the beta spectrum, Total decay rate, Angular momentum and parity selection rules, Comparative half-lives, Allowed and forbidden transitions, selection rules, parity violation, Two component theory of neutrino decay, Detection and properties of neutrino, Gamma decay, Multipole transitions in nuclei, Angular momentum and parity selection rules, Internal conversion, Nuclear isomerism.

UNIT-IV

Nuclear Reactions: Direct and compound nuclear reaction mechanisms, cross sections in terms of partial wave amplitudes, Compound nucleus, scattering matrix, Reciprocity theorem, Breit Winger one level formula, Resonance scattering.

Text and Reference Books:

S. No	Name	Author(S)	Publisher
1	Nuclear Structure, Vol.1(1969) and Vol.2	A. Bohr and B.R. Mottelson	Pearson
2	Introductory Nuclear Physics	Kenneth S. Krane	Wiley, New York, 1988
3	Atomic and Nuclear Physics Vol.2	G.N. Ghoshal	S. Chand and Co., 1997

Course Code	**PHY613**
Course Title	**Experimental Techniques**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	The objective of this course is to: introduce students to the basic experimental techniques used for the material characterization.
Course Outcomes (CO)	**Students will able:** CO1: To explain the working principles of the various Vaccum techniques. CO2: To understand the techniques involved in the fabrication of thin films. CO3: To understand the different techniques for the analysis of structure, surface of nanomaterials. CO4: To understand the working principle of different microscopy (SPM, SEM, TEM,STM, AFM etc).

UNIT-I

Vacuum techniques: Basic idea of gas throughput, conductance, mass flow, viscous and molecular flow regimes, transition regime conductance, pumping speed, Production of Vacuum; Basic idea pumping system, Physical Vapor Deposition; Hertz Knudsen equation, mass evaporation rate, Directional distribution of evaporating species, Evaporation of elements, compounds, alloys, e-beam, pulsed laser and ion beam evaporation, Glow Discharge and Plasma.

UNIT-II

Sputtering: mechanisms and yield, DC and RF sputtering, Nucleation & Growth: capillarity theory, atomistic and kinetic models of nucleation, basic modes of thin film growth, stages of film growth & mechanisms, Electrical, optical and mechanical methods for determination of the thickness of thin films.

UNIT-III

Techniques for the analysis of surfaces: AES, XPS/ESCA techniques for the analysis of surfaces, X-ray diffraction, data manipulation of diffracted X-rays for structure determination, XAS (X-ray absorption Spectroscopy), XAFS and EXAFS (X-ray Absorption Fine Structure and Extended X-ray Absorption Fine Structure)

UNIT-IV

Microscopy& Error analysis: Scanning Probe Microscopy, Scanning electron microscopy, Transmission electron microscopy, Scanning-tunneling microscopy, Electron probe-microanalysis , Atomic force microscopy, Optical microscopy, Error analysis; Least square fitting, Chi square test, Normal and Poisson distribution, propagation of errors, Plotting of graphs.

Text and Reference Books:

S. No	Name	Author(S)	Publisher
1	Vacuum Technology	A.Roth	Oxford: press Ltd., 1998
2	A User’s Guide to Vacuum Technology	J.F. O’Hanlon	John Wiley & Sons, 1989
3	Thin film phenomena	K.L. Chopra	McGraw Hill Inc, 1969
4	The material science of thin films	M. Ohring	Academic Press, 1992

Course Code	**PHY615**
Course Title	**Physics of Nanomaterials**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	The objective of this course is to: introduce students to the basic concepts of Nano technology and latest advance in it.
Course Outcomes (CO)	**Students will able:** CO1: To develop fundamental knowledge of nanomaterials. CO2: To correlate the properties of nano structures with their size, shape and surface characteristics. CO3: To explain the effects of quantum confinement on the electronic structure & corresponding physical and chemical properties of materials at nanoscale. CO4: To understand the physics of carbon nano tubes involving their synthesis and applications in different areas.

UNIT-I

Free electron theory and its features: Idea of band structure of 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. Top-down and bottom-up approaches, Physical and chemical methods for the synthesis of nanomaterials with examples.

UNIT-II

Determination of particle size: Determination of particle size and study of texture and microstructure, Increase in x-ray diffraction peaks of nanoparticles, shift in photoluminescence peaks, variation in Raman spectra of nanomaterials, photoemission and X-ray spectroscopy, magnetic resonance, microscopy: transmission electron microscopy, scanning probe microscopy.

