GANDHI INSTITUTE OF TECHNOLOGY AND MANAGEMENT (GITAM)

(Deemed to be University)

VISAKHAPATNAM * HYDERABAD * BENGALURU

Accredited by NAAC with A++ Grade

GITAM School of Science

CURRICULUM AND SYLLABUS

2 Year Postgraduate Programme
PPHYS02: M.Sc. Physics

w.e.f. 2024-25 admitted batch

(Updated on July 2024)

Master of Science in Physics (M.Sc. Physics) REGULATIONS
(W.e.f. 2024-25 admitted batch)

1. Admission into M.Sc. **Physics** program of GITAM University is governed by GITAM University admission regulations.

2. ELIGIBILITY CRITERIA

2.1. A pass in a B.Sc. degree with a minimum aggregate of 50% marks / a pass in any degree with a minimum aggregate of 50% marks along with Mathematics, Physics, and Chemistry/Electronics/Computer science or any related subject of equivalence as one of the subjects.

2.2. Admission into M.Sc. **Physics** (Master of Science in **Physics**) will be based on an All-India GITAM Admission Test (GAT) conducted by GITAM University and the rule of reservation, wherever applicable.

3. CHOICE BASED CREDIT SYSTEM

Choice Based Credit System (CBCS) is introduced with effect from the admitted Batch of 2015-16 based on UGC guidelines in order to promote:

- Student Cantered Learning
- Cafeteria approach
- Inter-disciplinary learning

Learning goals/ objectives and outcomes are specified leading to what a student should be able to do at the end of the program.

4. STRUCTURE OF THE PROGRAM

4.1 The Program Consists of

i) Foundation Courses (compulsory) which give general exposure to a student in communication and subject related area.

ii) Core Courses (compulsory).

iii) Discipline-centric electives which

a) are supportive to the discipline

b) give expanded scope of the subject

c) give their disciplinary exposure

d) nurture the student skills

iv) Open electives are of a general nature either related or unrelated to the discipline.

v) Practical Proficiency Courses, Laboratory and Project work.

4.2 Each course is assigned a certain number of credits depending upon the number of contact hours (lectures/tutorials/practical) per week.

4.3 In general, credits are assigned to the courses based on the following contact hours per week per semester.

- One credit for each Lecture / Tutorial hour per week.
- One credit for two hours of Practical per week.
- Eight credits for project.

4.4 The curriculum of the Four semesters M.Sc. **Physics** program is designed to have a total of 80 credits for the award of M.Sc. **Physics** degree.

5. MEDIUM OF INSTRUCTION

The medium of instruction (including examinations and project reports) shall be in English.

6. REGISTRATION

Every student has to register himself/herself for each semester individually at the time specified by the Institute / University.

7. ATTENDANCE REQUIREMENTS

7.1. A student whose attendance is less than 75% in all the courses put together in any semester will not be permitted to attend that end-semester examination and he/she will not be allowed to register for subsequent semester of study. He/she has to repeat the semester along with his / her juniors.

7.2. However, the Vice Chancellor on the recommendation of the Principal / Director of the Institute/School may condone the shortage of attendance to the students whose attendance is between 66% and 74% on genuine grounds and on payment of prescribed fee.

8. EVALUATION

8.1. The assessment of the student's performance in a Theory course shall be based on two components: Continuous Evaluation (40 marks) and Semester-end examination (60 marks).

8.2. A student has to secure an aggregate of 40% in the course in continuous and semester end examinations the two components put together to be declared to have passed the course, subject to the condition that the candidate must have secured a minimum of 24 marks (i.e., 40%) in the theory component at the semester-end examination.

8.3. Practical / Viva voce etc. course is completely assessed under Continuous Evaluation for a maximum of 100 marks and a student has to obtain a minimum of 40% to secure Pass Grade. Details of Assessment Procedure are furnished below in Table 1.

S. No.	Component of assessment	Marks allotted	Type of Assessment	Scheme of Examination
1	Theory	40	Continuous evaluation	(i) One mid-term examination for 30 marks. (ii) One Assignment and One presentation (OR) Two Assignments. Each 5 marks (5+5=10 marks)
		60	Semester-end examination	The semester-end examination shall be for a maximum of 60 marks.
	Total	100		
2	Practical's	100	Continuous evaluation	80 marks for performance, regularity, record/ and case study. Weightage for each component shall be announced at the beginning of the semester. 20 marks for the test conducted at the end of the Semester by the concerned lab Teacher.
	Total	100		
3	Project work	200	Project evaluation	200 marks for evaluation of the project work dissertation submitted by the candidate. The project work evaluation shall be conducted by internal examiners and project supervisor.

9. SUPPLEMENTARY EXAMINATIONS & SPECIAL EXAMINATIONS:

9.1 The odd semester supplementary examinations will be conducted on daily basis after conducting regular even semester examinations in April/May.

9.2 The even semester supplementary examinations will be conducted on daily basis after conducting regular odd semester examinations during November/December

9.3 A student who has completed his/her period of study and still has "F" grade in final semester courses is eligible to appear for Special Examination normally held during summer vacation.

10. PROMOTION TO THE NEXT YEAR OF STUDY

10.1 A student shall be promoted to the next academic year only if he/she completes the academic requirements of 60% of the credits till the previous academic year.

10.2 Whenever there is a change in syllabus or curriculum, he/she has to continue the course with new regulations after detention as per the equivalency established by the BoS to continue his/her further studies.

11. BETTERMENT OF GRADES

11.1 A student who has secured only a pass or second class and desires to improve his/her class can appear for betterment examinations only in 'n' (where 'n' is no. of semesters of the program) theory courses of any semester of his/her choice, conducted in summer vacation along with the Special Examinations.

11.2 Betterment of Grades is permitted ‘only once’, immediately after completion of the program of study.

12. REPEAT CONTINUOUS EVALUATION:

12.1 A student who has secured ‘F’ grade in a theory course shall have to reappear at the subsequent examination held in that course. A student who has secured ‘F’ grade can improve continuous evaluation marks up to a maximum of 50% by attending special instruction classes held during summer.

12.2 A student who has secured ‘F’ grade in a practical course shall have to attend Special Instruction classes held during summer.

12.3 A student who has secured ‘F’ grade in a combined (theory and practical) course shall have to reappear for theory component at the subsequent examination held in that course. A student who has secured an ‘F’ grade can improve continuous evaluation marks up to a maximum of 50% by attending special instruction classes held during summer.

12.4 The RCE will be conducted during summer vacation for both odd and even semester students. Students can register for a maximum of 4 courses. Biometric attendance of these RCE classes has to be maintained. The maximum marks in RCE be limited to 50% of Continuous Evaluation marks. The RCE marks are considered for the examination held after RCE except for final semester students.

12.5 RCE for the students who completed course work can be conducted during the academic semester. The student can register a maximum of 4 courses at a time in a slot of 4 weeks. An additional 4 courses can be registered in the next slot.

A student is allowed to Special Instruction Classes (RCE) ‘only once’ per course.

13. GRADING SYSTEM

Based on the student performance during a given semester, a final letter grade will be awarded at the end of the semester in each course. The letter grades and the corresponding grade points are as given in Table 2.

Table 2: Grades & Grade Points

Sl. No.	Grade	Grade Points	Absolute Marks
1	O (outstanding)	10	90 and above
2	A+ (Excellent)	9	80 to 89
3	A (Very Good)	8	70 to 79
4	B+ (Good)	7	60 to 69
5	B (Above Average)	6	50 to 59
6	C (Average)	5	45 to 49
7	P (Pass)	4	40 to 44
8	F (Fail)	0	Less than 40
9	Ab. (Absent)	0	-

GITAM SCHOOL OF SCIENCE
DEPARTMENT OF PHYSICS

M.Sc. Physics
(Effective from AD 2024-25)

I Semester				
		No. of courses	Credits	Total credits
Theory	Program Core	4	3	12
	PP_ Lab courses	2	2	4
	Skill enhancement	2	4	4
		Total semester credits		20

I - SEMESTER

S. No.	Course Code	Name of the Course	Category	Credits	Hours per Week		Maximum Marks	
					L/T	P		
1	SPH 701	Classical Mechanics	PC	3	3	0	60	40
2	SPH 703	Quantum Mechanics	PC	3	3	0	60	40
3	SPH 705	Electromagnetic Theory	PC	3	3	0	60	40
4	SPH 707	Mathematical Methods of Physics	PC	3	3	0	60	40
5	SSE 701/ SSE 703	Skill Enhancement Course*	SEC	2	0	4	--	100
6	IENT1051	Fundamentals of Entrepreneurship	SEC	2	2	0	-	100
7	SPH 721	General Physics Lab	PP	2	0	4	--	100
8	SPH 723	C-Programming Lab	PP	2	0	4	--	100
		Total	---	**20**				

II Semester				
		No. of courses	Credits	Total credits
Theory	Program Core	4	3	12
	Program elective	1	3	3
	PP_ Lab courses	2	2	4
	Professional communication	1	2	2
		Total semester Credits		21

II - SEMESTER

S. No.	Course Code	Name of the Course	Category	Credits	Hours per Week		Maximum Marks	
					L/T	P	Sem. End Exam	Con. Eval
1	SPH 702	Statistical Mechanics	PC	3	3	0	60	40
2	SPH 704	Atomic and Molecular Physics	PC	3	3	0	60	40
3	SPH 706	Advanced Quantum Mechanics	PC	3	3	0	60	40
4	SPH 708	Electronic Devices and Circuits	PC	3	3	0	60	40
Program Elective (One to Be Chosen)								
5	SPH 742	Electronic Measurements and Instrumentation (Common with M.Sc. Electronics)	PE	3	3	0	60	40
	SPH 744	Advanced Electromagnetic Theory	PE	3	3	0	60	40
	SPH 746	Physics of Semiconductor Devices	PE	3	3	0	60	40
	SPH 748	Introduction to General Relativity	PE	3	3	0	60	40
6	SAE 702	Professional Communication Skills	AEC	2	0	4	--	100
7	SPH 722	Modern optics and Nuclear Physics Lab	PP	2	0	4	--	100
8	SPH 724	Electronic Devices and Circuits Lab	PP	2	0	4	--	100
		Total	---	**21**				

III Semester				
		No. of courses	Credits	Total credits
Theory	Program Core	4	3	12
	Program elective	1	3	3
	Open Elective	1	2	2
	PP_ Lab courses	2	2	4
	Comprehensive Viva	1	2	2
		Total semester credits		23

III - SEMESTER

S.No.	Course Code	Name of the Course	Category	Credits	Hours per Week		Maximum Marks	
					L/T	P	Sem. End Exam	Con. Evaluation
1	SPH 801	Solid State Physics	PC	3	3	0	60	40
2	SPH 803	Nuclear and Particle Physics	PC	3	3	0	60	40
3	SPH 805	Analog and Digital Communication	PC	3	3	0	60	40
4	SPH 807	Electronics and Experimental methods	PC	3	3	0	60	40
Program Elective (One to Be Chosen)								
5	SPH 843	Introduction to Photonics	PE	3	3	0	60	40
	SPH 845	Radiation Physics	PE	3	3	0	60	40
	SPH 847	Dynamical Systems	PE	3	3	0	60	40
	SPH 849	Modern Optics and Laser Spectroscopy	PE	3	3	0	60	40
	SPH 851	Vacuum Science and Technology	PE	3	3	0	60	40
	SPH 853	Molecular Mechanics	PE	3	3	0	60	40
	SPH 855	Fundamentals of Quantum Computing	PE	3	2	2	60	40
	SPH 857	Introduction to Atmospheric physics	PE	3	3	0	60	40
	SPH 859	Data-Driven Physics	PE	3	3	0	60	40
Open Elective (One to Be Chosen)								
6	SOE 865	Biophysics	OE	2	2	0	60	40
	SOE 867	Bioelectronics	OE	2	2	0	60	40
	SOE 869	Environmental Physics	OE	2	2	0	60	40
	SOE 871	Physical principles in Biological Systems	OE	2	2	0	60	40
7	SPH 821	Analog and Digital Communication Lab	PP	2	0	4	--	100
8	SPH 823	Solid State Physics Lab	PP	2	0	4	--	100
9	SPH 891	Comprehensive Viva	PP	2	0	0	--	50
Total			---	**23**				

IV Semester				
		No. of courses	Credits	Total credits
Theory	Program Core	1	3	3
	Program elective	1	3	3
	PP_ Lab courses	1	2	2
	Project work	1	8	8
		Total semester credits		16

IV - SEMESTER

S.No.	Course Code	Name of the Course	Category	Credits	Hours per Week		Maximum Marks	
					L/T	P	Sem. end Exam	Con. Eval
1	SPH 802	Material Characterization Techniques	PC	3	3	0	60	40
Program Elective (One to Be Chosen)								
2	SPH 842	Introduction to thin film Technology	PE	3	3	0	60	40
	SPH 844	Soft Condensed Matter Physics	PE	3	3	0	60	40
	SPH 846	Advanced theories in Ferroics	PE	3	3	0	60	40
	SPH 848	Ultrafast Optics and Raman spectroscopy	PE	3	3	0	60	40
	SPH 850	Materials Science	PE	3	3	0	60	40
	SPH 852	Introduction to Photonic Quantum Computing	PE	3	3	0	60	40
	SPH 854	Topology in Quantum Materials	PE	3	3	0	60	40
	SPH 856	Physics of Strongly Correlated Quantum Matter	PE	3	3	0	60	40
3	SPH 822	Material Characterization Lab	PP	2	0	4	--	100
4	SPH 892	Project Work	PP	8	0	0	--	200
Total			---	**16**				

M.Sc. PHYSICS

I - SEMESTER

SPH 701 CLASSICAL MECHANICS

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessional: 40 Marks

Preamble: The subject deals with two main formalisms – Lagrangian and Hamiltonian, to explain the mechanics of an object under the action of forces and constraints. A separate unit on rigid body dynamics and canonical transformation are included to demonstrate the ease of understanding of mechanics of a complicated system. A particular unit on small oscillation is included, which is essential in the understanding of many quantum mechanics concepts also.

Objective: To understand new formalism and their transformations for physical systems

Unit-I The Lagrangian Formalism 9 hrs.

Constraints, Generalized coordinates, principle of virtual work, D-Alembert's Principle, Lagrangian equation from D-Alembert's principle, Lagrange's equation and its applications, Velocity dependent potential in Lagaragian formulation, Lagrange s equation in non-conservative systems. Generalized potential, Lagrange's equation in EM field, Hamilton's principle, and Lagrange's equation.

Unit-II Hamiltonian's Formalism 9 hrs.

Generalized momentum and Cyclic Coordinates, conservation theorems- linear and angular momentum and energy. Hamilton's equations, Applications of Hamiltonian dynamics- Harmonic oscillator, particle in central field, Electromagnetic field, and compound pendulum. Calculus of variation and Eulers Lagrange's equation, Deduction of Hamilton's principle from D Alembert's principle. Deduction of Lagrange's equation from variation principle and principle of least action.

Unit-III Rigid body Dynamics **9 hrs.**

Independent coordinates of rigid body, The Euler angles, infinitesimal rotations as vectors, components of angular velocity, angular momentum and inertia tensor, principal moments of inertia, Rotational kinetic energy of rigid body. Euler’s equation of motion for rigid body, torque free motion of rigid body and force free motion of a symmetrical top.

Unit-IV Canonical Transformation **9 hrs.**

Canonical transformations, Legendre transformation, generating functions, Equations of canonical transformation, conditions and applications of canonical transformations and infinitesimal canonical transformations Poisson brackets Lagrange’s bracket and relation and invariance of Poisson bracket with canonical transformation and Liouville’s theorem.

Unit-V Small Oscillations **9 hrs.**

Introduction, potential energy, and equilibrium-one dimensional oscillator-stable, unstable and neutral equilibrium. Two coupled oscillators-solution in differential equation, normal coordinates, and normal modes. Theory of small oscillations-secular equation and eigen value equation, solution of eigen value equation and small oscillations in normal coordinates.

Textbooks:

1. Classical Mechanics by H. Goldstein, Narosa Publishing House 2nd Edition 1980
2. Introduction to Classical Mechanics by Takwale Puranik, TMH, 1979
3. Classical Mechanics by J.C.Upadhaya, Himalaya Publisher, 2005

Course Outcomes:

1. The student will Learn the concept of generalized coordinates and deduce Lagrange’s equation, apply it to many systems to understand the efficiency of the Lagrange’s formalism
2. Learn about cyclic coordinates and related conservation theorems based on Hamilton’s formalism.
3. Will gain an understanding of the principle of least action. Learns to determine the Euler angles to describe the motion of a rigid body and study the Euler’s equation of motion for rigid bodies.
4. Understand the concepts of Canonical transformation to obtain the

generalized cyclic coordinates. The student will learn the techniques of Poisson's brackets and Liouville's theorem.

5. The student will be able to formulate the models of Oscillators to describe various physical systems.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**2**	**2**	**1**	**2**		**2**	**2**		**2**	**2**	**2**
CO2	**2**	**2**	**1**	**2**		**2**	**2**		**2**	**2**	**2**
CO3	**2**	**2**	**1**	**2**		**2**	**2**		**2**	**2**	**2**
CO4	**2**	**2**	**1**	**2**		**2**	**2**		**2**	**2**	**2**
CO5	**3**	**3**	**3**	**2**	**1**	**2**	**2**		**2**	**2**	**2**
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

I – SEMESTER

SPH 703 QUANTUM MECHANICS

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessionals: 40 Marks

Preamble: This course imparts knowledge on the advanced level of quantum mechanics

Objective: To develop familiarity with advanced mathematical formalisms in understanding and interpreting systems in microscopic dimension.

Unit-I General Formalism of Wave Mechanics 9 hrs.

Linear vector space, Postulates of wave mechanics, Operators and their properties, Hermitian operators, Eigen values and eigen functions, Commutator algebra, Bra-Ket vectors and their properties, Dirac-delta function and Korncker- delta function, Matrix representation, Change of basis, uncertainty relation, momentum representation.

Unit-II Schrodinger's Wave Equation and its Applications 9 hrs.

Times dependent and time independent Schrodinger's wave equation, Admissibility conditions of the wave function, Stationary state solution, continuity equation, Ehrenfest's theorem, article in a potential well, a box, step potential ($E > V$ and $E < V$), Rectangular potential barrier ($E > V$ and $E < V$), Square well potential ($E > V$ and $0 < E < V$) and harmonic oscillator.

Unit-III Spherically Symmetric Potentials 9 hrs.

Particle moving in spherically symmetric potential, system of two interacting particles, rigid rotator, free particle, three-dimensional square well, three-dimensional harmonic oscillator, hydrogen atom, hydrogen orbits, three-dimensional square well potential and the deuteron.

Unit-IV Angular Momentum **9 hrs.**

Angular momentum operators, Commutation relations, Eigen values and Eigen functions of angular momentum operators, general angular momentum, spin angular momentum, Pauli' spin operators and their properties, Addition of angular momenta: Clebsch- Gordon coefficients and its properties.

Unit-V Perturbation Theory **9 hrs.**

Time independent perturbation theory: (1) non-degenerate system- first order and second order corrections to energy and wave functions, first order corrections to anharmonic oscillator and He atom (2) degenerate systems-first order correction to wave function and energy, first order Stark effects, spin orbit interaction, Variation method: ground state and first excited state of the Helium atom.

Textbooks:

1. A textbook of Quantum Mechanics by P. Mathews and K.Venkatesan, TMH,1979
2. Quantum Mechanics by E.Merzbacher, Wiley Publishers, 3rd Edition,1997
3. Quantum Mechanics by Leonard Schiff TMH 3 Edition,1968 Nd
4. Modern Quantum Mechanics by J.J.Sakurai, Pearson nEddu.,2 edition,2010
5. Quantum Mechanics by G. Aruldhas, PHI, 2 Edition,2009

Course Outcomes:

1. Quantum mechanical postulates and various types of representation of eigen states, Operator formalism and calculation of specific values of the operators
2. the time-dependent and time-independent Schrödinger equation for simple potentials like for instance the harmonic oscillator and hydrogen like atoms, as well as the interaction of an electron with the electromagnetic field
3. Application of specific problems to three dimensional systems
4. Understand operator formalism, angular momentum states, general angular momentum, angular momentum addition rules.
5. approximate methods for solving the Schrödinger equation using perturbation theory and the variational method.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**2**	**2**		**2**		**2**	**2**	**2**	**2**	**2**	**2**
CO2	**2**	**2**		**2**		**2**	**2**	**2**	**2**	**2**	**2**
CO3	**2**	**2**		**2**		**2**	**2**	**2**	**2**	**2**	**2**
CO4	**2**	**2**		**2**		**2**	**2**	**2**	**2**	**2**	**2**
CO5	**2**	**2**		**2**		**2**	**2**	**2**	**2**	**2**	**2**
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

I – SEMESTER

SPH 705 ELECTROMAGNETIC THEORY

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessionals: 40 Marks

Preamble: The course deals with static, moving charges and their associated phenomena

Objective: To attribute the principles of Electricity and Magnetism with its application to images, boundaries, and propagation through media.

Unit-I Electrostatics 9 hrs.

Electric field, Coulomb's law, Continuous charge distribution, Divergence of E, curl of E, Applications of Gauss's law, Electric Potential-Poisson's and Laplace equation, Potential of localized charge distribution, Work done to move a charge, Energy of point and continuous charge distribution, Induced charges, surface charge and the force on a conductor, Dielectrics, Electric displacement, Gauss's law in dielectrics, polarization.

Unit-II Boundary Value Problems 9 hrs.

Laplace's equation in 1D, 2D and 3D, Boundary conditions, Classic image problem, induced surface charge, Force and Energy, Boundary value problems and their solutions by separation of variables. Multipole expansion. Electric dipole and quadrupole moments.

Unit-III Magnetostatics 9 hrs.

Lorentz force law, Magnetic fields, Magnetic forces, currents, Biot -Savarts Law-Steady currents, magnetic field of steady current, Divergence, and curl of B –Straight line currents, Applications of amperes law, Magnetic vector potential.

Magnetization-Diamagnets, para, ferromagnets, torques and forces in magnetic dipoles Field of magnetized object-bound currents and physical interpretation, Amperes law in magnetized materials.

Unit-IV Electrodynamics **9 hrs.**

Electromotive force-ohm's law, Motional EMF, Faraday laws, Induced electric field, Inductance, Energy in magnetic fields. Maxwell equations-magnetic charge, Maxwell equations in matter, Charge and Energy equation, pointing theorem.

Unit-V Electromagnetic waves **9 hrs.**

Waves in one dimension-wave equation, sinusoidal waves, Boundary conditions, reflection, transmission, polarization, Electromagnetic wave equation for E and B, Monochromatic plane waves, energy, and momentum in EM waves. The Potential formulation-scalar and vector potential, gauge transformations, coulomb, and Lorentz gauge transformations

Textbooks:

1. Introduction to Electrodynamics by Griffiths, PHI, 3rdEdition, 1999
2. Classical Electrodynamics by J.D. Jackson, John Wiley, 3rd Edition, 1998
3. Foundations of Electromagnetic Theory by John R. Reitz, Frederick J. Milford, Robert W. Christy, Wiley, 4th Edition 2008

Course Outcomes:

1. The student will learn to specify the constitutive relationships for electric fields based on Coulomb's law, Gauss's theorem and understand why they are required.
2. Will understand the importance of dielectrics in the major role played by them in electronic devices. He/she learns the importance of boundary value problems, and the application of boundary conditions to solve different filed problems.
3. Understands the Laplace's equation and different multipoles. Calculates the magnetic fields due to different types of currents.
4. Understand the basic mechanism of magnetism and differences between Dia, para, ferro magnets. Learns about pointing theorem and the electromagnetic energy transfer in medium.
5. Knowledge of physical interpretation, and ability to apply Maxwell's equations to determine fields. Formulate and analyze problems (solving for potentials, fields) involving media with different boundaries. Learns about EM waves and their nature, propagation etc.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**2**	**2**		**2**		**2**	**2**	**2**	**2**	**2**	**2**
CO2	**2**	**2**		**2**		**2**	**2**	**2**	**2**	**2**	**2**
CO3	**2**	**2**		**2**		**2**	**2**	**2**	**2**	**2**	**2**
CO4	**2**	**2**		**2**		**2**	**2**	**2**	**2**	**2**	**2**
CO5	**2**	**2**		**2**		**2**	**2**	**2**	**2**	**2**	**2**
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

I – SEMESTER

SPH 707 MATHEMATICAL METHODS OF PHYSICS

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessionals: 40 Marks

Preamble: To quantify physical systems using mathematical methods

Objective: To analyze the role of a few Mathematical Methods for the interpretation of Physical systems.

Unit-I Complex analysis 9 hrs.

Analytic function, CR equations, Elementary functions of complex variable, Harmonic functions, Cauchy Integral theorem, Evaluation of integrals. Cauchy's residue theorem and Evaluation of residues and evaluation of Contour integration.

Unit-II Special functions 9 hrs.

Legendre, Hermite, Laguerre and Bessel differential equations and solution, Recursion formula, Generating function, Recurrence relations and orthogonal properties.

Unit III Fourier series 9 hrs.

Determination of Fourier coefficients- Fourier series even and odd functions, Fourier series in arbitrary interval, half range Fourier sine and cosine expansions.

Unit-IV Laplace Transforms 9 hrs.

Introduction, Laplace transform, Laplace transform of some standard functions, properties of Laplace transform, Evaluation of integral using Laplace transform, Laplace transform of periodic functions, Inverse Laplace transforms, application of Laplace transform to differential equations with constant coefficients and applications to simultaneous differential equations.

Unit-V Matrices **9 hrs**.

Introduction, Matrix, Definitions associated with matrices, ad joint of square matrix, reciprocal of matrix, Elementary transformations, rank of matrix, non-homogenous and homogenous linear equations, Linear dependence and independence of vectors, Eigen values and Eigen vectors, Caley- Hamilton theorem, minimal polynomial and equation of matrix, Function of square matrix and similarity of matrices.

Textbooks:

1. Mathematical Physics by B.D.Gupta, Vikas publishing House, 3rd Edition 2004
2. Mathematical Physics by R.V. Church Hill
3. Engineering Mathematics by E.Kreyszig, Wiley Publishers
4. Engineering Mathematics by Ravish R Singh, Mukul Bhatt, TMH

Course Outcomes:

1. Realization and evaluation of analytic, poles and zeros of complex variables. Evaluation of residues and contours with relevant theorems. Understand the differential equations of special differential equations.
2. Generating functions and recursion relations of special differential equations. Understanding Fourier series for evaluation of coefficients
3. Application of Fourier series for physical problems. Understanding Laplace transforms and its application to periodic functions.
4. Understanding Inverse Laplace transform and its transformation from time and frequency domain. Gains knowledge of matrices with properties and determination of Eigen values and Eigen vectors
5. Understand matrices and its representation in equation.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	2	2		2		2	2		2	2	2
CO2	2	2		2		2	2		2	2	2
CO3	2	2		2		2	2		2	2	2
CO4	2	2		2		2	2		2	2	2
CO5	2	2		2		2	2		2	2	2
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

I – SEMESTER

SKILL ENHANCEMENT COURSE

SSE 701: BASIC COMPUTER CONCEPTS

L	T	P	S	J	C
0	0	4	0	0	2

Hours per week: 4

Credits: 2 Continuous Evaluation: 100 Marks

Preamble: The course gives an understanding about the characteristics and classification of computers, various components of computer along with different operating systems that are available. It gives hands-on training on the packages MS-Word, MS-Power Point, and MS-Excel. The course also comprehends AI tools.

Objective:

- To introduce components of digital computers and their working along with the outline of Operating Systems.
- To give hands-on training on MS-Word, Power Point and Excel features.

Basics of Computers:

Definition of a Computer - Characteristics and Applications of Computers Block Diagram of a Digital Computer – Classification of Computers based on size and working –Central Processing Unit – I/O Devices, Primary, Auxiliary and Cache Memory – Memory Devices. Software, Hardware, Firmware and People ware – Definition and

Types of Operating System – Functions of an Operating System – MS-DOS –MS Windows, UNIX.

MS-Word

Features of MS-Word – MS-Word Window Components – Creating, Editing, formatting, and Printing of Documents – Headers and Footers – Insert/Draw Tables, Table Auto format – Page Borders and Shading – Inserting Symbols, Shapes, Word Art, Page Numbers, Equations – Spelling and Grammar – Thesaurus – Mail Merge.

MS-PowerPoint

Features of PowerPoint – Creating a Blank Presentation - Creating a Presentation using a Template - Inserting and Deleting Slides in a Presentation – Adding Clip Art/Pictures - Inserting Other Objects, Audio, Video- Resizing and Scaling of an Object –Slide Transition – Custom Animation.

MS-Excel

Overview of Excel features – Creating a new worksheet, selecting cells, Entering, and editing Text, Numbers, Formulae, referencing cells – Inserting Rows/Columns –Changing column widths and row heights, auto format, changing font sizes, colors, shading.

Reference Books:

1. Fundamentals of Computers, V.Raja Raman, PHI Learning Pvt. Ltd, 2010.
2. Microsoft Office 2010 Bible, John Walkenbach, Herb Tyson,
3. Michael R. Groh and Faithe Wempen, Wiley Publications, 2010.

Course Outcomes:

1. Able to understand fundamental hardware components that make up a computer's hardware and the role of each of these components.
2. Understand the difference between an operating system and an application program, and what each is used for in a computer.
3. Acquire knowledge about AI tools.
4. Create a document in Microsoft Word with formatting that complies with the APA guidelines.
5. Write functions in Microsoft Excel to perform basic calculations and to convert number to text and text to number.
6. Create a presentation in Microsoft PowerPoint that is interactive and legible content

M.Sc. PHYSICS

I – SEMESTER

SKILL ENHANCEMENT COURSE

SSE 703: INFORMATION TECHNOLOGY TOOLS

L	T	P	S	J	C
0	0	4	0	0	2

Hours per week: 4 Continuous Evaluation: 100 Marks

Credits: 2

Preamble: The course enables the student to understand networking concepts related to the Internet and introduce social Networking sites and the working of email. It gives orientation of Block Chain technology. It gives hands-on training in SPSS, R Programming, and creation of simple HTML documents.

Objective:

- To enable the student to understand networking concepts related to the Internet and introduce the social Networking sites and working of email.
- To give orientation of Block Chain technology.
- To give hands on training in SPSS, R Programming, and creation of simple HTML documents

Introduction to Internet: Networking Concepts, Data Communication –Types of Networking, Internet, and its Services, Internet Addressing –Internet Applications–Computer Viruses and its types –Browser –Types of Browsers.

Internet applications: Using Internet Explorer, Standard Internet Explorer Buttons, entering a Web Site Address, Searching the Internet– Introduction to Social Networking: twitter, Tumblr, LinkedIn, Facebook, Flickr, skype, yahoo!, google+, YouTube, WhatsApp, etc.

E-mail: Definition of E-mail, Advantages and Disadvantages, User Ids, Passwords, Email Addresses, Domain Names, Mailers, Message Components, Message Composition, Mail Management, Email Inner Workings.

WWW-Web Applications, Web Terminologies, Web Browsers, URL–Components of URL, Searching WWW –Search Engines and Examples.

Block Chain technology: What is Block Chain, Blockchain Architecture, How Block chain Transaction Works? Why do we need Blockchain? Block chain versions, Block chain Variants, Block chain Use Cases, Important Real-Life Use Cases of Block chain Bitcoin cryptocurrency: Most Popular Application of Block chain, Block chain vs. Shared Database, Myths about Block chain, Limitations of Block chain technology.

SPSS: SPSS Commands Descriptive Statistics, Hypothesis Testing, Test of Difference, Analysis of Variance- One Way ANOVA, Non-Parametric Tests, Correlation Analysis, Regression Analysis.

R Programming: Becoming familiar with R, Working with Objects, Introduction to Graphical Analysis.

HTML: WEB Terminology, Structure of HTML Document, HTML – Head and Body tags, Semantic tags- HR- Heading, Font, Image & Anchor tags, Different Types of Lists using Tags, Table Tags, Image Formats – Creation of Simple HTML Documents.

Reference Books:

1. In-line/On-line: Fundamentals of the Internet and the World Wide Web by Raymond Greenlaw and Ellen Hepp, 2nd Edition, TMH.
2. Microsoft Office 2010 Bible by John Walkenbach, Herb Tyson, Michael R. Groh, and Faithe Wempen, Wiley Publications.

Course Outcomes:

1. Enable to understand the basic networking concepts, types of networks, Internet Explorer, and www.
2. Outline the Block chain architecture, Bitcoin Crypto currency, and Limitations of Block Chain.
3. Choose different statistical tests to be performed on the data sets.
4. Demonstrate the R programming with simple graphs.
5. To make use of commands to structure HTML document

M.Sc. PHYSICS

I – SEMESTER

<table>
<tr><td>Course Code: IENT1051</td><td colspan="7">Course Title: Fundamentals of Entrepreneurship</td></tr>
<tr><td rowspan="2">Semester:</td><td rowspan="2">Course Type: Core</td><td>L</td><td>T</td><td>P</td><td>S</td><td>J</td><td>C</td></tr>
<tr><td>2</td><td></td><td></td><td></td><td></td><td>2</td></tr>
<tr><td colspan="8">Home Programme(s): UG and PG Courses</td></tr>
<tr><td colspan="8">Course Leader:</td></tr>
</table>

Introduction

Entrepreneurship is a vital life skill that fosters curiosity, creativity, and a focus on seizing opportunities. By embracing entrepreneurship, individuals can achieve professional independence, tackle complex challenges with innovative solutions, and take calculated risks. This course, "Introduction to Entrepreneurship," is designed to provide students with essential knowledge and practical skills for their entrepreneurial journey. Contrary to popular belief, entrepreneurship can indeed be learned, and this course dispels those myths. It offers a comprehensive understanding of the entire entrepreneurial process, from generating ideas to launching a minimum viable product (MVP). Through a combination of theory and hands-on activities, students will explore various aspects of entrepreneurship, such as identifying opportunities, discovering customers, designing solutions, and employing lean startup methods. To succeed, students must demonstrate self-direction and a genuine enthusiasm for learning, whether independently or in collaboration with peers.

Learning Objectives

S. No.	Learning Objective
1	Understand the fundamental concepts and processes of entrepreneurship.
2	Identify and evaluate business opportunities.
3	Know the techniques for effective problem-solving.
4	Recognize the customer discovery and market sizing.
5	Effectively communicate your Venture Idea

Course outline and indicative content

Unit I: Entrepreneurial Process and Mindset **L-6**

Introduction to Entrepreneurship, Pilot Your Purpose, Innovation, Risk-Taking and Value Creation, Myths around Entrepreneurship, Distinct Types of Entrepreneurship, Entrepreneurial vs. Managerial Mindset.

Unit II: Problem Identification and Ideation **L-6**

Entrepreneurship Opportunity identification, Market and Need Analysis, Problem Discovery, Problem Statement Canvas, Evaluating and Selecting Ideas

Unit III: Customer Discovery **L-6**

Users and Buyers, Target Group and Persona, Customer Research Methods (People Shadowing, laddering etc.), Use Cases, Market Sizing, Customer Value Proposition

Unit IV: Solution Design **L-6**

Principles of Effective Solution Design, Prototyping Methods and Tools, Building and Testing Prototypes, Gathering Feedback on Prototypes, Iterating and Refining Solutions, Building Minimum Viable solution.

Unit V: Crafting your Venture Narrative **L-6**

Can you make money? Tell your venture story

Course Outcomes

On successful completion of this course, students will be able to:

S. No.	Learning Outcome	Assessment
1	To discover emotional competencies needed for entrepreneurial career	A1
2	Effectively utilize frameworks like the Problem Statement Canvas and Business Model Canvas for business planning and development.	A3
3	Implement customer research methods such as shadowing and laddering to gather insightful data.	A2
4	Build and refine a minimum viable product (MVP) based on real customer feedback.	A3
5	Present a process pitch that integrates learnings across all units to propose a viable entrepreneurial venture.	A4

Assessment Methods

Task	Task type	Task mode	Weightage (%)
A1	**Class Participation and Activities**: Engagement in class discussions, group activities, and case studies throughout the course.	Individual	20
A2	**Problem Statement and Ideation Report**: A detailed report identifying a market problem, supported by a Problem Statement Canvas.	Group	20
A3	**Customer Discovery Assignment**: A comprehensive analysis of target customers, including persona creation and market sizing.	Group	20
A4	**Process Pitch**: Share your learning from the course	Group	40

**as per grouping made by the course facilitator (no deviation permitted)*

Evaluation pattern

A1: Classroom Participation and Engagement

a) Class Participation – 5 Marks.
b) Group discussions- 5 Marks,
c) Group Activity – 5 Mark
d) Case Study discussion- 5 Marks.

A2: Problem Statement and Ideation.

a) Problem Identification - 5 Marks.
b) Drawings / Prototype Product or Service-5 Marks
c) Discussion on Market Survey-5 Marks
d) Problem Statement Canvas-5 Marks.

A3: Customer Discovery Assignment

a) Analysis on Target Customers - 10 Marks.
b) Report on Market Size - 10 Marks

A4: Process Pitch

a) Presentation from Problem Identification to Launching a Product or Service - 40 Marks.

Learning and Teaching Activities

In classrooms

Reflection videos, Case Discussions, Simulations

Outside classrooms

Field Visits

Teaching and Learning Resources

"Entrepreneurship: Theory, Process, and Practice" by Donald F. Kuratko

Other Books

- The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses by Eric Ries
- Blank, S. and Dorf, B. (2012) The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company. BookBaby, Pennsauken.
- Osterwalder, A., & Pigneur, Y. (2010) Business Model Generation: A Handbook for Visionaries, Game Changers, And Challengers Wiley.
- Neck, Heidi & Greene, Patricia & Brush, Candida. (2014). Teaching entrepreneurship: A practice-based approach. 10.4337/9781782540564.

Documentaries

- Bloomberg Game Changers (e.g. Zuckerberg, Brin & Page; Jobs, Musk, etc.) - YouTube

- Elon Musk: The future we're building and boring | TED – YouTube
- Inspirational series about the entrepreneurial path of 5 of the most admired business entrepreneurs: Cornelius Vanderbilt (Railroads), John D. Rockefeller (Oil), Andrew Carnegie (Steel), J.P. Morgan (Banking) and H. Ford (Automobile).
- 6 Tips on Being a Successful Entrepreneur | John Mullins | TED - YouTube

Learning articulation (LO – PO mapping and SDG mapping)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	1	2	2	1	3	3	2	2	2	3	2	2	1	2
CO2	2	3	3	2	2	2	3	2	2	1	3	3	2	1	2
CO3	1	3	3	3	2	3	3	2	3	2	3	3	2	1	2
CO4	2	2	3	3	3	3	3	1	3	1	3	2	2	1	2
CO5	2	3	3	2	2	2	3	1	2	1	3	3	2	1	2

Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation

M.Sc. PHYSICS

I – SEMESTER

SPH 721 GENERAL PHYSICS LAB

L	T	P	S	J	C
0	0	4	0	0	2

Hours per week: 4 Continuous Evaluation: 100 Marks

Credits: 2

Objective: To impart knowledge in fundamental concepts of light, constants of solids, velocity of waves through media, and quantum behavior of light.