UNIT-III

Introduction to quantum wells wires and dots: preparation using lithography; Size and dimensionality effects: size effects, conduction electrons and dimensionality, potential wells, partial confinement, properties dependent on density of states, surface passivation and core/shell nanoparticles, Nanostructured semiconductors and films, single electron tunneling; Application: Infrared detectors, Quantum dot Lasers.

UNIT-IV

Carbon molecules: nature of carbon bond; new carbon structures; Carbon clusters: small carbon clusters, structure of C60, alkali doped C60; Carbon nanotubes and nanofibres: fabrication, structure, electrical properties, vibrational properties, mechanical properties, Application of carbon nanotubes: field emission and shielding, fuel cells, chemical sensors, catalysis.

Text and Reference Books:

S. No	Name	Author(S)	Publisher
1	Introduction to Nanotechnology	Charles P. Poole Jr. and Franks J. Qwens	John Wiley & Sons, 2006
2	Quantum Dot Heterostructures	D. Bimerg, M. Grundmann and N.N. Ledentsov	John Wiley & Sons, 1989
3	Physics of Semiconductor Nanostructures.	K.P. Jain (Narosa),	Wiley, 1997

Course Code	**PHY617**
Course Title	**Nonlinear and Fiber Optics**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	The objective of the course to equip the students with knowledge of basics of nonlinear optics, various nonlinear phenomena, multiphoton processes, nonlinear optical materials and fiber optics.
Course Outcomes (CO)	**Students will able:** CO1: To explain the wave propagation an anistropic crystal and polarization respose of materials to light. CO2: To understand the theory and experiments involved in optics. CO3: To explain the use of organic and inorganic materials, X- ray diffraction ,FTIR, FT-NMR in qualitative study. CO4: To understand the applications of optical fibres, optical sensors and its classifications.

UNIT-I

Introduction: frequency dependent and intensity dependent refractive index, Wave propagation in an anisotropic crystal, Polarization response of materials to light, Second harmonic generation, Sum and difference frequency generation, Phase matching, four wave mixing, Third harmonic generation, Self focusing, Parametric amplification, Bistability.

UNIT-II

Two photon process: Theory and experiment, Three photon process parametric generation of light, Oscillator, Amplifier, Stimulated Raman scattering, Intensity dependent refractive index optical Kerr effect, photorefractive, electron optic effects.

UNIT-III

Basic requirements: Inorganics, Borates, Organics, Urea, Nitro aniline, Semi organics, Thio urea complex, X-ray diffraction, FTIR and FT-NMR qualitative study, Kurtz test, Laser induced surface damage threshold.

UNIT-IV

Introduction to Optical fibers: Principle, Structure of Optical fibers, Acceptance angle and cone, Numerical aperture and acceptance angle, Fiber modes, Types of optical fibers, Fiber bandwidth, Fabrication of optical fibers, Loss in optical fibers, Fiber optical communication, splicing, Light source for optical fiber, Photo-detectors, Fiber optical sensors and its classification, Fiber endoscope, Attenuation coefficient – Material absorption.

Text and Reference Books:

S. No	Book Name	Author(S)	Publisher
1	Non Linear Optics	Robert W. Boyd	Academic Press New York
2	The principles of nonlinear optics	Y.R. Shen	John Wiley, New York,1984
3	Lasers and nonlinear optics	B.B. Laud	New age international (p) ltd.
4	Fiber-optics communication system	Govind P. Aggarwal	John Wiley& Sons

Course Code	**PHY611**
Course Title	**Nuclear Physics Lab**
Type of course	Practical
L T P	0 0 4
Credits	2
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	Aim of Nuclear Physics Lab is to train the students for advanced techniques in nuclear physics so that they can investigate various relevant aspects and be confident to handle sophisticated instruments of nuclear physics.
Course Outcomes (CO)	**Students will able:** CO1: To provide knowledge about the measurement of radiations using counters, detectors. CO2: To study absorption of radioactive particles in matter using counter, detectors. CO3: To make relevant measurements of energy and decay spectra using basic experimental facilities and apply Poisson statistics. CO4: To investigate the statistics of radioactive measurements.

1. Pulse-Height Analysis of Gamma Ray Spectra.
2. Calibration of Scintillation Spectrometer.
3. Least square fitting of a straight line.
4. Study of absorption of gamma rays in matter.
5. Study of Compton Scattering Effect.
6. To study the characteristics of a G.M. Counter.
7. To determine the Dead time of a G.M. Counter.
8. Absorptions of Beta Particles in Matter.
9. Source strength of a Beta Source.
10. Window thickness of a G.M. Tube.
11. To investigate the statistics of radioactive measurements.
12. Study of Poisson distribution.
13. Study of Gaussian distribution.