1. Specific Charge of Electron
2. Rydberg constant
3. Boltzmann Constant
4. Ultrasonic Interferometer
5. Franck Hertz Experiment- Existence of discrete states of the atom
6. Thermo EMF
7. Determination of Planck's constant
8. Laws of photo electric effect
9. Hall Effect

Course Outcomes:

1. The students will understand different types of bonds in materials
2. Identify the characteristics behavior of semiconductors and conductors
3. Determine the band gap, magneto resistance, resistivity, and charge carrier concentration in semiconductors.
4. Comprehend the concepts through simple experiments.
5. Verify principles of quantum mechanics
6. Evaluate theoretical calculations using experimental observations.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1		2	2	2	2	2	2	2	2		2
CO2		2	2	2	2	2	2	2	2		2
CO3		2	2	2	2	2	2	2	2		2
CO4		2	2	2	2	2	2	2	2		2
CO5		2	2	2	2	2	2	2	2		2

Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation

M.Sc. PHYSICS

I - SEMESTER

SPH 723 C-PROGRAMMING LAB

L	T	P	S	J	C
0	0	4	0	0	2

Hours per week: 4 Continuous Evaluation: 100 Marks

Credits: 2

1. Arranging words in alphabetical order
2. Finding of largest and smallest from a set of numbers
3. Multiplication of two square matrices
4. Write functions for (i) reverse the string (ii) converting integer into string
5. Write functions for (i) string copy (ii) string compare (iii) Replace a sub-string with another string
6. Sorting series of elements.
7. Exchange elements of two arrays using pointers.
8. Number of sums of all integers greater than 100 and less than 200 that are divisible by a given integer x.
9. Reverse digits using while loop
10. Read n numbers into an array, and compute the mean, variance, and standard deviation.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1		2	2	2	2	2		2	2		2
CO2		2	2	2	2	2		2	2		2
CO3		2	2	2	2	2		2	2		2
CO4		2	2	2	2	2		2	2		2
CO5		2	2	2	2	2		2	2		2
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

II - SEMESTER

SPH 702 STATISTICAL MECHANICS

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessionals: 40 Marks

Preamble: This course deals with the theory of ensembles and their applicability, classical and quantum statistics, Bose-Einstein condensation, free Fermi gas, theory of white dwarfs and physics behind the Chandrasekhar limit; theory of non-ideal gases, theory behind magnetism.

Objective: Conceptual understanding with Molecular basis for thermodynamics, to explore the connectivity of microscopic and macroscopic phenomena qualitatively.

Unit- I Statistical Description of Systems of Particles and their Thermodynamics 9hrs.

Specification of the state of a system, Statistical ensemble, Phase space Basic postulates, Probability calculations, Behavior of the density of states, Thermal interaction, Mechanical interaction, and General interaction. Dependence of the density of states on the external parameters, Statistical calculation of thermodynamic quantities

Unit- II Interpretation of Ensembles 9 hrs.

Isolated system, System in contact with a heat reservoir, simple application of the Canonical distribution and Grand canonical ensemble, Probability distribution functions, mean energies, Fluctuations in energy and density in a canonical ensemble and Grand Canonical ensemble, Connection with thermodynamics.

Unit- III Applications of Statistical Mechanics 9 hrs.

Partition functions and their properties, calculation of thermodynamic quantities, Gibbs paradox, Validity of the classical approximation, specific heats of solids-Dulong and Petits law, Einstein specific heat theory, Debye specific heat theory, Equipartition theorem, Applications as- harmonic oscillator.

Unit- IV Quantum Statistics of Ideal Gases 9 hrs.

Identical particles and symmetry requirements, Formulation of the statistical problems, the quantum distribution functions, Maxwell-Boltzmann statistics, Photon statistics, Bose- Einstein statistics, Fermi Dirac statistics- Calculation of dispersions, Equation of state for Ideal Bose and fermi gas, Bose- Einstein condensation, Theory of white dwarf stars, Quantum statistics in the classical limit.

Unit- V System of Interacting Particles 9 hrs.

Lattice vibrations and Normal modes, non-ideal classical gas, Calculation of partition function-low densities, Equation of state, viral coefficients and its evaluation with integrals, Ferromagnetism- interaction between spins, Weiss molecular field approximation, high and low temperatures. Phase Transitions- Phase diagram, Thermodynamic description, 1st, and 2nd order phase transitions, Clausius Clapeyron equation and Landau theory of phase transitions.

Textbooks:

1. Fundamental Statistical and Thermal physics F.Reif ,Waveland PR Inc, 4th Edition, 2008
2. Statistical Mechanics by K. Huang Wiley, 2nd Edition,1987

Course Outcomes:

1. Learned how to approach a problem statistically. Gained knowledge on how accessible states determine the properties of systems. Learned about different interactions.
2. Gained knowledge on the intimate relationship between thermodynamics and statistical mechanics. Acquired basic ideas on various ensembles.
3. How to explain physical phenomena using different ensembles
4. Distribution laws of Fermi Dirac, Maxwell Boltzmann, and Bose Einstein statistics are understood Behavior of FDS, BES, and MBS at different temperatures are understood.
5. Behavior of non-ideal gases are understood. Gained knowledge on how ferromagnetism, specific heats can be explained based on statistical mechanics.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**3**	**3**		**3**		**3**	**3**		**2**		**2**
CO2	**3**	**3**		**3**		**3**	**3**		**2**		**2**
CO3	**3**	**3**		**3**		**3**	**3**		**2**		**2**
CO4	**3**	**3**		**3**		**3**	**3**		**2**		**2**
CO5	**3**	**3**		**3**		**3**	**3**		**2**		**2**
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

II - SEMESTER

SPH 704: ATOMIC AND MOLECULAR PHYSICS

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessionals:40 Marks

Preamble: This course introduces the basic ideas of atomic and molecular physics. It teaches students how to apply quantum mechanics and extract information from many-electrons atoms and molecules and research in atomic and molecular physics.

Objective: To introduce the origin of atomic structure, molecular structure with vibrational, rotational, and electronic Spectra

Unit-I Vector Atom Model 9 hrs.

Bohr-Sommerfeld model of atomic structure, atomic quantum numbers – hydrogen spectrum – fine structure of hydrogen atom, Larmor precession, Electron spin, Vector atom model, Spectroscopic terms and their notations, Stern and Gerlach Experiment, Spin - Orbit interaction and fine structure, Relativistic corrections for energy levels of hydrogen atom, Lamb shift.

Unit-II Many-electron atoms 9 hrs.

Identical particles, Pauli's exclusion principle and electronic configuration, Spectrum of helium. Central field approximation and the periodic table, L-S and j-j coupling, Landau g factor – Equivalent and nonequivalent electrons, Spectrum of alkali and alkaline atoms.

Unit- III Hyperfine Structure of Spectral Lines 9 hrs.

Normal and anomalous Zeeman Effect, Paschen-Bach & Stark effect, Isotope Effects, Nuclear Spin and Hyperfine Splitting, Intensity Ratio and Determination of Nuclear Spin, Zeeman Effect in Hyperfine Structure, Origin of X-ray Spectra and Electron Paramagnetic Resonance.

Unit- IV Molecular Physics **9 hrs.**

Types of Molecular spectra, Born-Oppenheimer approximation, rotational spectra of diatomic molecule as a rigid rotator, Energy levels and Spectra of a non-rigid diatomic molecule, Effect of isotopic substitution on rotational spectra, Vibrational-Rotational spectra, vibrating diatomic molecule as a harmonic oscillator and as anharmonic oscillator. Electronic Spectra, Frank Condon principle.

Unit- V Raman and NMR Spectroscopy **9 hrs.**

Raman Spectroscopy-Raman scattering classical and quantum theories, Vibrational and rotational Raman spectra, Selection rules, Infrared spectroscopy –basic concept of IR spectroscopy –IR spectrometer –Principle and Instrumentation. NMR spectra-principle, spectrometer, Chemical shifts, and applications.

Textbooks:

1. Principles of Modern Physics by A.K.Saxena, 2nd Edition, Narosa Publishing, 2010
2. Fundamentals of Molecular Spectroscopy by C.N.Banwell and E.M Cash, TMH 4th Edition, 1994
3. Atomic and Molecular Spectra - Rajkumar
4. Introduction to Atomic Spectra H. E. White

Course Outcomes:

1. Understanding the atomic structure through atomic models. Understanding the fine structure in Hydrogen atom by using spin – orbit interaction. Introducing Pauli’s exclusion principle and electronic configuration.
2. Extract spectroscopic information from single and many electron atoms.
3. Understanding the fine structure of the atoms in the presents of magnetic and electric fields.
4. Understanding the origin of X-ray and principle of EPR
5. Understanding the types of molecular spectra.
6. Understanding electronic transitions in different molecules using Frank-Condon principle. Understanding the principle of Raman and IR spectroscopy.
7. Understanding the NMR spectroscopic technique for analyzing various material properties.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**3**	**3**		**3**		**3**	**3**		**2**		**2**
CO2	**3**	**3**		**3**		**3**	**3**		**2**		**2**
CO3	**3**	**3**		**3**		**3**	**3**		**2**		**2**
CO4	**3**	**3**		**3**		**3**	**3**		**2**		**2**
CO5	**3**	**3**		**3**		**3**	**3**		**2**		**2**
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

II - SEMESTER

SPH 706: ADVANCED QUANTUM MECHANICS

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessionals: 40 Marks

Preamble: This course imparts knowledge on the advanced level of quantum mechanics

Objective: To develop knowledge in the foundations of quantum mechanics and its applications to advanced phenomena/systems/problems.

Unit- I Approximate Methods 9 hrs.

WKB Approximation, connecting formulas, its validity, Barrier penetration, Alpha emission, and bound states in Potential well and Bohr Sommerfeld quantum condition, Perturbation theory for time evolution problems- harmonic perturbation, transition of continuum states.

Unit- II Scattering 9 hrs.

Scattering differential cross-section, the scattering of the wave packet, Born approximation and its applications, Partial wave analysis method, Expansion of a plane wave in terms of partial waves, determination of the phase shifts and scattering amplitude, optical theorem, and applications.

Unit- III Identical particles and Many Electrons Atoms 9 hrs.

Indistinguishable particles, interchange symmetries, exchange degeneracy, Pauli's exclusion principle, a spin of two and three electrons, spectra of Helium atom, ortho and para helium, Many Electro atoms- Central field approximation, Thomas Fermi model of atom, Hartree equation and Hartree Fock Equation (statement only).

Unit- IV Relativistic Wave Equations **9 hrs.**

Introduction-Generalization of Schrödinger equation, Klein Gordan Equation- its interpretation, Plane wave solutions, Charge and current densities, Interaction with electromagnetic field and Nonrelativistic limit, Dirac Equation- Relativistic Hamiltonian, Position probability density, Dirac matrices, Plane wave solutions, Spin of Dirac particle, Negative energy states, Magnetic Moment of electron, Spin orbit interaction.

Unit -V Quantization of Fields **9 hrs.**

Introduction, Classical approach to field theory, Relativistic Lagrangian and Hamiltonian of charged particle in electromagnetic field, Lagrangian and Hamiltonian formulations Quantum equation, second quantization, Quantization of non-relativistic Schrodinger equation, Klein Gordan equation.

Textbooks:

1. A text book of Quantum Mechanics- P. Mathews and K.Venkatesan
2. Quantum MechanicsG.Aruldas
3. Quantum Mechanics-V.K.Thankappan
4. Fundamentals of Quantum Mechanics R.D.Ratna Raju

Course Outcomes:

1. The approximation methods will be understood and attributed to various problems
2. Concepts of Scattering differential cross section, the scattering of wave packet is realized with phase shifts and scattering amplitude
3. Indistinguishable particles, symmetries, Pauli's exclusion principle are realized and extended to many electrons systems
4. Schrodinger wave equation is understood under relativistic conditions and Concept of negative energy is understood.
5. Lagrangian and Hamiltonian formulations are understood

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**3**	**3**		**3**		**3**	**3**		**2**		**2**
CO2	**3**	**3**		**3**		**3**	**3**		**2**		**2**
CO3	**3**	**3**		**3**		**3**	**3**		**2**		**2**
CO4	**3**	**3**		**3**		**3**	**3**		**2**		**2**
CO5	**3**	**3**		**3**		**3**	**3**		**2**		**2**
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

II – SEMESTER

SPH 708 ELECTRONIC DEVICES AND CIRCUITS

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 — End Examination: 60 Marks

Credits: 3 — Sessionals: 40 Marks

Preamble: Electronics is a primary subject to gain knowledge about the basic semiconducting materials and the art of making devices – from diode, transistors, amplifiers, oscillators to memory devices. The course is designed to motivate students to develop an understanding of essential devices in detail, which are building blocks for modern-day electronic devices.

Objective: To analyze electronic devices for their characteristics, amplification, and frequency response. Implementation of logic circuits with Boolean expressions and their application to counters with sequential logic gates.

Unit-I BJT and FET amplifiers **9 hrs.**

Bipolar Junction Transistor: configurations, Biasing, BJT as an amplifier, BJT characteristics, Frequency response of BJT, Applications of Transistor. Field Effect Transistor: Construction and characteristics, Biasing, FET as an amplifier, and Applications of FET. MOSFET: Introduction, Depletion and Enhancement type MOSFETs. Feedback concepts: Practical feedback circuits, Feedback amplifiers, Oscillator operation, types of oscillators

Unit-II Operational Amplifiers **9 hrs.**

Op-amp basics, parameters, Differential and common mode operation, virtual ground, practical op- amp circuits – Integrator, Differentiator and Summing amplifier. Op-amp Applications- Constant gain multiplier, Voltage to Current Converter, Current to Voltage Converter, Instrumentation Amplifier, Oscillators, Logarithmic and Anti Logarithmic Amplifiers, Schmitt trigger, Comparators.

Unit-III Linear ICs and Optoelectronic Devices **9 hrs.**

Linear Ics: About IC 555 (Timer) and its applications: A stable, Monostable and Bistable multivibrators. VCO (IC 566), PLL (IC 565). Optoelectronic Devices Structure and operation, characteristics, spectral response, and applications of LDR, Photo Voltaic cell, Photo diode, Photo transistor, LED, and LCD.

Unit-IV Combinational Logic Circuits: **9 hrs.**

Simplification of Boolean expressions: Algebraic method, Karnaugh map method, EX-OR, EX-NOR gates, Encoders and Decoders, Multiplexers and Demultiplexers. Digital arithmetic operations and circuits: Binary addition, subtraction, multiplication, and division. Design of adders, subtractors and Parallel binary adders.

Applications of Boolean Algebra: Magnitude comparator, Parity generator and checker, Code converters, seven segment decoder /Driver display, ALU design.

Unit-V Sequential Logic Circuits **9 hrs.**

Flip-Flops: NAND latch, NOR latch, R-S, J-K, T-flip-flops, D-Latch Counters: Asynchronous (ripple) counters, Counters with MOD number <2 n, Down counter, Synchronous counters, Up- down counter, Ring counter, Johnson counter. Applications of counters Registers: Shift registers, PIPO, SISO, SIPO, PISO, State diagrams.

Textbooks:

1. Electronic Devices and Circuit Theory R. Boylestad and L. Nashelsky- 10th Edition – Pearson
2. Digital Systems Principals and Applications Ronald J Tocci- 10th Edition –Pearson
3. Digital Design Morris Mano- 4th Edition Pearson
4. Op-Amp Applications Ramakanth Gaykward – 4th Edition- PHI

Course Outcomes:

1. Understand Bipolar Junction transistor (BJT), Field effect transistor (FET), their characteristics and applications as amplifiers, feedback circuits.
2. Student understands the basics of OP-Amp and Op-amp applications.
3. Understand the construction of IC555 timer and its application as multivibrators.
4. Learn the binary number system, Boolean operations, binary Gates, different athematic devices like Adders, subtractors, encoders, decoders, multiplexers, etc.
5. Learn the Karnaugh map technique to simplify the Boolean expressions. and understands the concept of sequential logic circuits – Flip flops, counters, and registers.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	2	2		2		2	2		2		2
CO2	2	2		2		2	2		2		2
CO3	2	2		2		2	2		2		2
CO4	2	2		2		2	2		2		2
CO5	2	2		2		2	2		2		2
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

II - SEMESTER

SPH 742 ELECTRONIC MEASUREMENTS AND INSTRUMENTATION

(Common with M.Sc. Electronic Science)

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3

Credits: 3

End Examination: 60 Marks

Sessionals: 40 Marks

Preamble: This course was designed to introduce Instrumentation techniques

Objective: To explain basic concepts of measurement, importance of signal generators and analyzers.

Unit-I Fundamental Measurements **9 hrs.**

Accuracy, Precision, Types of errors, Standards of measurements, Electronic Instruments: RMS, BJT and FET voltmeters, electronic multimeter, Q meter, LCR meter, vector impedance meter, Power meter, Measurement of Inductance, Capacitance and Effective resistance at high frequency, CRO- study of various stages in brief, measurement of voltage, current, phase and frequency, Digital and storage oscilloscopes.

Unit-II Instruments for Generation and Analysis of waveforms **9 hrs.**

Signal generators, function generator, wave analyzers- Harmonic distortion analyzer, spectrum analyzer and spectrum analysis. Recording Instruments: X-Y, Strip chart, Magnetic tape and Digital tape recorders, Transducers: Classification of transducers, Strain gauze, LVDT Thermocouple, Piezo- electric and photoelectric transducers, Flow measurement transducer.

Unit-III Data Acquisition Systems **9 hrs.**

D/A conversion- Linear weighted and ladder type. A/D conversion- Digital ramp ADC, Successive approximation method, Data loggers, Signal Conditioning of the inputs, Computer based data systems, Electronic Indicating instruments: Seven Segment Display, Fourteen Segment Display, Nixie tube, LED, and LCD display devices.

Unit-IV Bio-Medical Instrumentation **9 hrs.**

Sources of Biomedical Signals, Basic Medical Instrumentation System, Origin of Bioelectric signals, Recording Electrodes- Electrode-tissue interface, Skin contact impedance, Biosensors, Measurement of Heart rate, Blood pressure measurement, blood flow meters. Bio-Medical Instruments: ECG, EEG, EMG, Electronic Pacemaker.

Unit-V Medical Imaging Systems **9 hrs.**

Radiography, X-Ray machine, CT scanner, Nuclear Medical Imaging systems: Physics of Radio Activity, Radiation Detectors, Gamma Camera, NMR imaging. Ultrasonic Imaging Systems, Ultrasonic Therapy Unit, Angiography and Fluoroscopy.

Textbooks:

1. Electrical and Electronic Measurements and Instrumentation Sawhney, Dhanpat Rai Publications, 3rd Edition, 2005
2. Handbook of Biomedical Instrumentation- Khandpur by Tata McGraw Hill- 2nd Edition
3. Medical Instrumentation by Application & Design – John G. Webster, Houghton Mifflin & Co., Boston
4. Biomedical Instrumentation by Marvin D. Wirs, Chilton Book Co., London

Course Outcomes:

1. Deals with fundamentals of measurements in electronic circuits and operation of CRO
2. To understand the Instruments for Generation and Analysis of waveforms and describe recording instruments.
3. Will be able to understand data Acquisition Systems and know about LCD/LED Displays
4. To understand bioelectric potentials and the construction of medical systems.
5. Will be able to understand medical imaging systems and know the operation of NMR

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**2**	**2**		**2**		**2**	**2**		**2**		**2**
CO2	**2**	**2**		**2**		**2**	**2**		**2**		**2**
CO3	**2**	**2**		**2**		**2**	**2**		**2**		**2**
CO4	**2**	**2**		**2**		**2**	**2**		**2**		**2**
CO5	**2**	**2**		**2**		**2**	**2**		**2**		**2**
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

II – SEMESTER

SPH 744 ADVANCED ELECTROMAGNETIC THEORY

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 | End Examination: 60 Marks

Credits: 3 | Sessionals: 40 Marks

Preamble: It is an advanced course on electrodynamics with a focus on Maxwell's equations, radiating systems and accelerated radiating systems and electromagnetic waves in a medium.

Objective: To gain knowledge on electromagnetic wave transmission, radiating systems and its interaction with matter.

Unit- I Electromagnetic Fields and Waves **9 hrs.**

Axiomatic classical electrodynamics, Complex notation, and physical observables. Physical observables and averages Maxwell equations in Majorana representation, wave equations for E and B The time-independent wave equations for E and B, Electromagnetic Potentials and Gauges- scalar potential, vector potential, electrodynamics potentials, Gauge conditions- Lorenz-Lorentz gauge Coulomb gauge, velocity gauge and Gauge transformations

Unit –II Fundamental Properties of the Electromagnetic Field **9 hrs.**

Discrete symmetries, Charge conjugation, spatial inversion and time reversal, C symmetry P symmetry, T symmetry, Continuous symmetries, General conservation laws- Conservation of electric charge, Conservation of energy. Conservation of linear (translational) momentum- Gauge-invariant operator formalism, Conservation of angular (rotational) momentum- Gauge-invariant operator formalism Electromagnetic duality and Electromagnetic virial theorem.

Unit- III Radiation and Radiating Systems **9 hrs.**

Radiation of linear momentum and energy, Monochromatic signals Finite bandwidth signals and radiation of angular momentum. Radiation from a source at rest– electric multipole moments, Hertz potential, Electric dipole radiation, Magnetic dipole radiation. Radiation from an extended source volume at rest- Radiation from a one-dimensional current distribution.

Unit- IV Accelerated Radiating Systems **9 hrs.**

Radiation from a localized charge in arbitrary motion –The Lienard-Wiechert potentials, Radiation from an accelerated point charge –The differential operator method, The direct method, small velocities, Bremsstrahlung, Cyclotron and synchrotron radiation in general case and virtual photons.

Unit- V Electromagnetic Fields and Matter **9 hrs.**

Maxwell’s macroscopic theory- Polarization and electric displacement, Magnetization and the magnetizing field, Macroscopic Maxwell equations. Phase velocity, group velocity and dispersions. Radiation from charges in a material medium –Vavilov-Cerenkov radiation Electromagnetic wave in conductive media, wave equations for E and B and plane waves.

Textbooks:

1. Classical Electrodynamics J.D Jackson, 3rdEdition, Wiley, 1998.
2. Introduction to Electrodynamics D.Grifiths, PHI, 3rd Edition, 1999
3. Electromagnetic waves and Radiating systems K.Jordan and E Balmen Wiely, 2nd Ed.

Course Outcomes

1. Understanding Maxwell's equations and wave equations for E and B, Electrodynamics potentials and different transformations will be understood.
2. Understanding various symmetries, and understanding conservation of energy, conservation of linear momentum and conservation of angular momentum in fields.
3. Learn about linear momentum and energy of radiation with radiations from electric dipole and magnetic dipole will be understood.
4. Learn about radiation from moving charges, Lienard-Wiechert potentials, Cyclotron and

synchrotron radiation will be understood.

5. Maxwell's macroscopic theory will be learned. Along with Radiation from charges in a material medium

	PO 1	**PO 2**	**PO3**	**PO 4**	**PO 5**	**PO6**	**PSO 1**	**PSO 2**	**PSO3**	**PSO4**	**PSO5**
CO1	**3**	**3**		**3**		**3**	**3**		**2**		**2**
CO2	**3**	**3**		**3**		**3**	**3**		**2**		**2**
CO3	**3**	**3**		**3**		**3**	**3**		**2**		**2**
CO4	**3**	**3**		**3**		**3**	**3**		**2**		**2**
CO5	**3**	**3**		**3**		**3**	**3**		**2**		**2**

Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation

M.Sc. PHYSICS

II – SEMESTER

SPH 746 PHYSICS OF SEMICONDUCTOR DEVICES

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessionals: 40 Marks

Preamble: The course provides an introduction to the basic concepts in semiconductors, various transistors, and photonic devices. It develops the design of integrated circuit skills in electronic devices.

Objective: Understanding transport phenomena in solids, applications of semiconductor devices and microwave devices in design of amplifiers.

Unit- I Transport phenomena in Solids. 9 hrs.

Energy bands: insulator, metal semiconductor, intrinsic and extrinsic semiconductor, direct and indirect semiconductor, Fermi level variation in semiconductor, temperature dependence of carrier concentration, carrier dynamics in semiconductors, carrier transport by drift and diffusion scattering low field response, high field transport, impact ionization, band to band tunneling charge injection and quasi-Fermi levels.

Unit- II Bipolar Transistors 9 hrs.

BJT static performance parameters: Emitter injection efficiency r devices nay, base transport factor, collector efficiency and current gain, Transient response: Cutoff saturation, the switching cycle, frequency limitations of transistors, secondary effects in real devices: Early effect and punch through thermal effects, current crowding effect, high injection, and Krik effect.

Unit- III Field Effect Transistors 9 hrs.

MOS device: MOS as capacitor, V-I characteristics, Depletion and Enhancement MOSFET, Complementary MOSFET, important issues in real devices: short channel effects, substrate bias, effects, latch-up, sub-threshold characteristics, leakage currents, a charge transfer device, basic principle applications.

Unit- IV Microwave and Photonic Devices 9 hrs.

Tunnel diode, IMPATT and Gunn diode, varactor diode, characteristics of microwave transistor, tunnel transistor, LED, photodetectors, solar cells, semiconductor lasers

Unit -V Integrated Circuits 9 hrs.

Evolution of ICs: Small Scale Integration, Medium Scale Integration, Low Scale Integration, Very Large- Scale Integration, Monolithic and Hybrid circuits, Monolithic IC process: Crystal growth, Wafer preparation, Metallization, Testing, Bonding and Packaging.

Textbooks:

1. Solid state electronic devices, Ben. G. Streetman and S. Banerjee, PHI, 6th Edition, 2005
2. Semiconductor devices - Basic principles, Jasprit Singh (John Wiley), 1st Edition, 2000

Course Outcomes:

1. Understanding the classifications of materials-based band theory and transport phenomena in Solids.
2. Understanding the working and performance of BJT and different effects in BJT.
3. Understanding the working of FET and characteristics of FET.
4. Understanding the working and performance of different diodes and different detectors.
5. Understanding the different techniques for designing ICs and design integrated circuit skills in electronic devices.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**1**	**2**	**2**	**2**		**2**		**2**	**2**		**2**
CO2	**1**	**2**	**2**	**2**		**2**		**2**	**2**		**2**
CO3	**1**	**2**	**2**	**2**		**2**		**2**	**2**		**2**
CO4	**1**	**2**	**2**	**2**		**2**		**2**	**2**		**2**
CO5	**1**	**2**	**2**	**2**		**2**		**2**	**2**		**2**
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

II – SEMESTER

SPH 748 INTRODUCTION TO GENERAL RELATIVITY

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessionals: 40 Marks

Course Description:

This course offers a comprehensive introduction to General Relativity (GR), the theory of gravitation formulated by Albert Einstein. It aims to provide students with a deep understanding of the geometric nature of gravity and its implications for the structure of space-time.

Course Objectives:

- Understand the Principles of General Relativity.
- Develop Proficiency in Tensor Calculus and Differential Geometry.
- Understand Geodesic Equation and Motion in Curved Space-Time.
- Understanding the Einstein Field Equations.
- Understanding the origin of gravitational waves.

Prerequisite: Special theory of relativity.

Unit-I Basic Introduction **5 hrs.**

Accelerated reference frames, Ehrenfest Paradox, The equivalence principle, Principle of general covariance, Manifolds, Curvilinear coordinates, Effect of gravity on light, Metric tensor.

Learning outcomes: After the completion of this Unit the student

- will get grasp on fundamental principles in General relativity along with a brief introduction curvilinear coordinate.

Unit-II: Tensor Analysis **10 hrs.**

Covariant and contravariant vectors and tensors, The coordinate transformations of covariant and contravariant vectors and tensors, tensor operations, the properties of the metric tensor, Covariant derivatives, Christoffel symbols, Curvature tensor, Curvature Scalar.

Learning outcomes: After the completion of this Unit the student

- will get exposed to the mathematical tools required for the formulation and manipulation of the Einstein field equations, such as tensor calculus and differential geometry.

Unit- III: Particle in a Gravitational Field **10 hrs.**

Gravitational fields in non-relativistic mechanics, The gravitational field in relativistic mechanics, Distances and time intervals, The relation of the Christoffel symbols to the metric tensor, Geodesic equation.

Learning outcomes: After the completion of this Unit the student

- will get sufficient knowledge to calculate and interpret the trajectories of particles in curved space-time and understand the influence of gravitational fields on their motion.

Unit- IV: The Gravitational Field Equations **10 hrs.**

The curvature tensor, Properties of the curvature tensor, Einstein-Hilbert Action, The energy-momentum tensor, The gravitational field equations, Newton's law from Gravitational Field Equations, The centrally symmetric gravitational field, Schwarzschild Solution for centrally Symmetric gravitational Fields.

Learning outcomes: After the completion of this Unit the student

will understand Einstein field equations.

Unit- V: Gravitational waves **10hrs.**

Linearized Gravity, Weak field approximation, Weak gravitational fields, Wave solutions in linearized gravity and Gravitational radiation, Polarization states of gravitational waves (plus and cross modes), Detection methods of Gravitational Waves.

Learning outcomes: After the completion of this Unit the student

- will understand the origin of gravitational waves by linearizing Einstein's equation.

Textbooks:

1. A first course in general relativity - B Schutz, Cambridge University Press, ISBN: 978-0521887052
2. Gravitation: Foundations and Frontiers - T. Padmanabhan, Cambridge University Press, ISBN:978-0521882231
3. Gravitation - Charles W. Misner, Kip S. Thorne, and John Archibald Wheeler, Princeton University Press, ISBN:978-0691177793

References:

1. General Relativity : The Theoretical Minimum – Leonard Susskind and Andre Cabannes
2. The classical theory of fields – L.D Landau and E.M Lifshitz, Butterworth-Heinemann, ISBN:978-0750627689
3. General theory of Relativity - PAM Dirac, Princeton University Press, ISBN: 978-0691011462
4. Gravity -James B Hartle, Pearson, ISBN:978-0805386622
5. General Relativity -R. Wald, Overseas, ISBN: 8188689270
6. The Large-Scale Structure of Space Time - S. Hawking and J. Ellis, Cambridge University Press ISBN: 978-0521099066
7. Gravitation and Cosmology - S. Weinberg, John Wiley & Sons Inc, ISBN: 978-0471925675

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	1	2	2	2		2		2	2		2
CO2	1	2	2	2		2		2	2		2
CO3	1	2	2	2		2		2	2		2
CO4	1	2	2	2		2		2	2		2
CO5	1	2	2	2		2		2	2		2
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

II – SEMESTER

SAE 702 PROFESSIONAL COMMUNICATION SKILLS

L	T	P	S	J	C
0	0	4	0	0	2

Hours per week: 4

Credits: 2 Continuous Evaluation: 100 Marks

Objective:

To enable students to

1. acquaint themselves with basic English grammar.
2. acquire presentation skills.
3. develop formal writing skills.
4. develop creative writing skills.
5. keep themselves abreast with employment-readiness skills.

UNIT-I Back to Basics:

Tenses, Concord – Subject Verb Agreement, Correction of Sentences-Error Analysis, Vocabulary building

UNIT -II Oral Presentation

What is a Presentation? Types of Presentations, Technical Presentation – Paper Presentation Effective Public Speaking, Video Conferencing,

UNIT- III Documentation

Letter –Writing, E-mail Writing & Business Correspondence, Project Proposals, Report Writing, Memos, Agenda, Minutes, Circulars, Notices, Note Making

UNIT- IV Creative Writing

Paragraph Writing, Essay writing, Dialogue Writing, Précis Writing, Expansion of Hints, Story Writing

UNIT V Placement Orientation

Resume preparation, group discussion – leadership skills, analytical skills, interviews –Types of Interviews, Preparation for the Interview, Interview Process

Textbooks:

1. Essentials of Business Communication by Rajendra Pal and J S Kalahari, Sultan Chand & Sons, New Delhi.
2. Advanced Communication Skills by V. Prasad, Atma Ram Publications, New Delhi.
3. Effective Communication by Ashraf Rizvi, McGraw Hill Education; 1 edition (27 June 2005)
4. Interviews and Group Discussions How to face them, T.S.Jain, Gupta, First Edition, New Delhi.
5. High School English Grammar and Composition, PCWeek & Martin, N.D.V.Prasada Rao (Editor), S.Chand, 1995.

M.Sc. PHYSICS

II – SEMESTER

SPH 722: MODERN OPTICS AND NUCLEAR PHYSICS LAB

L	T	P	S	J	C
0	0	4	0	0	2

Hours per week: 4 Continuous Evaluation: 100 Marks

Credits: 2

Objective: Analyze and visualize Laser light and Radiation from radioactive sources

1. He-Ne Laser –Diffraction Grating
2. Divergence of Laser Beam
3. Optical Fiber- Numerical Aperture and Bending losses
4. Optical Fiber Characteristics
5. Plateau Characteristics
6. Intensity variation of radiation
7. Inverse square law for gamma radiation
8. Absorption Coefficient of material
9. Statistical Aspects of Radiation
10. Beta back scattering factor
11. Dead time and Resolving time

Course Outcomes:

1. understand the physics principles behind the experiments and identify errors in the experiments.
2. understand the functions of components used in the experiments
3. Gained the ability to set the proper experimental conditions for the measurement of a physical quantity with a given apparatus
4. Design a measurement involving nuclear or natural radiation
5. Match the type of detector to the intended measurement process

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**2**	**2**	**2**	**2**		**2**	**2**	**2**	**2**		**2**
CO2	**2**	**2**	**2**	**2**		**2**	**2**	**2**	**2**		**2**
CO3	**2**	**2**	**2**	**2**		**2**	**2**	**2**	**2**		**2**
CO4	**2**	**2**	**2**	**2**		**2**	**2**	**2**	**2**		**2**
CO5	**2**	**2**	**2**	**2**		**2**	**2**	**2**	**2**		**2**

Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation

M.Sc. PHYSICS

II – SEMESTER

SPH 724 ELECTRONIC DEVICES AND CIRCUITS LAB

L	T	P	S	J	C
0	0	4	0	0	2

Hours per week: 4 Continuous Evaluation: 100 Marks

Credits: 2

Objective: Application of various electronic devices in design of frequency and amplification. Implementation of logic gates for Boolean algebra with conversion from one system to another and its states for counting.

Any 10 Experiments

1. Active Band pass filter (IC 741)
2. Astable multivibrator (IC 555)
3. Wein bridge oscillator (IC 741)
4. Op-amp as Differentiator (IC 741)
5. Op-amp as Integrator (IC 741)
6. Twin T filter (IC 741)
7. Implementation of logic gates
8. Study of Adder and Subtractor (IC 7483)
9. Binary to Gray code converter (IC 7486)
10. BCD to Excess-3 code converter (7486)
11. Design of Flip-Flops with basic gates (IC 7486)
12. Multiplexer and Demultiplexer (IC 74151, 74154)
13. UP-Down counter (IC 74192,74193)

Course outcomes

1. Understanding the principles of active bandpass filters using IC 741.
2. Analyzing the operation and characteristics of astable multivibrators employing IC 555.
3. Investigating the working principle and frequency stability of Wein bridge oscillators with IC 741.
4. Exploring the functionality of operational amplifiers (op-amps) as differentiators using IC 741.
5. Demonstrating the operation of operational amplifiers (op-amps) as integrators with IC 741.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	1	2	2	2		2		2	2		2
CO2	1	2	2	2		2		2	2		2
CO3	1	2	2	2		2		2	2		2
CO4	1	2	2	2		2		2	2		2
CO5	1	2	2	2		2		2	2		2
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.SC. PHYSICS

III SEMESTER

SPH 801 SOLID STATE PHYSICS

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessionals: 40 Marks

Preamble:

This course explores the structure and behavior of crystalline materials, covering topics such as crystal structure, lattice vibrations, and electrical properties. Students will study atomic composition, lattice vibrations, and magnetic and superconducting phenomena in materials. The course also examines electrical conductivity, dielectric behavior, and the fascinating realm of magnetism and superconductivity.

Course Objectives:

- Comprehend the basics of crystallography, including crystal structures, unit cells, symmetry operations, and reciprocal lattice.
- Understand classical lattice heat capacity and quantum theories, such as Einstein and Debye models, and their implications.
- Explore the various mechanisms of electrical and thermal transport in materials.
- Explore dielectric losses, relaxation phenomena, and spectroscopic techniques.
- Explore permanent magnetic moments and ferromagnetic domains, along with the concepts of antiferromagnetism and ferrimagnetism.

Unit -I Introduction to Crystals 9 hrs.

Crystal structure, Unit cell, Symmetry operations-translation and point, crystal types, Indices of lattice direction and plane, interplanar spacing, the density of atoms in crystal plane, Crystal structure simplest, CsCl, NaCl, Alkali metals, Diamond, and HCP. Reciprocal lattice, Braggs law, Laue interpretation of crystals, Imperfections in Crystal- Point, line, Burger vector, dislocation, and Surface imperfections.

Unit -II Lattice Vibrations (no change) **9 hrs.**

Introduction, Dynamics of chain of identical atoms, diatomic linear chain, Reststrahlen band, theory of harmonic approximation, Normal modes of real crystals, quantization of lattice vibration. Classical Lattice heat capacity, quantum theory of lattice heat capacity-average thermal energy of harmonic oscillator, Einstein and Debye model and Anharmonic effects-thermal expansion, phonon collision and thermal conductivity

Unit -III Electronic theory of Solids **9 hrs.**

Free electron gas, electrical conductivity, Fermi surface and its effects on electrical conductivity, failure of free electron model, Energy bands in solids-Bloch theorem, periodicity of Bloch functions and eigen values, Kronig Penney model, nearly free electron model, zone schemes for energy bands, tight binding approximation, estimation of cohesive energy. Concept of holes effective mass, Hall effect and thermoelectric power

Unit -IV Dielectric Properties of materials **8 hrs.**

Polarization, dielectric constant, local electric field, dielectric constant, and its measurement, dielectric polarizability, sources of polarizability- theory of electronic, ionic and orientation. Dielectric losses, Dielectric Relaxation, Dielectric Spectroscopy, piezo, pyro and ferroelectric properties of crystals, ferroelectricity, ferroelectric domains.