Course Code	**PHY629**
Course Title	**Project Part I**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	To carry out basic research in theoretical and experimental Physics.
Course Outcomes (CO)	**Students will able:** CO1: To measure and progress in particular area of subjects. CO2: To frame the background of particular area of the subject. CO3: To study the concern literature of particular field of physics. CO4: To formulate research problem of particular field of physics.

- Project supervisor would be allocated a project to the student at the start of the semester and research project would be undertaken in discussion with the project supervisor.
- Student has to complete the literature review on allocated topic.
- At the end of the semester the student has to prepare a project report as per the university guidelines for this semester.

SEMESTER IV

Course Code	**PHY602**
Course Title	**Particle Physics**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	The objectives of particle physics are to identify a simple object out of which all matter is composed and to understand the forces which cause them to interact and combine to make more complex things.
Course Outcomes (CO)	**Students will able:** CO1: To describe the types of basic interactions and invariance principles. CO2: To apply the concepts and principles/laws on quantum numbers including Parity, Isospin. CO3: To describe the weak interactions including, V-A weak interaction theory and Cabbibo theorem. CO4: To get knowledge of spontaneous breaking of symmetry and Goldstone theorem,Abelian and Non-Abelian gauge fields.

UNIT-I

Elementary Particles and Their Properties: Historical survey of elementary particles and their classification, determination of mass, life time, decay mode, spin and parity of muons,pions, kaons and hyperons. Experimental evidence for two types of neutrinos, production and detection of some important resonances and antiparticles.

UNIT-II

Symmetries and Conservation Laws: Conserved quantities and symmetries, the electric charge, baryon number, leptons and muon number, particles and antiparticles, hypercharge (strangeness), the nucleon isospin, isospin invariance, isospin of particles, parity operation, charge conservation, time reversal invariance, CP violation and CPT theorem, the KO – KO doublet unitary symmetry SU(2), SU (3) and the quark model.

UNIT-III

Weak Interaction: Classification of weak interactions, Fermi theory of beta decay, matrix element, classical experimental tests of Fermi theory, Parity non conservation in beta decay, lepton polarization in beta decay, the V-A interaction, parity violation in P-decay. Weak decays of strange-particles and Cabibbo's theory.

UNIT-IV

Gauge theory and GUT: Gauge symmetry, field equations for scalar (spin 0), spinor (spin ½), vector (spin-1) and fields, global gauge invariance, local gauge invariance, Feynmann rules, introduction of neutral currents. Spontaneously broken symmetries in the field theory, standard model.

Text and Reference Books:

S. No	Name	Author(S)	Publisher
1	Subatomic Physics	H. Fraunfelder and E.M. Henley	N.J. Prentice Hall
2	Introduction to Elementary Particles	D. Griffiths	Wiley-VCH-2008
3	Introduction to High Energy Physics	D.H Perkins	Cambridge University Press, 2000

Course Code	**PHY604**
Course Title	**Radiation Physics**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	Understand the basic physics of the electromagnetic and particulate forms of ionizing radiation. Understand the distinctions between the units of radiation quantity, exposure and dose. Be familiar with some of the methods used to measure radiation dose.
Course Outcomes (CO)	**Students will able:** CO1: To study nuclear radiation and its radiation quantities. CO2: To understand in detail about different dosimeters. CO3: To study nuclear radiation effects and its detection and protection. CO4: To understand about different radiation shielding.

UNIT-I

Ionizing Radiations and Radiation Quantities: Types and sources of ionizing radiation, fluence, energy fluence, kerma, exposure rate and its measurement - The free air chamber and air wall chamber, Absorbed dose and its measurement , Bragg Gray Principle, Radiation dose units(rem, rad, Gray and sievert), dose commitment, dose equivalent and quality factor.

UNIT-II

Dosimeters: Pocket dosimeter, films, solid state dosimeters such as TLD, SSNTD, chemical detectors and neutron detectors. Simple numerical problems on dose estimation.

UNIT-III

Radiation Effects and Protection: Biological effects of radiation at molecular level, acute and delayed effects, stochastic and non-stochastic effects, Relative Biological Effectiveness (RBE), linear energy transformation (LET), Dose response characteristics. Permissible dose to occupational and non-occupational workers, maximum permissible concentration in air and water, safe handling of radioactive materials, The ALARA, ALI and MIRD concepts, single target, multitarget and multihit theories, Rad waste and its disposal, simple numerical problems.

UNIT-IV

Radiation Shielding: Thermal and biological shields, shielding requirement for medical, industrial and accelerator facilities, shielding materials, radiation attenuation calculations-The point kernal technique, radiation attenuation from a uniform plane source. The exponential point-Kernal. Radiation attenuation from a line and plane source.

Text and Reference Books:

S. No	Name	Author(S)	Publisher
1	Nuclear Reactor Engineering	S. Glasstone and A. Sesonke	Van Nostrand Reinhold
2	Radiation Theory	Alison. P. Casart	
3	Radiation Biology	A. Edward Profio	Radiation Bio/Prentice Hall, 1968

Course Code	**PHY606**
Course Title	**Reactor Physics**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	The aim of the subject is to provide the knowledge about nuclear reactors.
Course Outcomes (CO)	**Students will able:** CO1: To understand the interaction of neutron with matter. CO2: To study the detail aspects of moderation of neutrons. CO3: To study homogenous and heterogeneous reactor assemblies. CO4: To get detail information of power reactors.

UNIT-I

Interaction of Neutrons with Matter in Bulk: Thermal neutron diffusion, Transport and diffusion equations, transport mean free path, solution of diffusion equation for a point source in an infinite medium and for an infinite plane source in a finite medium, extrapolation length and diffusion length-the albedo concept.

UNIT-II

Moderation of Neutron: Mechanics of elastic scattering, energy distribution of thermal neutrons, average logarithmic energy decrement, slowing down power and moderating ration of a medium. Slowing down density, slowing down time, Fast neutron diffusion and Fermi age theory, solution of age equation for a point source of fast neutrons in an infinite medium, slowing down length and Fermi age.

UNIT-III

Theory of Homogeneous Bare Thermal and Heterogeneous Natural Uranium Reactors: Neutron cycle and multiplication factor, four factor formula, neutron leakage, typical calculations of critical size and composition in simple cases, The critical equation, material and geometrical buckling, effect of reflector, Advantages and disadvantages of heterogeneous assemblies, various types of reactors with special reference to Indian reactors and a brief discussion of their design feature.

UNIT-IV

Power Reactors Problems of Reactor Control: Breeding ratio, breading gain, doubling time, Fast breeder reactors, dual purpose reactors, concept of fusion reactors, Role of delayed neutrons and reactor period, In hour formula, excess reactivity, temperature effects, fission product poisoning, use of coolants and control rods.

Text and Reference Books:

S. No	Name	Author(S)	Publisher
1	The elements of Nuclear reactor Theory	Gladstone & Edlund	Vam Nostrand, 1952
2	Introductions of Nuclear Engineering	Murray	Prentice Hall, 1961

Course Code	**PHY608**
Course Title	**Physics of Materials**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	To engage the students in advanced education, research, and development in materials science, develops critical reasoning to identify fundamental issues and analytical thinking about research.
Course Outcomes (CO)	**Students will able:** CO1: To understand the vaccum technology involving different vaccum pumps. CO2: To study the basic concepts about the thin film technology. CO3: To know different types & applicationsof Polymer, Ceramics, Liquid Crystals and Nano phase Materials and its characteristics. CO4: To understand various methods involved in material characterization.

UNIT-I

Vacuum Technology: Basic ideas about vacuum, Throughput, Conductance, Vacuum pumps: rotary pump, diffusion pump, ion pump, molecular pump, cryopump.

Vacuum gauges: pirani gauge, penning gauge, ionization gauge (hot cathode ionization gauge, cold cathode ionization gauge).

UNIT-II

Thin Film: Thin Film and growth process, Influence of nature of substrate and growth parameters (substrate temperature, thickness, deposition rate).

Thin film deposition techniques: thermal evaporation, chemical vapor deposition, sprays pyrolysis, sputtering, Epitaxial growth,

Thin-film thickness measurement techniques: film resistance method, optical method, microbalance method.

UNIT-III

Polymers, Ceramics, Liquid Crystals and Nano phase Materials: Characteristics, Application and Processing of polymers: Polymerization, Polymer types, Stress- Strain behavior, melting and glass transition, thermosets and thermoplasts.

Characteristics, Application and Processing of Ceramics, glasses and refractories.

Liquid Crystals: classification and applications, Nano phase materials: synthesis and applications.