Unit -V Magnetic and Superconducting Materials **10 hrs.**

Classification of Magnetic Materials-Overview of magnetic materials, Types: ferromagnetic, antiferromagnetic, ferrimagnetic, Dia- and paramagnetic; Atomic Theory of Magnetism-Hund's rules and magnetic moments, Langevin theory of Dia- and Para magnetism, Quantum theory and magnetic susceptibility formulation; Permanent Magnetic Moments-Origin and characteristics, Weiss molecular field in ferromagnetism, Ferromagnetic domains and domain theory; Antiferromagnetism and Ferrimagnetism- Concepts and characteristics, Magnetic properties and applications

Superconductivity: Type-I and Type-II superconductors, Josephson junctions and their applications, BCS theory and microscopic mechanism

Textbooks:

1. Introduction to Solid State Physics by Charles Kittel
2. Solid State Physics by Neil W. Ashcroft and N. David Mermin
3. Solid State physics by M.A.Wahab Narosa Publishing House, 2005
4. Dielectric Spectroscopy of Electronic Materials: Applied Physics of Dielectrics, by Yuriy Poplavko, 2021, Woodhead Publishing ISBN: 978-0-12-823518-8

Course Outcomes:

Upon successful completion of this course, you will be able to:

1. Apply your knowledge of Bravais lattices, reciprocal lattices, and diffraction patterns to characterize crystal structures.
2. analyze lattice vibrations, understanding theories of heat capacity, and applying quantum models to real crystals.
3. Describe the free electron theory and its limitations in explaining electronic specific heat and Interpret the Hall effect and thermoelectric power as manifestations of band structure and carrier properties.
4. analyze and apply knowledge of dielectric properties, including polarization, losses, and the unique characteristics of ferroelectric materials.
5. demonstrate competence in classifying magnetic materials, understanding atomic theories of magnetism, and analyzing the properties and applications of superconductors

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	3	3	2	2	2	3		2	2	2	2
CO2	3	3	2	2	2	3	2	2	2	2	2
CO3	3	3	2	2	2	3	2	2	2	2	2
CO4	3	3	2	2	2	3	2	2	2	2	2
CO5	3	3	2	2	2	3		2	2	2	2

Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation

M.Sc. PHYSICS

III – SEMESTER

SPH 803 NUCLEAR AND PARTICLE PHYSICS

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 | End Examination: 60 Marks

Credits: 3 | Sessionals: 40 Marks

Preamble: To attribute and realize particle phenomena of matter.

Objective: Acquaintance of basic laws of nuclear and particle physics to understand the nuclear stability and decay mechanisms.

Unit-I General Properties, Nuclear Forces and Models 9 hrs.

Introduction to nuclear properties, semi empirical mass formula, nuclear magnetic dipole moment, electric quadrupole moment. Deuteron bound state problem-excited states of the deuteron, Nucleon- nucleon scattering, Proton-proton and neutron-neutron interactions, nuclear shell model: magic numbers, spin orbit interaction, prediction of angular momenta and parities for ground states.

Unit-II Radioactivity and Nuclear Decay 9 hrs.

The radioactive decay law, production and decay of radioactivity, natural radioactivity, α-decay process, Geiger Nuttal Law, Gamow's theory of α decay, Fermi's theory of γ decay, selection rules, parity violation in γ -decay, properties of neutrino, energetics of gamma decay, selection rules, angular correlation, Internal conversion.

Unit-III Nuclear Reactions 9 hrs.

Introduction, kinds of nuclear reactions, conservation laws, nuclear reaction kinematics, charged particle reaction spectroscopy, neutron spectroscopy, nuclear cross section, compound nucleus, nuclear transmutations by α, protons, neutrons, deuterons, nuclear reactions with heavy ions, nuclear reaction cross section, different stages of nuclear reactions.

Unit IV Nuclear Energy **9 hrs.**

Nuclear Fission, types of fission, distribution of fission products, neutron emission in Fission, fissile and fertile materials, spontaneous fission, Bohr-Wheeler theory of nuclear fission, Nuclear Fusion, plasma fusion reactions, energy balance, Solar fusion, types of nuclear reactors.

Unit-V Elementary Particle Physics **9 hrs.**

Introduction, Classification of elementary particles, Particle interactions and families, symmetries and conservation laws of energy and momentum, angular momentum, parity, Baryon number, Lepton number, isospin, strangeness quantum number, Gellman and Nishijima formula, K-mesons and hyperons, Elementary ideas of CP and CPT invariance, Quark model and Grand Unified Theories.

Textbooks:

1. Introductory Nuclear Physics-Kenneth S. Krane
2. Nuclear Physics D.C.Tayal, Himalaya publishing Co.,
3. Introduction to Nuclear Physics Harald A.Enge
4. Atomic Nucleus RD Evans
5. Introduction to Elementary Particles by D. Griffiths

Course Outcomes:

1. The introduction to different properties of the nucleus. The student is able explain the origin of the various terms in the semi-empirical mass formula and in the nuclear shell model. Explain the different forms of radioactivity and account for their occurrence.
2. The student is able to explain alpha, beta and gamma decay at a basic particle physics level. Able to perform basic calculations of alpha, beta, and gamma decay. The student is able to understand the nuclear reactions and their classifications.
3. Performs basic kinematics of nuclear reactions with different incident particles. Able to explain the concepts of fission (spontaneous and induced), chain reactions and fusion, and perform the associated calculations demonstrating energy release.
4. Learns to apply the concepts of fission and fusion to power generation and the sun as examples.
5. Learns the classification of elementary particles according to their quantum numbers and

draw simple reaction diagrams (Feynman diagrams). Learn the concepts of Quark model and other unification theories.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**2**	**2**		**2**		**3**	**2**		**2**		**2**
CO2	**2**	**2**		**2**		**3**	**2**		**2**		**2**
CO3	**2**	**2**		**2**		**3**	**2**		**2**		**2**
CO4	**2**	**2**		**2**		**3**	**2**		**2**		**2**
CO5	**2**	**2**		**2**		**3**	**2**		**2**		**2**
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

III – SEMESTER

SPH 805 ANALOG AND DIGITAL COMMUNICATION

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 — End Examination: 60 Marks

Credits: 3 — Sessionals: 40 Marks

Preamble: To introduce concept of modulation with Analog and Digital information signals.

Objective: Understanding communication between transmitter and receiver with baseband, band pass, coding techniques in communication systems.

Unit-I Amplitude Modulation **9 hrs.**

Introduction, Amplitude Modulation, Amplitude Modulation index, MI for Sinusoidal Modulation Index, Frequency spectrum, Average Power for sinusoidal amplitude modulation. Effective voltage and current for Sinusoidal Amplitude Modulation. Amplitude Modulator circuits and Amplitude demodulator circuits and superheterodyne receiver

Unit II Single Side Band Modulation **9 hrs.**

Non sinusoidal modulation, double side band suppressed carrier modulation. Introduction to single side band, principles of SSB, balanced Modulators, SSB generation and SSB reception, modified SSB systems, signal to noise ratio for SSB systems and commanded single side band.

Unit-III Angle Modulation **9 hrs.**

Introduction, frequency modulation, Sinusoidal F.M, frequency spectrum of sinusoidal FM, Average Power of sinusoidal FM. Non-Sinusoidal Modulation, Deviation ratio. Measurement of modulation index for sinusoidal FM. Phase Modulation- equivalence between PM and FM. FM Transmission - Direct and Indirect methods.FM detectors- Slope detector, balanced double tuned detector and PLL detector.

Unit-IV Pulse Modulation 9 hrs.

Introduction to pulse modulation-Digital line wave forms: symbols, bits and bauds, functional notation for pulses, line codes and waveforms, unipolar -NRZ – RZ, Polar line codes. Pulse Modulation- Pulse amplitude modulation, Pulse code modulation, pulse frequency modulation pulse position modulation and pulse width modulation.

Unit-V Digital Modulation and Transmission 9 hrs.

Sampling Theorem, Signal reconstruction, Pulse Code Modulation (PCM) Quantization, Digital carrier systems-Amplitude shift keying, Phase shift keying and Frequency shift keying and Differential phase shift keying, Differential PCM and Delta modulation.

Textbooks:

1. Electronic Communications- Dennis Roddy and John Collins
2. Modern Digital and Analog Communication System - B.P.Lathi
3. Principles of Communication System – H.Taub and D.Schilling

Course Outcomes:

1. Helps to understand the Modulation and Demodulation of Amplitude modulation.
2. Helps to understand generation and reception of SSB modulation.
3. Understands the different methods for generation and detection of FM and PM.
4. Understand the various pulse modulations with generation and detection.
5. Acquire knowledge of Sampling theorem and reconstruction of digital signal

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	1	2		2		3			2		2
CO2	1	2		2		3			2		2
CO3	1	2		2		3			2		2
CO4	1	2		2		3			2		2
CO5	1	2		2		3			2		2
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

III – SEMESTER

SPH 807 ELECTRONICS AND EXPERIMENTAL METHODS

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessional: 40 Marks

Preamble:

This course provides a comprehensive understanding of semiconductor devices, electronic circuit design, applications of optoelectronic devices such as solar cells, LEDs, an introduction to signal processing techniques, and hands-on experiences with data interpretation and analysis.

Course Objectives:

1. Understand the fundamental principles of semiconductor devices, including diodes, transistors, and field-effect devices.
2. Understand the principles of operational amplifiers and their diverse applications in electronic circuits.
3. Explore the principles of solar cells, LEDs and photodetectors.
4. Analyze modulation techniques and calculate signal-to-noise ratios.
5. Analyze the propagation of errors and implement least squares fitting in data analysis.

Unit-I Semiconductor Devices: 9 hrs.

Semiconductor devices (diodes, junctions, transistors, field effect devices, homo- and hetero-junction devices), device structure, device characteristics, frequency dependence and applications- Microwave devices and their applications, RF (Radio Frequency) amplifiers and oscillators, Power electronics applications of diodes and transistors

Unit-II Electronics and Circuit Design: 8 hrs.

Operational amplifiers and their applications. Digital techniques and applications (registers, counters, comparators and similar circuits). A/D and D/A converters. Microprocessor and microcontroller basics.

Unit-III Opto-electronic devices 9 hrs.

solar cells -Thin-film solar cells and their advantages, multi-junction solar cells for improved efficiency; **Photo-detectors-principle of operation,** Avalanche photodiodes and their use in low-light conditions, Phototransistors, and their applications in amplifying light signals; **LEDs-principle and working of LEDs,** Organic LEDs (OLEDs), Quantum dot LEDs

Unit-IV Signal Processing and Measurements: 10 hrs.

Fourier transforms, lock-in detectors- Phase-sensitive detection using lock-in amplifiers, Lock-in amplifiers in spectroscopy and imaging; modulation techniques, signal-to-noise ratio calculation- Adaptive noise cancellation techniques, Digital signal processing for noise reduction; measurement uncertainties- Uncertainty analysis in measurements using statistical methods, Calibration procedures for precision instruments.

Unit-V Data Acquisition and Analysis: 9 hrs.

Data interpretation and analysis. Precision and accuracy. Error analysis, propagation of errors. Least squares fitting, Linear and nonlinear curve fitting, Chi-square test, Introduction to transducers, data acquisition systems, statistical analysis methods.

Textbooks:

1. Semiconductor Physics and Devices (SIE) | 4th Edition, by Donald A. Neamen
2. "Operational Amplifiers and Linear Integrated Circuits" by Robert F. Coughlin and Frederick F. Driscoll
3. "Optoelectronics & Photonics: Principles & Practices" by Safa O. Kasap
4. "Signal Processing and Linear Systems" by B. P. Lathi
5. Data Analysis Techniques for Physical Scientists by G.F. Knoll

Course Outcomes:

1. Demonstrate a deep understanding of semiconductor device principles.
2. Understand the basics of electronic circuit design.
3. Understand the basics of microprocessors and microcontrollers and their applications.
4. Understand the principles and working of various types of LEDs and their applications.
5. Apply Fourier transforms in signal processing and analysis.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**2**	**2**	**2**	**2**	**2**	**2**		**1**		**1**	**2**
CO2	**2**	**2**	**2**	**2**	**2**	**2**		**1**		**1**	**2**
CO3	**2**	**2**	**2**	**2**	**2**	**2**		**1**		**1**	**2**
CO4	**2**	**2**	**2**	**2**	**2**	**2**		**1**		**1**	**2**
CO5	**2**	**2**	**2**	**2**	**2**	**2**		**1**		**1**	**2**
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

III – SEMESTER

SPH 843 INTRODUCTION TO PHOTONICS

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessional: 40 Marks

Preamble: The course will outline the different concepts in photonics and will introduce the q- parameters of lens systems, properties of Gaussian beam profile, Nonlinear optics, materials, and photo detector and diodes.

Objective: Learning the principles of light propagation and its interactions with matter for photonic processes.

Unit-I Laser Cavity Modes 9 hrs.

Line shape function and Full Width at half maximum (FWHM) for Natural broadening, Collision broadening, Doppler broadening, Longitudinal and Transverse modes. ABCD matrices and cavity Stability criteria for confocal resonators. Quality factor, Q-Switching, Mode Locking in lasers. Expression for Intensity for modes oscillating at random and modes locked in phase. Methods of Q- Switching and Mode locking.

Unit-II Gaussian Beam 9 hrs.

Complex amplitude of Gaussian beam, Properties of Gaussian Beam-Intensity, power, beam radius, beam divergence, depth of focus, and phase. q –parameter and its properties-beam waist location of the waist, and Radius of curvature of the wave front, Gaussian beam reflection from a spherical mirror, Gaussian beam transmission through an arbitrary optical system, Hermite - Gaussian beams, Laguerre Gaussian, and Bessel beams.

Unit-III Transformation of a Gaussian Beam by Lens 9 hrs.

Transformation of the q-parameters by a lens system, size of the waist of the emergent beam from a lens, location of the waist of the emergent beam, Rayleigh range of the emergent beam, Angle of the far field divergence of the emergent beam, Beam propagation factor m2, The Gaussian beam in spherical mirror cavity, Resonance frequencies of the cavity.

Unit-IV Nonlinear Optics 9 hrs.

Nonlinear optical media, second order nonlinear optics- Second harmonic generation and rectification, Phase matching condition, Difference frequency generation, sum frequency generation, Electro-optic effect- Pockels electro-optic effect, Kerr electro-optic effect, three wave mixing, third order nonlinear effects-Third harmonic generation (THG) Optical Kerr effect, Self-phase modulation, self-focusing, Four wave mixing, optical phase conjugation, Degenerate four wave mixing.

Unit-V Semiconductor Photon Detectors 9 hrs.

Photodetectors- the p-n photodiode, the p-i-n photodiode, hetero structure photodiodes, array detectors, Properties of semiconductor photo detectors-quantum efficiency, responsivity, and response time, Avalanche photodiodes-principles of operation, Gain and responsivity, Response time, Noise in photodetectors-photoelectron noise, Gain noise, Circuit noise, signal to noise ratio and receiver sensitivity.

Textbooks:

1. Lasers -Theory and Applications – K.Thyagarajan and A.K. Ghatak (MacMillan)
2. Fundamentals of Photonics- Bahaa E Saleh.
3. Elements of Photonics, Volume 1-Keigo Izuka
4. Laser fundamentals – William T. Silfvast (Cambridge)
5. Optical Electronics – Ajoy Ghatak and .Thyagarajan Cambridge)

Course Outcomes:

1. Learns about the different line broadening mechanisms and q-switching method and mode locking in lasers to get the pulsed operation of lasers
2. Basics of Gaussian beam profile of a laser beam and their characteristics further conversion of Gaussian beam into other types such as Bessel, Laguerre beams.
3. Introduce q-parameters of the lens system and the transformation of Gaussian beam in a lens system, design of resonating cavity of the laser and for different resonance frequencies.
4. Introduction to the nonlinear optical phenomena with reference to the nonlinear optical materials.
5. Different methods like electro-optic effect, four wav mixing, self-focusing, phase conjugation will be learned thoroughly.
6. Concepts of the photo detector, semiconductor diode detector, principles of operation, efficiency noise level of the photo detector will be understood.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	3	3		2	2	3	2		2		2
CO2	3	3		2	2	3	2		2		2
CO3	3	3		2	2	3	2		2		2
CO4	3	3		2	2	3	2		2		2
CO5	3	3		2	2	3	2		2		2
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

III – SEMESTER

SPH 845 RADIATION PHYSICS

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessional: 40 Marks

Preamble: Radiation physics is one of the core branches of physics dealing with the understanding of different types of radiation, their origin, properties, detection, and the applications in various fields of technology.

Objective: Introducing the concept of radiation and its interaction with matter, measurement of radiation using various detectors and its protection.

Unit – I Introduction to Radiations **9 hrs.**

Types of radiation – electromagnetic spectrum – atomic and nuclear structure – nuclear forces – x- rays- Radioactivity– nuclear transformation – nuclear reactions– production of radioactive materials – radioactive decay – half- life, mean life – transient sector equilibrium - Radioisotopes in medicine and health care.

Unit – II Interactive of Radiation with Matter **9 hrs.**

Photoelectric effect, Compton effect and pair production, – attenuation and absorption of radiation – exponential law– half value layer – interaction of charged particles – neutron interactions– optical interactions – ultrasound interactions. Radiation detectors –principles of radiation detection– ionization chamber, proportion counter, GM tubes, semiconductor detector, gamma ray spectrometer.

Unit – III Radiation Dosimetry **9 hrs.**

Radiological units and their measurement – Curie, Roentgen Gray, RAD and Sievert – applications of units in radiological safety – Exposure rate, Dose rate, air kerma, tissue air ratio (TAR) – percentage depth dose (POD), tissue maximum ratio (TMR) – dose limits Measurement of exposure and dose – internal dosimetry and external dosimetry – doses from various sources of radiation - Film badges - TLDs

Unit – IV Environmental impact of radioactivity and radioisotopes 9 hrs.

Biological effects of radiation, cosmic radiation, and cosmogenic radionuclides- naturally occurring long-lived radionuclides – Radon and its decay products – Environmental impact of uranium industry – Nuclear Energy and the environment – Other man-made radiation sources in the environment – radioactive wastes

Unit – V X-rays and x-ray machines 9 hrs.

Cobalt therapy units - quality assurance and calibration of therapy units, Basics of NMR and MRI, nuclear medicine x-ray machines – cobalt therapy units - quality assurance and calibration of therapy units. Nuclear medicine –Invitro and In vivo - SPECT, PET, Radiation protection – ICRP framework of radiological protection –measures of radiation protection – special facilities for handling radioisotopes

Textbooks:

1. Physics of Radiation Therapy by F.M.Khan, 3rd Edition, Lippincott Williams & Wilkins
2. Basic medical radiation physics by Leonard Stanton , Appleton-Century-Crofts,
3. Fundamentals of Radiochemistry by D.D.Sood, A.V.R.Reddy and N.Ramamoorthy, IANCAS Publication, 3rd edition, BARC, Mumbai.
4. Source book on atomic energy by Samuel Glass tone, Affiliated East-West Press Pvt.Ltd

Course Outcomes:

1. To be aware of the electromagnetic spectrum, classification of the EM spectrum based on energy of radiation and the origin of each type of radiation.
2. To Know the phenomena of Radioactivity in nuclear materials, the related terms like Half lifetime, mean life, and the applications of radioisotopes in medicine/ healthcare systems.
3. To understand the construction and working of radiation detectors.
4. Quantifying and analysis of the radiation measurements with the impact of radiation on environment and safety measures.
5. Details of Uranium industry and other man-made radiation sources in the environment with study of X-rays, X-rays machines, NMR and MRI and importance in the field of medical instrumentation.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**3**	**3**		**2**	**2**	**3**	**2**		**2**		**2**
CO2	**3**	**3**		**2**	**2**	**3**	**2**		**2**		**2**
CO3	**3**	**3**		**2**	**2**	**3**	**2**		**2**		**2**
CO4	**3**	**3**		**2**	**2**	**3**	**2**		**2**		**2**
CO5	**3**	**3**		**2**	**2**	**3**	**2**		**2**		**2**

Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation

M.Sc. PHYSICS

III – SEMESTER

SPH 847 DYNAMICAL SYSTEMS

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessional: 40 Marks

Preamble: This course focuses on dynamics of differential equations of different order, Hamiltonian dynamics along with Lagrangian formulation, basics and advancements of perturbation theory, chaotic Hamiltonian systems and the complications in their mapping, and nonlinear evolution of systems

Objective: To introduce the nonlinear phenomena of physical systems and its relevance to natural phenomena with simple models.