UNIT-IV

Characterization of Materials: Powder and single crystal X-ray diffraction, Transmission electron microscopy, Scanning electron microscopy, Low Energy Electron Diffraction (LEED), Auger electron microscopy, Atomic force microscopy.

Course Outcome:

Text and Reference Books:

S. No	Name	Author(S)	Publisher
1	Vacuum Technology	A. Roth	North Holland Pub. Co., 1976
2	Thin Film Phernomeon	K.L. Chopra	R E Kriegn Pub. Co., 1979
3	High Temperature Superconductors	E.S.R. Gopal & SV. Subramanyam-	Wiley, 1989
4	Material Science and Engg.	W.D. Callister	Wiley, 1994

Course Code	**PHY610**
Course Title	**Geophysics**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	To locate or detect the presence of subsurface structures or bodies and determine their configuration (i e size determine their configuration (i.e. size, shape, depth) and physical properties (i.e. physical parameters).
Course Outcomes (CO)	**Students will able:** CO1: To study the overview of the structure and evolution of the Earth as a dynamic planet within our solar system. CO2: To study the Geodynamics and Geochronology of earth surface. CO3: To understand the radioactivity & radioactive contents in different rocks. CO4: To describe different nuclear techniques involved to detect rock density, concentration of radioactive elements in rock.

UNIT-I

Seismology and Interior of the Earth: Origin of earth, shape, size, mass and density of the earth. Theory of seismic waves. The variation of P and S wave velocity, temperature, density, pressure and elastic parameters with depth. Mineralogical and chemical composition of crust, mental and core. Formation of core. Earthquake; effects, types, mechanism, source parameter, and hazard assessment.

UNIT-II

Geochronology and Geodynamics: Geological Time Scale, Radioactive dating methods (U-Pb, Th-Pb, Pb-Pb, Rb-Sr, K-Ar, and C-14), Fission Track dating, Interpretation and discordant ages, age of earth,

Heat flow: thermal and mechanical structure of the continental and oceanic lithosphere.

Plate tectonics theory: kinematics, dynamics and evolution of plates; types of boundaries, processes. Geodynamics of Indian plate.

UNIT-III

Radioactivity of Rocks: Magnetic differentiation, Browns reaction series, Radioactivity of rocks, soil, water and air, Uranium mineralization and its occurrences in India,

Radiometric survey of rocks: ground and air borne surveys, Radiometer and emanometer, Role of radiometry in geophysical prospecting, gamma logging and gamma testing.

UNIT-IV

Nuclear Techniques: Gamma-transmission method for determination of rock densities in Laboratory and in-situ. Gamma spectrometric analysis for U, Th and K in rock/soil.

Neutron activation analysis: Equation for buildup of induced activity.

Text and Reference Books:

S. No	Name	Author(S)	Publisher
1	The Solid Earth	C.M.R. Fowler	Cambridge University Press
2	Interior of the earth	M.H.P. Bott	Edward Arnold, London, 1982
3	The Earth’s age and Geochronology	D.York and R.M. Fraquhar	Cambridge University Press

Course Code	PHY612
Course Title	**Nano Technology**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	The primary aim is to prepare students for a career in nanotechnology by providing them with a sound grounding in multidisciplinary area of nanoscale science.
Course Outcomes (CO)	**Students will able:** CO1: To understand different methods involved in synthesis nanomaterials. CO2: To determine the basic properties of nanoparticles using different characterization techniques. CO3: To understand the physics of carbon nano tubes, fullerenes, graphene involving their synthesis and applications. CO4: To gain basic knowledge of nanosemiconductors devices, nanosensors and their applications in different areas.

UNIT-I

Introduction and Synthesis of Nano Materials: Basic idea of nanotechnology, nano materials, nanoparticles.

Physical Techniques of Fabrication: inert gas condensation, Arc Discharge, RF plasma, Ball milling, Molecular Beam Epitaxy, Chemical Vapour deposition, Electrodeposition,

Chemical Methods: Metal nanocrystals by reduction, Photochemical synthesis, Electrochemical synthesis, Sol-gel.

Lithographic Techniques: AFM based nanolithography and nanomanipulation, E-beam lithography and SEM based nanolithography, X ray based lithography.

UNIT-II

Characterization Techniques: X-ray diffraction, data manipulation of diffracted X-rays for structure determination, Scanning Probe microscopy, Scanning Electron microscopy, Transmission Electron Microscopy, Scanning Tunneling Microscopy, Optical microscopy, FTIR Spectroscopy, Raman Spectroscopy, DTA, TGA and DSC measurements.

UNIT-III

Carbon Nanotubes and other Carbon based materials: Preparation of Carbon nano tubes, Properties of CNT (Electrical, Optical, Mechanical, Vibrational properties), Application of CNT (Field emission, Fuel Cells, Display devices).

Carbon based materials: Preparation of Fullerence, Graphene preparation, characterization and properties, DLC and nanodiamonds.

UNIT-IV

Nanosemiconductors and Nano sensors: Semiconductor nanoparticles, optical luminescence and fluorescence from direct band gap semiconductor nanoparticles, carrier injection, polymers-nanoparticles, LED and solar cells, electroluminescence.
Micro and Nanosensors; fundamentals of sensors, biosensor, MEMS and NEMS, packaging and characterization of sensors.

Text and Reference Books:

S. No	**Name**	**Author(S)**	**Publisher**
1	Introduction to nanoscience and Nanotechnology	K.K. Chattopadhyay and A.N. Banerjee	PHI Learning Pvt. Ltd. 2009
2	Nanotechnology Fundamentals and Applications	Manasi Karkare,	I.K.- International Publishing House, 2008.
3	Nanostructures and Nanomaterials Synthesis, Properties and Applications	Guoahong Cao	Imperial College Press, 2004
4	Physical Properties of Carbon Nanotube	D. Satio, G. Dresselhaus and M. S. Dresselhaus	Imperial College Press, 1998

Course Code	**PHY614**
Course Title	**Spintronics**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	The objective of the course is to give flavor to the students how spintronic can be used over the present electronics.
Course Outcomes (CO)	**Students will able:** CO1: To study the optical properties & various types of spintronics-based devices. CO2: To understand the theory of charge and spin in quantum dots. CO3: To understand about spin based transport in the device. CO4: To understand magnetic dynamics and application of spin transfer torque.

UNIT-I

Optical properties of III-V-based MAS: Hole-mediated ferromagnetism, Optical properties, Photo induced ferromagnetism, Photo-induced magnetization rotation effect of spin injection, Spin dynamics, Magnetization reversal by electrical spin injection, Circularly polarized light emitters and detectors, Bipolar spintronics, Concept of spin polarization, Optical spin orientation, Spin injection in metallic F/N junctions, Spin relaxation in semiconductors, Bipolar spin-polarized transport and applications, Magnetic p-n junctions.

UNIT-II

Charge and spin in single quantum dots: Constant interaction model, Spin and exchange effect, Controlling spin states in single quantum dots, Charge and spin in double quantum dots Hydrogen molecule model, Stability diagram of charge states, Spin relaxation in quantum dots, Spin blockade in single-electron tunnelling, Cotunneling and the Kondo effect.

UNIT-III

Single-electron transport: Model Hamiltonian, Metallic or ferromagnetic island, Quantum dot Transport regimes, Weak coupling, Quantum dots, Non-Collinear geometry, Ferromagnetic islands, Metallic islands and Shot noise, Cotunneling, Strong coupling – Kondo effect, RKKY interaction between quantum dots.

UNIT-IV

Spin-transfer torques: Intuitive picture of spin-transfer torques, two magnetic layers, Spin-transfer-driven magnetic dynamics, Applications of spin transfer torques, Electrons in micro- and nanomagnets, Micron-scale magnets and Coulomb blockade, Ferromagnetic nanoparticles, Magnetic molecules and the Kondo effect, Magnetic tunnel junctions, Tunnel-based spin injectors, Spin-Hall effect.

Text and Reference Books:

S. No	Name	Author(S)	Publisher
1	Concepts in Spin Electronics	Sadamichi Maekawa	Oxford Univeristy Press
2	Spintronics	Tomasz Dieti, David D Awshalom	Elsevier
3	Nanomagnetism and Spintronics: Fabrication Materials, Characterization and Application	Farzad Nasirpouri, Alain Nogaret	World Scientific

Course Code	**PHY616**
Course Title	**Solar cell and its application**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	The objective of the course is to study renewable, clean source of electricity and its applications.
Course Outcomes (CO)	**Students will able:** CO1: To measure and evaluate different solar energy technologies through knowledge of the physical function of the semiconductor devices. CO2: To study different types of solar cells. CO3: To understand the basic principle, working and applications of photoelectrochemical solar cell and dye sensitized solar cells. CO4: To understand the polymer, nanostructure involved in fabrication of solar cells.