Unit- I Dynamics of Differential Equations 9 hrs.

Introduction to systems, Integrations of linear second order equations, Integration of nonlinear second order equations, Dynamics of phase plane, linear stability analysis, time dependent integrals and non-autonomous systems.

Unit- II Hamiltonian Dynamics 9 hrs.

Lagrangian formulation of mechanics, Hamiltonian formulation of mechanics, canonical transformations, Hamilton Jacobi equations and action angle variables, and integrable Hamiltonians.

Unit- III Classical Perturbation Theory 9 hrs.

Elementary perturbation theory, canonical perturbation theory, many degrees of freedom and problem of small divisors, Kolmogorov –Arnold-Moser theorem and its invariants.

Unit- IV Chaos in Hamiltonian Systems and Mappings 9 hrs.

Surface of section, Area preserving mapping, fixed points, and the Poincare-Birkhoff -Fixed point theorem, Homoclinic and Heteroclinic points, criteria for local chos, criteria for onset and widespread chaos, statistical concepts in chaotic systems and Hamiltonian chaos in fluids.

Unit -V Nonlinear Evolutions **9 hrs.**

Dynamics of dissipative systems and turbulence, experimental observations, and theories on onset of turbulence. Basic properties of KdV equation, inverse scattering transform-basic principles, Inverse scattering transform KdV equation, Hamiltonian structure of integrable systems, soliton systems and Dynamics of non-integrable evolution equations.

Textbooks:

1. Chaos and Integrability in Non-linear Dynamics M. Tabor (Wiley), 1989
2. Chaos: An Introduction to Dynamical Systems (Textbooks in Mathematica2nd Sciences) Kathleen T. Alligood, Tim D. Sauer & James A. Yorke Springer,
3. Regular and stochastic motion Lichtenber & Lieberman, Springer, 2nd Edition, 1992
4. Chaos in Guage Theories by Biro Muller (World Scientific), 1995

Course Outcomes:

1. Introduces the fundamental differential equations and integration of nonlinear second order equations.
2. Enables the basic understanding the formalisms of Lagrangian and Hamiltonian
3. Focusses on the understanding of perturbation and various orders of it.
4. Improves the understanding of chaotic systems and the difficulties Hamiltonian formalism for chaotic liquids
5. Targets the dynamics of dissipative systems and related turbulence.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	3	3		2		3	2		2		2
CO2	3	3		2		3	2		2		2
CO3	3	3		2		3	2		2		2
CO4	3	3		2		3	2		2		2
CO5	3	3		2		3	2		2		2
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

III – SEMESTER

SPH 849 MODERN OPTICS AND LASER SPECTROSCOPY

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessional: 40 Marks

Preamble: This course introduces the optical fibers and their working principle, optical phenomenon based on Fourier analysis, Physics behind the laser, resonators, and various pulsed and continuous lasers.

Objective: Introductory aspects of Modern optics for mode propagation and amplification.

Unit- I Fiber optics and Holography **9 hrs.**

Basic Characteristics of optical fiber, Ray, and modal analysis of single and multimode fibers (Step index and graded index), Graded Index fiber, Single and Multimode fibers, material dispersion, Fiber losses, Holography.

Unit-II Fourier Optics **9 hrs.**

Propagation of light in free space-spatial harmonic functions and plane waves, Spatial spectral analysis, Amplitude modulation, Transfer function of free space, Frequency modulation, Impulse response function of free space, Huygens-Fresnel's principle, Optical Fourier transforms-Fourier transform in the far field, Fourier transform using lens, Diffraction (Fourier treatment).

Unit-III Light Amplification **9 hrs.**

Einstein coefficients, absorption and emission cross sections, Light amplification, Threshold condition, Line broadening mechanisms–natural, collisional, Doppler broadenings, Quantum theory of evaluation of Einstein’s coefficients, rate equations for 2 –level, 3-level, 4-level systems, Variation of laser power around threshold.

Unit- IV Optical Resonators **9 hrs.**

Modes of a rectangular cavity, Spherical mirror resonators, Q factor, Line width of a laser, Mode selection-transverse and longitudinal modes, pulsed operation of lasers-Q switching, Mode locking, Techniques for Q switching and mode locking.

UNIT –V Laser Systems **9 hrs.**

Ruby laser, He-Ne Laser, Semiconductor laser, Nd: YAG and Nd: Glass laser, Ti: Sapphire laser, CO2 lasers and AR ion lasers, Fiber laser, Dye laser.

Textbooks:

1. Laser’s fundamentals and applications K. Thyagarajan, Ajoy Ghatak
2. Introduction to Photonics, B. E. A. Saleh
3. Quantum Electronics A. Yariv

Course Outcomes:

1. Learns about the basic principles and applications of fiber optics and holography. Understands the concepts behind optical fiber communications. Understands the communications using optical fibers.
2. He/she learns about the frequency modulation in optical fiber communication. He/she learns about the process of light amplification in different-level laser systems.
3. The basics of the light amplifications process, Einstein’s coefficients will be understood. Learn the basics of laser resonators.
4. The techniques for the pulsed operation of lasers like Q switching mode locking will be understood. The working and construction of different types of laser systems will be understood.
5. The operation of He, Ne, Ruby, Ti: sapphire lasers will be learned.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**3**	**3**		**2**		**3**	**2**		**2**		**2**
CO2	**3**	**3**		**2**		**3**	**2**		**2**		**2**
CO3	**3**	**3**		**2**		**3**	**2**		**2**		**2**
CO4	**3**	**3**		**2**		**3**	**2**		**2**		**2**
CO5	**3**	**3**		**2**		**3**	**2**		**2**		**2**

Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation

M.Sc. PHYSICS

III – SEMESTER

SPH 851: VACUUM SCIENCE AND TECHNOLOGY

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessional: 40 Marks

Course objective: The main objective of this course is to know the basic fundamental principles involved for the production of vacuums, working principles of vacuum pumps, gauges, vacuum component and materials used in vacuum systems.

Unit- I INTRODUCTION TO VACUUM SCIENCE 9 hrs.

Vacuum principles: Basic concepts of Vacuum; Kinetic theory of gases; Gas laws, Pressure ranges; Types of flow; Flow calculations, Conductance, Pumping speed, and pumping time Vacuum generation: Production of vacuum, Types of Vacuum pumps, Diaphragm pump, Rotary vane pump, Diffusion Pump, Turbomolecular Pump (TMP), Sorption pumps: Adsorption pumps, Sublimation pumps, Sputter-ion pumps; Cryon Pump.

Unit-II MEASUREMENT OF LOW PRESSURES 9 hrs.

Direct and Indirect pressure measurement vacuum gauges- McLeod gauge – Diaphragm gauge, Thermal conductivity (Pirani) Guage, Ionization vacuum gauges: penning Guage, Hot cathode ionization Guage, Bayard-Alpert ionization gauge, Calibration of vacuum gauges, Mass flow meters and controllers, Analysis of gas at low pressures: Residual gas analyzers, Quadrupole mass spectrometer

Unit-III LEAK DETECTION AND TESTING METHODS 9 hrs.

Types of leaks, Leak rate, Real leak, Virtual leak, Leak detection and test methods: Pressure rise and drop tests, Tests using vacuum gauges, Bubble immersion test, Pressure test, Foam-spray test, Halogen and Helium leak detectors.

Unit-IV VACUUM MATERIALS AND COMPONENTS 9 hrs.

Introduction to vacuum materials, classification of vacuum materials, cleaning procedures for materials in ultrahigh vacuum, Design and Fabrication of vacuum chambers, flanges, couplings, and components for different applications. Stainless steel, copper OHFC, Aluminum and ceramic vacuum components.

Unit-V PROCESS AND APPLICATIONS OF VACUUM TECHNOLOGY 9 hrs.

High-Vacuum-Based Processes: Brief overview on Sputtering, Plasma etching, Ion beam technology and pulsed laser deposition. Applications of vacuum technology in High energy particle accelerators, Synchrotrons, Semiconductor Industry, Fusion experiments, Analytical instruments.

Textbooks:

1. Vacuum Technology, A. Roth, North Holland, Elsevier Science B.V. 1990.
2. Handbook of vacuum science and technology, Dorothy M. Hoffman, Bawa Singh, John H. Thomas, III, Academic press limited, San Diego, USA, 1998
3. A User's Guide to Vacuum Technology (Third Edition), John F. O'Hanlon, John Wiley & Sons, Inc., New York, United States, 2003.
4. Vacuum Science and Technology, V. Vasudeva Rao, T.B. Ghosh, and K.L. Chopra, Allied Publications, New Delhi, India, 1998.
5. Introduction to Vacuum Technology, Dr. A. K. Bhushan, Indian Vacuum Society, BARC, Mumbai, 2013.

Course outcomes: The student will be able.

1. To apply the kinetic theory of gases and basic rules of vacuum science in the design of gas transport and to know the working principles of different vacuum pumps.
2. To know the operation range of vacuum gauges used for the measurement of low pressures.
3. To know the principles of leak detectors and measurement of leaks using leak detectors for troubleshooting the vacuum system.
4. To know the materials and components used for the fabrication and design of vacuum systems.
5. To have an overview of the role of vacuum equipment in modern industrial processes and particularly in the semiconductor industry.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1		2	2	2		2		2	2	2	2
CO2		2	2	2		2		2	2	2	2
CO3		2	2	2		2		2	2	2	2
CO4		2	2	2		2		2	2	2	2
CO5		2	2	2		2		2	2	2	2

Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation

M.Sc. PHYSICS

III – SEMESTER

SPH 853 MOLECULAR MECHANICS

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessional: 40 Marks

Course Objective:

The course aims to provide a comprehensive understanding of molecular modeling techniques and computational methods for simulating molecular systems.

Unit-I Concepts in Molecular Modeling 9 hrs.

Introduction, Coordinate Systems, Potential energy surfaces, Molecular graphics, and Surfaces of modeling

Unit-II Computational Quantum Mechanics 9 hrs.

Introduction, one electron atoms, Polyelectronic atoms and molecules, Molecular orbital calculations, The Hartree Fock equations, Basis sets, calculating molecular properties using ab into Quantum mechanics, Approximate molecular orbital theories, Hackle Theory, Performance of Semi-empirical Methods.

Unit-III Computational Methods of Systems 9 hrs.

Introduction, Open–Shell systems, Electron Correlation, Practical Considerations when performing ab initio Calculations, Energy Component Analysis, Valence Bond Theories, Density Functional Theory.

Unit-IV Empirical Force Field Models 9 hrs.

Introduction, Some general features of Molecular Mechanics Force Fields, Bond Stretching, Motions, Cross Terms: Class 1, 2 and 3 Force Fields, Introduction to Non-bonded Interactions, Electrostatic Interactions, Vander Waals Interactions.

Unit-V Many-Body Systems 9 hrs.

Effective fair potentials, hydrogen bonding in molecular mechanics, force field models for simulation of liquid water, united atom force field, derivatives of molecular mechanics energy functions, calculation of thermodynamic potentials, force field parametrization, force field of inorganic molecules, and solid-state systems.

Textbooks

1. Molecular Modeling Principal and Applications, Andrew R. Leach, 2nd ed. PHI
2. Essentials of Computational Chemistry Theories and Models, Christopher J. Cramer, John Wiley.

Course outcomes:

1. formulate the basis for and the most important approximations in key molecular computational models.
2. Choose a computational model for various chemical problems.
3. Apply modern molecular-level software on presented problems.
4. Assess computational results critically.
5. Understand how to optimize different molecular structures.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	2	2	2	2		2	2	2	2		2
CO2	2	2	2	2		2	2	2	2		2
CO3	2	2	2	2		2	2	2	2		2
CO4	2	2	2	2		2	2	2	2		2
CO5	2	2	2	2		2	2	2	2		2
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

III – SEMESTER

SPH 855 FUNDAMENTALS OF QUANTUM COMPUTING

L	T	P	S	J	C
2	0	2	0	0	3

Hours per week: 4 End Examination: 60 Marks

Credits: 3 Sessional: 40 Marks

Course objectives

This course aims to provide a self-contained, comprehensive introduction to quantum computing and to impart the necessary knowledge to the learner so that he/she can implement the well-known algorithms of quantum computing.

Unit-I Introduction to quantum computing 6 hrs.

Quantum computing — motivation, foundations, and prominent applications. Major players in the industry (IBM, Microsoft, Righetti, D-Wave, etc.) Qubits, Qubits vs. bits, Types of Qubits: Spin, Trapped Atoms and Ions, Photons, and Superconducting Circuits; The challenges of qubit storage.

Learning outcomes

After completion of this unit, the student will be able to

1. **relate** to the relevance of the emerging field of quantum computing (L1)
2. **understand** QUBITs and types of QUBITs.

Unit-II Mathematical foundation for quantum computing 6 hrs.

Matrix Algebra: basis vectors and orthogonality, inner product and Hilbert spaces, matrices and tensors, unitary operators and projectors, Dirac notation, eigenvalues, and eigenvectors.

Learning outcomes

After completion of this unit, the student will be able to

1. **interpret** the basis, and their properties over Hilbert spaces (L2)
2. **apply** unitary operators (L3)

3. **make use of** the bracket notation of Dirac (L3)
4. **solve** for eigenvalues and eigenvectors of a matrix (L3)

Unit-III Building blocks for quantum program **10 hrs.**

Details of q-bit system of information representation: Bloch sphere, multi-qubits states, Quantum superposition of qubits, Quantum entanglement, Operation on qubits: Measuring and transforming using gates, Quantum Logic gates and Circuit: Pauli, Hadamard, phase shift, controlled gates, Ising, Deutsch, swap, etc.

Learning outcomes

After completion of this unit, the student will be able to

1. **explain** Bloch sphere representation. (L2)
2. **interpret** the concepts of quantum bits, their superposition, and quantum entanglement. (L2)
3. **make use of** various quantum logic gates. (L3)

Unit-IV Techniques for quantum algorithms **8 hrs.**

Basic techniques exploited by quantum algorithms: Amplitude amplification, Quantum Fourier transform, Phase kick-back, Quantum phase estimation, Quantum walks.

Learning outcomes

After completion of this unit, the student will be able to

1. **interpret** the idea of amplitude amplification used for many, including Grover's search algorithm(L3)
2. **make use of** the idea of quantum Fourier transform that is used in Shor's algorithm (L3)
3. **relate** phase kick-back to quantum phase estimation (L3)
4. **summarize** the quantum walks and compare them to classical random walks (L2)

Unit-V Quantum algorithms and toolkits **10 hrs.**

Major Algorithms: Shor's Algorithm, Grover's Algorithm, Deutsch's Algorithm, Deutsch -Jozsa Algorithm

OSS Toolkits for implementing the Quantum program.

- IBM quantum experience
- Rigetti PyQuil (QPU/QVM)
- Google Cirq

Learning outcomes

After completion of this unit the student will be able to

1. **apply** the widely used quantum algorithms for several basic problems (L3).
2. **assess** Shor's quantum algorithm used for integer factorization and discrete logarithm computation (L5).
3. **examine** the deterministic algorithms - Deutsch's and Deutsch -Jozsa algorithm (L4).
4. **compare** three well-known opensource toolkits (L2).

Textbooks:

1. Nielsen, M., & Chuang, I. *Quantum Computation and Quantum Information: 10th Anniversary Edition*. 2010, Cambridge University Press.
2. David McMahon, Quantum Computing Explained, 2008, Wiley
3. Forest SDK PyQuil: https://pyquil.readthedocs.io/en/stable/
4. IBM Experience: https://quantumexperience,ng,bluemix.net
5. Cirq | Google Quantum AI: https://quantumai.google/cirq

Reference Books:

1. Chris Bernhardt, Quantum Computing for Everyone (The MIT Press).
2. Eric R. Johnston, Nic Harrigan, Mercedes and Gimeno-Segovia "Programming Quantum Computers: Essential Algorithms and Code Samples, SHROFF/ O'Reilly
3. Parag Lala Quantum Computing 1st Edition 2019 McGraw Hill
4. Robert S. Sutor Dancing with Qubits 2019 pack publishing

Websites:

1. https://qiskit.org/textbook/preface.html
2. https://quantumai.google/cirq/experiments
3. https://pyquil-docs.rigetti.com/en/stable/basics.html

Coursera:

1. https://www.coursera.org/learn/introduction-to-quantum-information

NPTEL/Swayam:

2. https://onlinecourses.nptel.ac.in/noc22_cs79/preview

Course Outcomes

At the end of this course, the students will be able to:

1. motivated to learn about major concepts and industry leaders of quantum computing.
2. Explain basic concepts from Linear Algebra necessary for understanding of quantum computers. (L2).
3. interpret and make use of quantum logic gate circuits. (L4).
4. make use of several quantum algorithms (L5).
5. experiment with quantum algorithm on major toolkits (L4).

List of Practical's:

1. Simulate Single Qubit Gates- Pauli gates and Hadamard gate using QISKIT.
2. Simulate Single Qubit Gates- P-, U-, I, S, and T-gates using QISKIT.
3. Simulate Multiple Qubits and Entangled States using QISKIT.
4. Simulate Basic Circuit Identities using QISKIT.
5. Visualizing Bloch Sphere
6. Simulate quantum walks using numpy/scipy
7. Building Quantum dice
8. Composing simple quantum circuits with q-gates and measuring the output into classical bits.
9. Qiskit Implementation of Quantum Fourier transform
10. Implementation of Shor's Algorithms
11. Implementation of Grover's Algorithm
12. Implementation of Deutsch's Algorithm
13. Implementation of Deutsch-Jozsa's Algorithm

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	2	2	2	2		2	2	2	2		2
CO2	2	2	2	2		2	2	2	2		2
CO3	2	2	2	2		2	2	2	2		2
CO4	2	2	2	2		2	2	2	2		2
CO5	2	2	2	2		2	2	2	2		2
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

III – SEMESTER

SPH 857 INTRODUCTION TO ATMOSPHERIC PHYSICS

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessional: 40 Marks

Description: This course provides a basic understanding of the structure, physical parameters principles, underlying principles and phenomena in Earth's atmosphere.

Pre-requisite: 10+2 Math and Physics;

Course Objectives:

1. To understand Atmospheric Components and Structure.
2. To introduce students to the basic principles of atmospheric thermodynamics.
3. To familiarize students with dynamic systems of the Earth's atmosphere.
4. To understand the Earth's radiation budget.
5. To appreciate the approach of climate/weather prediction modelling.

Unit-I Introduction to Earth's Atmosphere

A brief survey: Physical parameters, components and their role in climate. Horizontal and vertical structure of atmosphere, the Earth systems: Oceans, Hydrological cycle, Carbon cycle, and Earth's crust, Brief history of Earth's climate and how it evolved.

Unit-II Thermodynamics of Atmosphere:

Basic Thermodynamics, gas laws, the hydrostatic equation, first law and adiabatic processes-lapse rate, the second law of thermodynamics and entropy, dry and moist air. Static stability

Unit-III Dynamic Atmosphere:

Equation of motion, Geostrophic approximation. Atmospheric circulation-vertical and horizontal: Boundary layer, ITCZ, Monsoons; surface energy balance and bulk aerodynamic parameters.

Unit-IV Earth's Radiation Budget

Radiation laws, Planck's distribution and Inverse square law; Physics of scattering, emission and absorption; Radiative transfer equation – derivation, Radiative heating profiles of the atmosphere

Unit-V Climate Dynamics and concepts of modelling:

Introduction, Climate sensitivity and feedback, Climate change, Atmospheric dynamics.

Basic concepts of climate and weather modelling

Assessment:

Students will be evaluated through quizzes, assignments, laboratory exercises, and a final examination. Additionally, class participation and engagement in discussions will contribute to the assessment process.

Course Outcomes:

By the end of the course, the students will be able to

1. describe the major components of the atmosphere and explain the vertical structure of the atmosphere (L2).
2. understand the thermodynamics to analyse atmosphere temperature, pressure, and humidity variations (L3).
3. explain the formation of pressure systems, understand global wind patterns, and describe the causes of weather patterns and phenomena (L2).
4. understand the fundamentals of solar radiation and their role in atmospheric heating and cooling (L2).
5. Comprehend the basic patterns in climatic parameters and familiar in climate/weather modelling (L2).

References:

1. Atmospheric Science-An introductory Survey: Second Edition by John M Wallace and Peter V Hobbs, https://www.gnss-x.ac.cn/docs/Atmospheric%20Science%20An%20Introductory%20Survey%20(John%20M.%20Wallace,%20Peter%20V.%20Hobbs)%20(z-lib.org).pdf
2. The Physics of Atmosphere- John Houghton, https://www.gbv.de/dms/bs/toc/336225636.pdf
3. An Introduction to Atmospheric Thermodynamics-2nd edition by Anastasios Tsonis-Cambridge University Press, https://www.cambridge.org/core/books/an-introduction-to-atmospheric-thermodynamics/CE41FAD800F16284992D653F9AA7D622
4. An Introduction to Dynamic Meteorology, Fourth Edition by James R. Holton
5. Introduction to climate dynamics and climate modelling by Goosse H., P.Y. Barriat, W. Lefebvre, M.F. Loutre, and V. Zunz, http://climate.envsci.rutgers.edu/climdyn2019/Goosse.pdf

6. FORECASTERS' REFERENCE BOOK, Meteorological Office College https://www.weather.gov/media/zhu/ZHU_Training_Page/Met_Tutorials/Forecasters_Reference_Book_1997.pdf
7. Archived NPTEL Lectures: https://archive.nptel.ac.in/courses/119/106/119106008/
8. Archived NPTEL Lectures: https://archive.nptel.ac.in/courses/115/107/115107121/

	PO 1	**PO 2**	**PO3**	**PO 4**	**PO 5**	**PO6**	**PSO 1**	**PSO 2**	**PSO3**	**PSO4**	**PSO5**
CO1		**1**	**2**	**2**		**2**		**2**	**2**		
CO2		**1**	**2**	**2**		**2**		**2**	**2**		
CO3		**1**	**2**	**2**		**2**		**2**	**2**		
CO4		**1**	**2**	**2**		**2**		**2**	**2**		
CO5		**1**	**2**	**2**		**2**		**2**	**2**		
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

III – SEMESTER

SPH 859 DATA-DRIVEN PHYSICS

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessional: 40 Marks

Course Description:

Data-driven methods in physics employ large datasets and advanced computational techniques to understand physical phenomena, make predictions, and solve complex problems. These methods often complement traditional theoretical and experimental approaches, providing powerful tools for modern scientific inquiry. In this course, students will explore the following : Machine learning tools, Bayesian Methods, Enhancement of traditional computational techniques using Machine learning, Generative models and their applications to physics.

Course Objectives:

Apply techniques learned in the course to extract meaningful patterns, correlations, and optimal solutions from data-intensive physical and engineering problems.
Decide on the appropriate data-driven technique for a given problem and modify the technique as needed.
Gain hands-on experience with writing large codes for data analysis and problem-solving.
Develop proficiency in coding and find ease with coding tasks.
Integrate theoretical knowledge with practical coding skills to solve complex, data-intensive problems effectively.

UNIT I: Introduction **9 hrs.**

A review of linear algebra, probability theory and multivariate calculus required for machine learning. Review of Python programming.

UNIT II: Machine learning tools **9 hrs.**

Regression, Classification techniques, Gradient descent, Clustering, Neural networks, Deep Neural networks, Back-propagation, Convex and Constrained optimization.

UNIT III : Bayesian and Variational Inference **9 hrs.**

Posterior distribution, Markov Chain Monte Carlo, Bayesian networks, Bayesian optimization, Approximate Bayesian inference, Richardson-Lucy algorithm.

UNIT IV : Generative models **9 hrs.**

Normalizing flows, Generative adversarial networks, Variational auto-encoders, Diffusion models, Restricted Boltzmann machines.

UNIT V: Enhancement of traditional Computational techniques **9 hrs.**

Physics informed neural networks, Reinforcement Monte Carlo, Boltzmann Generators, Continuous time normalizing flows, Equivariant flows, Convolutional neural networks.

Textbooks:

1. Brunton S.L, & Kutz, J. N. (2019), Data-driven Science and Engineering :Machine learning, Dynamical Systems and Control, Cambridge University Press.

2. Calin O. (2020), Deep learning architectures: A mathematical approach, Springer series in data science. Deisenroth M.P, Faisal A.A, Ong C.S (2021) Cambridge University Press.

References:

1. Raissi M, Perdikaris P, Karniadakis GE. Physics-informed neural networks: A deep learning framework for solving forward and inverse problems involving nonlinear partial differential equations. Journal of Computational physics (2019)
2. George Em Karniadakis, Ioannis G. Kevrekidis, Lu Lu, Paris Perdikaris, Sifan Wang and Liu Yang, Physics informed machine learning, Nature Reviews Physics 3, 422–440 (2021)

3. Kobyzev, S. J. D. Prince and M. A. Brubaker, "Normalizing Flows: An Introduction and Review of Current Methods," in IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 43, no. 11, pp. 3964-3979, (2021)
4. David M. Blei, Alp Kucukelbir, Jon D. McAuliffe "Variational Inference: A Review for Statisticians" https://arxiv.org/pdf/1601.00670 (2016).

Course Outcomes:

At the end of this course, the students will be able to:

- Conceptual understanding of Machine learning tools.
- Develop practical ease in implementing simple to moderately hard machine learning models.
- Develop at least one hard machine model in the project.
- Develop ease in algorithmically manipulating machine learning models suitable to solve non-standard problems.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	2	2	2	2		2	2	2	2		2
CO2	2	2	2	2		2	2	2	2		2
CO3	2	2	2	2		2	2	2	2		2
CO4	2	2	2	2		2	2	2	2		2
CO5	2	2	2	2		2	2	2	2		2
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

III - SEMESTER

SOE 865 BIOPHYSICS

L	T	P	S	J	C
2	0	0	0	0	2

Hours per week: 2 End Examination: 60 Marks

Credits: 2 Sessional: 40 Marks

Preamble: Relevance of physical principles associated for various process in human body

Objective: To make familiar with biological phenomena with physical principles.

Unit- I Energy Around Us 9 hrs.

Forms of energy, ambient energy, molecular energy, molecular energy absorbance, molecular transduction, ionizing radiation, magnetic resonance and sound, Molecular contacts-Dissociation constants, methods of measuring dissociation constants, metal molecular coordination bond, and hydrogen bonding.

Unit- II Diffusion and Direct Transport 9 hrs.

Forces and flows, Fick's law of diffusion, Brownian motion, physical diffusion of ions and molecules, molecular motors, and intracellular cargo transport. Energy production of ATP and ADP, phosphocreatine, and glycolysis

Unit- III Force and Movement 9 hrs.

Skeletal length and tension relation, muscle contraction, cardiac and smooth muscle length-tension relation, Hill formalism of cross-bridge cycle, muscle shortening, lengthening, and power, calcium dependence of muscle velocity, smooth muscle latch, muscle tension transients and the law of Laplace for hollow organs.

Unit -IV Load Bearing and Fluid Flow 9 hrs.

Stress and strain, teeth and bone, blood vessels, tendons, ligaments, and cartilage. Fluid flow properties, synovial fluid flow, arterial blood flow, arteriole blood flow, viscosity and hematocrit, arterial stenosis, arterial asymmetry, and lung airflow

Unit -V Biophysical Interfaces **9 hrs.**

Surface tension, the action of surfactant on lung surface tension, membrane lipids, membrane curvature, membrane protein and carbohydrate environment, membrane protein transporters, membrane organization, ultrasonic pore formation, membrane diffusion and viscoelasticity, and membrane ethanol effects.

Textbooks:

1. Biophysics (A Physiological approach), Patrick. F.Dillon, Cambridge University Press,2012
2. Biophysics by an introduction, Rodney Cotterill, Wiely,2002
3. Biophysics by Daniel Goldfarb, Mc Graw Hill,2011

Course Outcomes:

1. To attribute energy around us of biological importance
2. To understand various transport phenomena for energy production
3. To understand the force and movement and their dependence on humans
4. To understand various properties related to load and fluid in the human body
5. To interpret biophysical phenomena across the interfaces.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1		1	2	2		2		2	2		
CO2		1	2	2		2		2	2		
CO3		1	2	2		2		2	2		
CO4		1	2	2		2		2	2		
CO5		1	2	2		2		2	2		
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

III - SEMESTER

SOE 867 BIOELECTRONICS

L	T	P	S	J	C
2	0	0	0	0	2

Hours per week: 2 End Examination: 60 Marks

Credits: 2 Sessional: 40 Marks

Preamble: Analyze sensing elements for biological activity

Objective: To measure, analyze and interpret, and present the data of living systems with working knowledge of electronic components related to biomedical devices and how these are different from traditional electronics.

Unit -I Introduction to Sensors 9 hrs.

Sensors, Nose as sensor, sensors and biosensors, components of biosensors, Aspects of sensors- Recognition elements-transducers, methods of immobilization, performance factors. Biocatalysts and bio affinity-based sensors, Advantages and limitations of biosensors and areas of application.

Unit -II Transduction Elements 9 hrs.

Electrochemical Transducers, Potentiometry and ion-selective electrodes-Nernst equation, cells and electrodes, reference electrodes, and quantitative relationships (with N. E). Voltammetry-Linear sweep and cyclic, Amperometry- kinetic and catalytic effects, Conductivity, Photometric sensors- optical techniques, optical transducers-device construction, solid phase absorption label sensors and applications.

Unit -III Sensing Elements 9 hrs.

Ionic recognition-ion selective electrodes, interferences, conductive devices, Modified electrodes, and screen-printed electrodes. Molecular recognition-chemical Recognition agents- thermodynamic complex formation, kinetic catalytic effects. Biological recognition agents- Enzymes, tissues, antibodies, and nucleic acids Immobilization- adsorption and microencapsulation.

Unit - IV Performance Factors 9 hrs.

Introduction, Selectivity-ion selective electrodes, enzymes, and antibodies. Sensitivity-linear range and detection. Time factors-response factors, recovery, and lifetimes. Precision and accuracy. Different transducers-urea, amino acid, and glucose biosensors, factors affecting the performance of sensors-amount of the enzyme, immobilization method, and pH.

Unit -V Electrochemical Sensors and Biosensors 9 hrs.

Potentiometric sensors-ionic selective electrodes-concentration and activities, calibration graph. Potentiometric Biosensors-pH linked, ammonia linked, carbon dioxide linked and iodine selective. Amperometric sensors-Direct electrolytic methods. Conductometric and biosensors- chemiresistors, biosensors based on chemiresistors, and semi-conductive oxide sensors.

Textbooks:

1. Chemical Sensors and Biosensors by Brain R.Eggins Wiley Publishers, 1stEdition
2. Biosensors: fundamentals and Applications by Anthony P. F. Turner, Isao Karibe, George S. Wilson Oxford University Press, 1987
3. Molecular Bioelectronics by C. Nicolini World Scientific,1996

Course Outcomes:

1. Understanding sensors and various types of biological sensors
2. Introduction to energy conversion elements.
3. Analyze sensing elements for biological phenomena
4. Measurement of sensing elements
5. Understanding electrochemical and biosensors of biological relevance

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1		**1**	**2**	**2**		**2**		**2**	**2**		
CO2		**1**	**2**	**2**		**2**		**2**	**2**		
CO3		**1**	**2**	**2**		**2**		**2**	**2**		
CO4		**1**	**2**	**2**		**2**		**2**	**2**		
CO5		**1**	**2**	**2**		**2**		**2**	**2**		
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

III – SEMESTER

SOE 869 ENVIRONMENTAL PHYSICS

L	T	P	S	J	C
2	0	0	0	0	2

Hours per week: 2 End Examination: 60 Marks

Credits: 2 Sessional: 40 Marks

Preamble: To realize the importance of the environment and its relevance to biological phenomena.

Objective: Application of physical concepts to earth system, with focus on human systems, water, ground, ozone, and fossil fuels

Unit-I Introduction to Environmental Physics 9 hrs.

The human environment: First, Second and Third law of Thermodynamics, Energy, and metabolism - Laws of thermodynamics and the human body

Energy transfers: Conduction, Convection, Newton's law of cooling, Radiation, Evaporation, Survival in cold climates, Survival in hot climates

Noise pollution: Domestic noise and the design of partitions

Unit-II Water 9 hrs.

Hydrosphere, Hydrologic cycle, Water in the atmosphere, Clouds, Physics of cloud formation, growing droplets in cloud, Thunderstorms

Wind: Measuring the wind, Physics of wind creation, Principal forces acting on air masses, Gravitational force, Pressure gradient, Cyclones and anticyclones, Global convection, Global wind patterns.

Unit-III Physics of Ground 9 hrs.

Soils, Soil and hydrologic cycle, Surface tension and soils, Water flow, Water evaporation, Soil temperature. Environmental Biophysics -Energy budget concept, radiation energy fluxes, energy equilibrium between biotic and abiotic environmental components, Ozone layer depletion – Greenhouse effect

Unit-IV Fossil Fuels **9 hrs.**

Nuclear power, Renewable resources – Hydroelectric power, Tidal power, Wind power, Wave power Biomass, Solar power – Solar collector, Solar photovoltaic Energy demand and conservation – Heat transfer and thermal insulation – Heat loss in buildings

Unit-V Environmental Impact of Radioactivity and Radioisotopes **9 hrs.**

Biological effects of radiation, cosmic radiation, and cosmogenic radionuclides- naturally occurring long-lived radionuclides – Radon and its decay products – Environmental impact of uranium industry – Nuclear Energy and the environment – Other man-made radiation sources in the environment – radioactive waste.

Textbooks:

1. Environmental Physics by E. Boeker & R. Van Grondelle, John Wiley & sons,1994
2. Concepts of Modern Physics by Beiser McGraw Hill, 5th Edition
3. The nature and properties of Soils by Brady, N.C. Tenth Edition. Mac Millan Publishing Co., New York,1990
4. Environmental Studies: The Earth as a living planet by Botkin, D.B and Kodler E.A., John Wiley and Sons Inc.,2000
5. Environmental Physics by M. Dželalija

Course Outcomes:

1. Understanding environment and thermodynamics of human body in relation to energy
2. Understanding water and wind for its formation and measurement.
3. Understanding the physics of soils
4. Understanding fossil fuels and the transfer of heat
5. Understanding the impact of radioactivity on biological phenomena

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1		**1**	**2**	**2**		**2**		**2**	**2**		
CO2		**1**	**2**	**2**		**2**		**2**	**2**		
CO3		**1**	**2**	**2**		**2**		**2**	**2**		
CO4		**1**	**2**	**2**		**2**		**2**	**2**		
CO5		**1**	**2**	**2**		**2**		**2**	**2**		
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

III – SEMESTER

SOE 871 PHYSICAL PRINCIPLES IN BIOLOGICAL SYSTEMS

L	T	P	S	J	C
2	0	0	0	0	2

Hours per week: 2 End Examination: 60 Marks

Credits: 2 Sessional: 40 Marks

Course Description:

Applying physical principles to understand biological systems is an exciting and rapidly evolving field of research. The tool kits like statistical physics, stochastic processes, fluid dynamics and nonlinear dynamics, among others, have helped understand the guiding principles of various biological processes. In this course, we will attempt to introduce the physics of biological systems using theoretical tools, with examples from diverse areas of biology such as pattern formation, low Reynolds number flows, and transport in cells, among others. The course aims to give a thorough and systematic exposure to tackle problems in biology using physical principles with a particular focus on recent research trends, thereby preparing the students with the necessary and adequate skills to excel in the academic and in the industrial world.

Course Objectives:

- Motivation to apply physical principles to understand the biological phenomena.
- Basics of transport through diffusion.
- Understanding and unfolding the fluid flows in biological systems.
- Applying the methods of Statistical Physics in the context of biological systems.
- Saptio-temporal patterns in Biology with special emphasis on recent research trends in Developmental Biology.

Prerequisite: Basic Calculus and Statistical Physics.

Unit-I: Basic Introduction 6 hrs.

DNA Packing and Structure, Shape and function, Numbers and sizes, Spatial scales in biology and time scales in biology.

Learning outcomes: After the completion of this Unit the student

- will find motivation to apply physical principles to problems in biology.
- will get systemic exposure to different scales in Biology.

Unit-III: Mechanism of Diffusive transport and its application in Biology 10 hrs.

Random walks and diffusion, Role of Random walks to model biology, Derivation of FRAP(Fluorescence recovery after photobleaching) equation, Fokker-Planck equations, Introduction to Drift-Diffusion equation and Solution, The cell signalling problem, molecular motors, and intracellular cargo transport.

Learning outcomes: After the completion of this Unit the student

- will get solid foundations in handling diffusion and Fokker-Planck equations, the most widely used equation to model transport in natural systems.
- Will be equipped with applying the diffusion-like equations in real biological systems.

Unit-III: Fluid Mechanics in Biology: Understanding Biological Flows 10 hrs.

Introduction to fluids, The Euler equations, viscosity and Reynolds number, Introduction to the Navier -Stokes equation, Various phenomena at low Reynolds number, Bacterial flagellar motion, Rotating flagellum.

Learning outcomes: After the completion of this Unit the student

- will gain a comprehensive understanding of fluid mechanics principles and their applications in biological systems, enabling them to analyze and model fluid behavior in various biological contexts.

Unit- IV: Statistical Physics and Molecular Biology: Principles and Applications 9 hrs.

Energy and equilibrium, Binding Problems, Transcription and translation, Internal States of macromolecules, Hemoglobin-Oxygen binding problem, Polymers in biology, Freely joined polymer model.

Learning outcomes: After the completion of this Unit the student

- will be introduced to the methods of Statistical physics in understanding and solving biological phenomena.

Unit-V: Spatio-temporal patterns in Biology **9 hrs.**

What is the pattern? Spatio-temporal patterns in biology, reaction-diffusion and spatial patterns, Pattern formation in reaction-diffusion system with stability, Condition for destabilization in pattern formation, Pattern formation in active matter, Mechanochemical and geometrodynamic patterns in cell and developmental biology.

Learning outcomes: After the completion of this Unit the student

- will get basic training in modelling pattern formation in biological systems.
- will be exposed to recent and rapidly growing areas of understanding Developmental Biology through the Principles of Physics.