UNIT-I

Basic of Semiconductor Physics: p-n junction, charge carriers in semiconductors, optical properties of semiconductors, Hetero- junctions.

Solar radiation outside the Earth's Atmosphere, Solar radiation at the earth's surface Instrument for measuring the solar radiation and sunshine, solar radiation data, solar radiation Geometry, solar radiation at tilted surfaces,

Solar energy fundamentals: nature of solar energy, conversion of solar energy, photochemical conversion of solar energy, photovoltaic conversion, photophysics of semiconductors and semiconductor particles, photocatalysis.

UNIT-II

Types of solar cells: P-N junction solar cell, current density, open circuit voltage and short circuit current,

Device physics of silicon solar cells: Semiconductor device equations, The p-n junction model of Shockley, Real diode characteristics,

Description and principle of working of crystalline silicon solar cells: Silicon cell development, Substrate production, cell processing, cell cost, Opportunities for improvement, polycrystalline and amorphous silicon solar cells, conversion efficiency, Elementary ideas of Tandem solar cells Manufacturing costs, Environmental issues, Challenges for the future.

UNIT-III

Photoelectrochemical solar cell: Semiconductor electrolyte interface, Basic principle and working of Graetzel Cell i.e., dye sensitized solar cells (DSSCs), Derivation of the Lifetime in DSSCs, factors affecting on efficiency of DSSCs, present DSSCs research and developments, limitations of DSSCs.

UNIT-IV

Introduction to conducting polymers, basic principle of HOMO & LUMO, bulk heterojunction polymer: solar cell Basic working principles, device architectures, single layer, Bilayer, Bulk heterojunction, diffuse bilayer heterojunction, tandem solar cell, efficiency relationship in organic bulk heterojunction solar cells. Quantisation effects in semiconductor nanostructures, optical spectroscopy of quantum wells, superlattices and quantum dots, Basic principle and working of quantum dot sensitized solar cells, effect of device architecture, theory of electron and light dynamic in QDSSCs.

Text and Reference Books:

S. No	Name	Author(S)	Publisher
1	Physics of Solar cell from principle to new concepts	Peter Wurfel	Wiley
2	Photolelectrochemical solar cell	Suresh Chandra	Chemical Communications
3	Solar energy conversion	A.E. Dixon and J.D. Leslie	Elsevier
4	Solar cells	Martin A. Green	University of New South Wales (1986)
5	Solid state electronic devices	B.G. Streetman	Pearson
6	Dye sensitized solar cell	Michael Graetzel	Review article

Course Code	**PHY618**
Course Title	**Science of renewable energy source**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	The aim and objective of the course on Science of renewable Energy Sources is to expose the M.Sc. (H.S.) students to the basics of the alternative energy sources like solar energy, hydrogen energy, etc.
Course Outcomes (CO)	**Students will able:** CO1: To know the energy demand of world and India. CO2: To understand the solar energy and different concepts to develop solar physics applications. CO3: To understand in general the production of hydrogen through solar energy and their storage applications. CO4: To study in detail about the wind energy, nature of wind, and their electronics applications.

UNIT-I

Production and reserves of energy sources: Production and reserves of energy sources in the world and in India need for alternatives, renewable energy sources.

UNIT-II

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 photoelectrochemical solar cells. Applications.

UNIT-III

Production of Solar hydrogen: 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.

UNIT-IV

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.

Text and Reference Books:

S. No	Name	Author(S)	Publisher
1	Solar Energy	S.P. Sukhatme	Tata McGraw-Hill, New Delhi
2	Solar cell devices	Fonash	Academic Press New York
3	Fundamentals of solar cell, photovoltaic solar energy	Fahrenbruch and Bube	Springer Berlin !983

Course Code	**PHY620**
Course Title	**Plasma Physics**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	To carry out basic research in theoretical and experimental Plasma Physics and the other is to use plasmas as a tool or technology for applications in other areas such as plasma based - material synthesis and development of propulsion systems.
Course Outcomes (CO)	**Students will able:** CO1: To understand the origin of plasma, conditions of plasma formation and properties of plasma. CO2: To classify propagation of electrostatic and electromagnetic waves in magnetized and non-magnetized plasmas. CO3: To describe the basics of boltzman& vlasvov equations. CO4: To describe the non-linear plasma theories.

UNIT-I

Basics of Plasmas: Occurrence of plasma in nature, definition of plasma, concept of temperature, Debye shielding and plasma parameter, Single particle motion in uniform E and B, non uniform magnetic field, grid B and curvature drifts, invariance of magnetic moment and magnetic mirror.

UNIT-II

Plasma Waves: Plasma oscillations electron plasma waves, ion waves, electrostatic electron and ion oscillations perpendicular to magnetic field upper hybrid waves, lower hybrid waves, ion cyclotron waves, Light waves in plasma.

UNIT-III

Boltzmann and Vlasov Equations: The fokker plank equation, integral expression for collision lern zeroth and first order moments, the single equation relaxation model for collision lern. Application kinetic theory to electron plasma waves, the physics of landau damping, elementary magnetic and inertial fusion concepts.

UNIT-IV

Non-linear Plasma Theories: Non-linear Electrostatic Waves, KdV Equations, Non-linear Schrodinger Equation, Solitons, Shocks, Non-linear Landau Damping.

Text and Reference Books:

S. No.	Name	Author(S)	Publisher
1	Introduction to Plasma Physics and Controlled Fusion	F. F. Chen	Springer, 1984
2	Plasma Physics	R. O. Dendy	Cambridge University Press
3	Ideal Magneto hydrodynamics	J. P. Friedberg	Springer edition, 1987
4	Fundamental of Plasma Physics	S. R. Seshadri	American Elsevier Pub. Co

Course Code	**PHY630**
Course Title	**Project Part II**
Type of course	Theory
L T P	4 0 0
Credits	4
Course prerequisite	B.Sc. with physics as one of major subjects
Course Objective	To carry out basic research in theoretical and experimental Plasma Physics and the other is to use plasmas as a tool or technology for applications in other areas such as plasma based - material synthesis and development of propulsion systems.
Course Outcomes (CO)	**Students will able:** CO1:To understand a methodology to solve the research problem. CO2: To design and carry out scientific experiments as well as accurately record the results of experiments. CO3: To analyze the data and interpret the results. CO4: To interpret the results and can write the research report.

- Student has to complete their experimental/theoretical research work and complied it.
- At the end of the semester the student has to prepare a project report as per the university guidelines.
- Upon submission of the project report, the projects would be evaluated based on a project presentation.

Course Code	**BOT001**
Course Title	**Natural Hazards and Disaster Management**
Type of course	Theory Course
L T P	3 0 0
Credits	3
Course prerequisite	Graduation
Course Objective	To learn about natural hazards, risk assessment and disaster management
Course Outcome (CO)	**Students will able:** CO1: To know the current overview of natural hazard materials. CO2: To discuss the physical aspects of vulnerability and elements of risk mapping, assessment. CO3:To know the development planning, sustainable development in the context of Climate Change.

UNIT I

Overview of natural hazards: Introduction to natural hazards, impact and mitigation in Global and Indian context; causes and consequences of geological hazards, flood, drought and climate change issues, forest hazard, tsunami and coastal hazards, cyclone hazards, snow avalanche, GLOF and glacier related hazards, extreme weather events, urban and industrial hazards.

UNIT II

Introduction to vulnerability and risk assessment: socio-economic and physical aspects of vulnerability and elements of risk mapping, assessment, and reduction strategies.

UNIT III

Earth observation: Data availability and key operational issues for DM: EO systems for natural hazards study: present (operational) and future systems; multi-temporal data sources, multi-temporal database organisation: Key operational issues, utilisation of geo-information products for disaster management (available through International cooperation e.g. International Charter etc.)

UNIT IV

Disaster management: framework of India and recent initiatives by Govt. of India with special emphasis on DRR HFA 2005-2015, MDG and SAARC comprehensive framework for DRR Disaster Management Support (DMS): Status in India for use of space inputs Mainstreaming DRR in Development Planning Sustainable development in the context of Climate Change Disaster Recovery-Strategy and case examples.

Text and Reference books:

S.No.	Name/Title	Author	Publisher
1	Environmental Hazards : Assessing Risk and Reducing Disaster	Keith Smith and Petley David, 2008.	Routledge
2	Geo-information for Disaster Management	van Oosterom Peter, ZlatanovaSiyka and FendelElfriede, 2005	Springer-Verlag
3	Geospatial Techniques in Urban Hazards and Disaster Analysis	Showalter, Pamela S. and Lu, Yongmei, 2010.	John Wiley and Sons.
4	An International Perspective on Natural Disaster: Occurrence, Mitigation and Consequences	Stoltman JP, Lidstone J and DechanoLM., 2004.	Kluwer Academic Publishers