Textbooks:

1. Biological Physics: Energy, Information, Life – Philip Nelson.

2. Physical Models of Living Systems – Philip Nelson.

3. Mathematical Biology I and II – J.D Murray.

Reference books:

1. Physical Biology of the cell – Rob Philips et al.

2. Biophysics- Searching for principles – William Bialek

Research papers to refer:

1. Pattern Formation in Active Fluids: Justin S. Bois, Frank Jülicher, and Stephan W. Grill (Phys. Rev. Lett.106, 028103).

2. How Active Mechanics and Regulatory Biochemistry Combine to Form Patterns in Development: Gross, Peter, K. Vijay Kumar, and Stephan W. Gril (Annual review of biophysics 46 (2017): 337-356).

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**1**	**1**	**2**	**2**		**2**		**2**	**2**		
CO2	**1**	**1**	**2**	**2**		**2**		**2**	**2**		
CO3	**1**	**1**	**2**	**2**		**2**		**2**	**2**		
CO4	**1**	**1**	**2**	**2**		**2**		**2**	**2**		
CO5	**1**	**1**	**2**	**2**		**2**		**2**	**2**		
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

III – SEMESTER

SPH 821 ANALOG AND DIGITAL COMMUNICATION LAB

L	T	P	S	J	C
0	0	4	0	0	2

Hours per week: 4 Continuous Evaluation: 100 Marks

Credits: 2

Objective: Understanding the design of communication circuits with electronic devices and MATLAB

1 Amplitude Modulation (Implementation with Circuit and Software)
2. Detection of Amplitude Modulation (Implementation with Circuit and Software)
3. Frequency Modulation (Implementation with Circuit and Software)
4. Pulse Width Modulation (Implementation with Circuit and Software)
5. Pulse Position Modulation (Implementation with Circuit and Software)
6. Amplitude Shift Keying
7. Phase shift Keying
8. Frequency shift keying
9. Phase-locked loop
10. Mixer

Course Outcomes:

1. Demonstrate generation and detection of analog and digital modulation techniques.
2. Understand the operations of analog and pulse modulation & demodulation techniques.
3. Design of communication circuits for continuous and pulse modulation methods
4. Acquire knowledge on MATLAB programming skills to simulate analog and pulse modulation and demodulation techniques
5. Develop the ability to compare the strengths and weaknesses of various modulation techniques

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**2**	**1**	**2**	**2**	**2**	**2**		**2**	**2**	**2**	
CO2	**2**	**1**	**2**	**2**	**2**	**2**		**2**	**2**	**2**	
CO3	**2**	**1**	**2**	**2**	**2**	**2**		**2**	**2**	**2**	
CO4	**2**	**1**	**2**	**2**	**2**	**2**		**2**	**2**	**2**	
CO5	**2**	**1**	**2**	**2**	**2**	**2**		**2**	**2**	**2**	
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

III - SEMESTER

SPH 823: SOLID STATE PHYSICS LAB

L	T	P	S	J	C
0	0	4	0	0	2

Hours per week: 4 Continuous Evaluation: 100 Marks

Credits: 2

Objective: Skill sets for deterministic parameters of solids and liquids responsible for their physical properties

1. Forbidden energy Gap of LED/ Ge/ Si.
2. Forbidden energy Gap of semiconductor
3. Lattice dynamics- I Dispersive relations of mono atomic lattice
4. Lattice dynamics –II Dispersive relations of Di atomic lattice
5. Resistivity of semiconductor- Four Probe method
6. Dielectric constant
7. B-H Curve
8. Susceptibility of liquid – Quink's Tube
9. Calibration of Electromagnet Course outcomes

Course Outcomes:

1. Demonstrate several key areas of solid-State Physics as outlined in the Course.
2. Apply their knowledge to solve problems in solid state physics.
3. Interpret experimental and computational results.
4. Demonstrate the orders of magnitude of the certain quantities and develop confidence.
5. Verification and illustration behaviour.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**2**	**1**	**2**	**2**	**2**	**2**		**2**	**2**	**2**	
CO2	**2**	**1**	**2**	**2**	**2**	**2**		**2**	**2**	**2**	
CO3	**2**	**1**	**2**	**2**	**2**	**2**		**2**	**2**	**2**	
CO4	**2**	**1**	**2**	**2**	**2**	**2**		**2**	**2**	**2**	
CO5	**2**	**1**	**2**	**2**	**2**	**2**		**2**	**2**	**2**	
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS III - SEMESTER

SPH 891 Comprehensive Viva

Credits: 2

Continuous Evaluation: 50 Marks

M.Sc. PHYSICS

IV-SEMESTER

SPH 802: MATERIAL CHARACTERIZATION TECHNIQUES

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessional: 40 Marks

Preamble: To measure various physical parameters with different experimental methods.

Objective: To make familiar with various experimental techniques in the characterization of materials

UNIT- I Nuclear Techniques 9 hrs.

Rutherford back scattering spectrometry, Low energy ion scattering, General picture of energy loss, Energy loss of MeV ions in solids, Comparison of energy loss to electrons and to nuclei, energy loss in compounds- Bragg's rule, The shape of backscattering spectrum, Depth profiles with RBS, Secondary Ion Mass Spectrometry (SIMS).

Unit – II Spectroscopic Techniques 9 hrs.

UV-Visible-NIR spectroscopy, Beer Lamberts law-band gap measurement, Infrared spectroscopy- instrumentation, and interpretation of vibrational spectra sample handling techniques, FTIR, Spectroscopic Ellipsometry, Electron spin resonance spectroscopy.

Unit- III X-ray Techniques 9 hrs.

Xray Absorption, Extended X-ray absorption fine structure (EXAFS), X-ray Photoelectron spectroscopy, Experimental considerations-radiation sources, electron spectrometers, photoelectron energy spectrum, Diffraction of X-rays by crystal, Bragg's Law, X-ray spectrometer, Diffraction directions, diffraction under nonideal conditions-Scherrer equation for the estimation of particle size. Comparison of X-ray scattering by solids, liquids, and gases.

Unit – IV Microscopic Techniques 9 hrs.

Transmission electron microscopy (TEM), Thermionic and field emission scanning electron microscopy (SEM), energy dispersive X-ray (EDX) and wavelength dispersive X-ray (WDX) analysis, atomic force microscopy (AFM), Near-field scanning optical microscope (NSOM), Nano-indentation technique.

Unit – -V Magnetic, Thermal, and Electrical Analysis Techniques 9 hrs.

Vibrating sample magnetometer (VSM), Impedance analyzer, closed-cycle refrigerator, Thermal Gravimetric Analysis (TGA), Differential thermal analysis (DTA), Differential scanning calorimeter (DSC), four-probe method, Basics of I-V and C-V measurements on different materials.

Textbooks:

1. Fundamentals of surface and thin film analysis. C. Feldmann and J W Mayer
2. Elements of X-ray diffraction, B D Cullity
3. Nuclear radiation Detectors, V.S.Ramamoorthy and S.S.Kapur
4. Fundamentals of Molecular Spectroscopy, Colin Banwell, Elaine McCash 4th Ed.
5. Introduction to Nanotechnology, Charles P. Poole Jr., and Frank J. Owens Wiley

Course Outcomes

1. Familiarize nuclear experimental techniques for solid-state materials
2. To analyze infrared spectroscopic techniques to interpret spectra of molecules
3. To analyze X ray diffraction spectra for crystalline size
4. To analyze different methods for particle size, surface, and energy with microscopic methods
5. To study various magnetic, thermal, and electrical techniques for characterization of materials

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**2**	**2**	**2**	**2**		**2**		**2**	**2**	**2**	**2**
CO2	**2**	**2**	**2**	**2**		**2**		**2**	**2**	**2**	**2**
CO3	**2**	**2**	**2**	**2**		**2**		**2**	**2**	**2**	**2**
CO4	**2**	**2**	**2**	**2**		**2**		**2**	**2**	**2**	**2**
CO5	**2**	**2**	**2**	**2**		**2**		**2**	**2**	**2**	**2**
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

IV-SEMESTER

SPH 842 INTRODUCTION TO THIN FILM TECHNOLOGY

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessional: 40 Marks

Preamble: An introduction to basic thin film technology techniques, Growth processes, properties, and application of thin films.

Objective: To impart knowledge on physical and chemical processes with models for nucleation and growth of thin films.

Unit- I Thin film deposition techniques 9 hrs.

Why thin films? Vapour deposition techniques, physical vapour deposition- Thermal evaporation, DC, RF, ion beam Sputtering, Chemical vapour deposition, Solution deposition techniques: chemical solution deposition (CSD), electrochemical deposition (ECD). Thick film deposition techniques: Liquid- Phase Epitaxy (LPE), Screen Printing, melt Spinning, Dip Coating, Spinning, and Solution Casting. Monitoring and Analytical Techniques-Deposition Rate and Thickness Measurement.

Unit- II Nucleation and Growth of thin films 9hrs.

Elastic scattering, thermal accommodation coefficient, motion of adsorbed atoms on surface, surface energy of solids, vapour pressure above a cluster, Mechanisms of thin film formation.3D nucleation, 2D nucleation, Rate of Nucleation. Atomistic theory of nucleation, Kinetic nucleation theory, coalescence, ripening, film growth and microstructure, Grains in films, stresses in thin films, Ostwald's step rule.

Unit- III Epitaxy 9 hrs.

Relationship between substrate and epitaxial layer, growth morphology, structure and energy of epitaxial interface, strained layer epitaxy, defects in epitaxial layers, diffusion in epitaxial surfaces, Molecular beam epitaxy (MBE) technique.

Unit- IV Properties of thin films **9 hrs.**

Conducting films, semiconductor films, superconducting films, magnetic films, dielectric films, ferroelectric films, mechanical properties of thin films, optical properties of thin films, and diffusion in thin films.

Unit- V Applications of thin film **9 hrs.**

Anti-reflection coatings, Photovoltaic Devices, Solar Cells: General Analysis, Thin Film Solar Cells, Photon Detectors-photoconductive Detectors, Photo emissive Detectors. Thin Film Displays, Thin Film Transistors (TFT), Thin Film Diodes. Charge-Coupled Devices (CCDs): Principle, Applications. Wear- resistant coatings and lubricating Coatings. Decorative Applications.

Textbooks:

1. Thin Film Device Applications-K. L. Chopra and Indrajeet Kaur
2. Principles of Vapor Deposition of Thin Films- K.S.Sree Harsha,

Reference Books:

1. Thin Film Phenomena by K L Chopra
2. Material Science of thin films by Milton Ochring

Course Outcomes:

1. The student will learn the different routes of thin film preparation- Physical Vapor, Chemical Vapor, and solution-based deposition techniques.
2. The student will be aware of different process parameters and controlling instruments in thin film deposition.
3. Knowledge of different stages of nucleation and growth of thin film techniques will be acquired. A clear understanding of the concept of epitaxy and its importance in controlling the growth and morphology of thin films.
4. Gain an ability to study the mechanical, optical, magnetic, dielectric properties of thin films
5. The student acquires an understanding of the broad scope of applications of thin films in different fields.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**3**	**3**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**2**	**2**
CO2	**3**	**3**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**2**	**2**
CO3	**3**	**3**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**2**	**2**
CO4	**3**	**3**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**2**	**2**
CO5	**3**	**3**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**2**	**2**
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

IV-SEMESTER

SPH 844: SOFT CONDENSED MATTER PHYSICS

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessional: 40 Marks

Preamble: Aims in study of deformable materials for critical phenomena. Objective: Understanding the knowledge of easily deformed materials with thermal fluctuations and mechanical stresses for critical phenomena.

Unit- I Concepts of Condensed Matter 9 hrs.

Gaseous and liquid states, liquid gas phase transition, spatial correlation, ice-crystalized water, broken symmetry and rigidity, Dislocations- topological defects. Universality of water, Energies, and potentials-Energy scales, Vanderwaal attraction, Molecular Hydrogen-Heitler London approach and hard sphere repulsion.

Unit- II Structure and Scattering 9 hrs.

Elementary scattering theory, photons, neutrons and electrons, density operator and correlation functions, hard sphere liquids. Crystalline solids-unit cells and direct lattice, reciprocal lattice, periodic functions, and Bragg scattering. Symmetry and crystal structure-two and three-dimensional Bravais lattice and close packed structures.

Unit- III Thermodynamics of Homogenous fluids 9 hrs.

Laws of thermodynamics, thermodynamic potentials, stability criteria, homogenous function and equation of state, Ideal gas, spatial correlation in classical systems, ordered systems, Symmetry, order parameter and models- discrete symmetries and continuous symmetries and models.

Unit- IV Mean Field Theory 9 hrs.

Bragg William theory, landau theory, Ising and n vector models-nonlocal susceptibility and correlation length. Liquid gas transition-critical point and critical isochore, coexistence curve. Liquid–Solid transition- Are all crystals BCC, Criterion for freezing, changes in density and density fluctuation theory.

Unit- V Critical Phenomena 9 hrs.

Variational mean field theory-two inequalities, mean field approximation, Breakdown of mean field theory - mean field transition revisited. self-consistent field approximation. Critical exponents, Universality and scaling-exponents and scaling relations, scaled equation of state, multi critical points, amplitude ratios, calculation of critical exponents and amplitude ratios.

Textbooks:

1. Principles of Condensed Matter Physics P.M. Chaikin and T.C Lubensky Cambridge Univ. Press ,2000
2. Advanced Condensed matter Physics Leonard.M. Sander Cambridge Univ. Press Edition, 2009

Course Outcomes

1. Introduction to the concept of condensed matter and reason for formation of condensed matter is understood with different approaches for condensed matter for determination of energies and potential is realized.
2. Scattering phenomena of crystal structures if understood in two and three dimensions
3. Homogeneity of fluid with equation of state is understood
4. Understands the various theories of condensed matter for its properties
5. Enables to understand the transitions during condensed matter.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	3	3		3		3	3	3	2	2	2
CO2	3	3		3		3	3	3	2	2	2
CO3	3	3		3		3	3	3	2	2	2
CO4	3	3		3		3	3	3	2	2	2
CO5	3	3		3		3	3	3	2	2	2
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

IV - SEMESTER

SPH 846: ADVANCED THEORIES IN FERROICS

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessional: 40 Marks

Preamble: This course introduces the ferroic properties of materials and their applications for devices. This course is mainly aimed at materials science researchers.

Objective: Introduce the new and advanced functional ferroic materials with their synthesis and properties.

Unit- I Ferroics **9 hrs.**

Introduction, Ferroelectric materials, Crystal structures and space groups, Ferromagnetic materials, Magnetoelectric effects, Incompatibility between ferroelectricity and magnetism, Mechanisms for ferroelectric and magnetic integration, Ferro elasticity, Ferro elastic materials.

Unit- II Ferroelectric odors **9 hrs.**

Barium titanate: theory, Formation, and Dynamics of Domains, phase transitions and critical phenomenon, Antiferroelectric Transition, Piezoelectric Phenomena, Piezoelectric Materials Pyroelectric Phenomena, Pyroelectric Materials, Dielectrics - Time-Domain Approach and the Frequency-Domain Approach, Complex Permittivity, Debye Equations.

Unit- III Magnetic orders **9 hrs.**

Exchange interactions, Anisotropies in [100], [110] and [111] directions, Domains: size, shape, and motion. Bloch wall, Magnetization processes, Molecular field theory of antiferromagnetism, Types of antiferromagnetism, Ferrimagnets, Frustration, Spin glasses, Crystal Feld effects, Rare- earth ions and the electrostatic potential, ligand fields, Transition-metal ions-The Jahn-Teller effect, Quenching of the orbital angular momentum.

Unit- IV Magnetoelectric coupling 9 hrs.

Magnetoelectric materials, magnetoelectric coupling, Multiferroic, Type-1 and Type-2 multiferroics, Approaches to the coexistence of ferroelectricity and magnetism, independent systems, Ferroelectricity induced by lone-pair electrons, Geometric ferroelectricity in hexagonal manganite's, Spiral spin-order-induced multiferroicity, magnetoelectric coupling.

Unit- V Applications of Ferroics 9 hrs.

Magnetic field sensors using multiferroics, Electric field control of exchange bias by multiferroics: Exchange bias in CoFeB/BiFeO3 spin-valve structure, Exchange bias in Py/YMnO3 spin-valve structure, Multiferroics/semiconductor heterostructures as spin filters, four logical states realized in a tunnelling junction using multiferroics, Negative index materials.

Textbooks:

1. Dielectric phenomena in solids, Kwan Chi Kao, Elsevier Academic Press,2004
2. Ferroelectricity, Julio A. Gonzalo, Basilio Jirntnez, Wiley-VCH Verlag GinbH& Co 2005.
3. Magnetism and Magnetic materials J. M. D. Coey, Cambridge University Press, 2009.
4. Multiferroicity: the coupling between magnetic and polarization orders, K.F. Wang, J.-M. Liu and Z.F. Ren, Advances in Physics, 58, No. 4, 321–448, 2009

Course outcomes:

1. Various types of ferroics will be understood. Incompatibility between ferroelectricity and magnetism in materials will be understood. Piezoelectric, Piezoelectric, Pyroelectric materials properties are understood.
2. Some basics on Dielectrics, Debye equation is understood. About Exchange interactions, Anisotropies and Domains are understood.
3. About ligand fields, The Jahn-Teller effect and Quenching are understood. About Magnetoelectric, Multiferoics are learnt.
4. Different types of origin of ferroelectricity are understood. About Magnetic/electric field sensors are learnt
5. About spin-valve structure, Multiferroics/semiconductor heterostructures are learnt.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**3**	**3**		**2**	**2**	**3**	**3**	**2**	**2**	**2**	**2**
CO2	**3**	**3**		**2**	**2**	**3**	**3**	**2**	**2**	**2**	**2**
CO3	**3**	**3**		**2**	**2**	**3**	**3**	**2**	**2**	**2**	**2**
CO4	**3**	**3**		**2**	**2**	**3**	**3**	**2**	**2**	**2**	**2**
CO5	**3**	**3**		**2**	**2**	**3**	**3**	**2**	**2**	**2**	**2**
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

IV - SEMESTER

SPH 848 ULTRAFAST OPTICS AND RAMAN SPECTROSCOPY

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessional: 40 Marks

Preamble: Understand the knowledge of nonlinear optical phenomena for its generation, measurement, and its measurement

Objective: Understand the knowledge of nonlinear optical phenomena, the generation and measurement of ultrashort pulses.

Unit -I Methods for the generation of ultrashort laser pulses 9 hrs.

Mode locking Optical pulses, relation between pulse duration and spectral width, Methods for the Generation of Ultrashort Laser Pulses- Mode-Locking, Principle of the Mode-Locked Operating Regime the Active Mode-Locking Method.

Unit -II Pulse Measurements 9 hrs.

Introduction, Energy Measurements, Power Measurements, Measurement of the Pulse Temporal profile, Spectral Measurements, Amplitude–Phase Measurements.

Unit -III Spectroscopic Methods for Analysis of Sample Dynamics 9 hrs.

Pump–Probe" Methods, General Principles, Probe-Induced Raman Scattering, Time-Resolved Emission Spectroscopy: Broad-Bandwidth Photo detectors, Transient-Grating Techniques, Principle of the Method: Degenerate Four-Wave Mixing (DFWM)

Unit- IV Ultrafast laser ablation 9 hrs.

Nonlinear optical media, second order nonlinear optics-second harmonic generation and rectification, phase matching condition, difference frequency generation, sum frequency generation, electro-optic effect, Pockels electro-optic effect, Kerr electro-optic effect, three wave mixing, third order nonlinear effects, -Third harmonic generation, self-phase modulation, self- focusing.

Unit- V Raman spectroscopy **9 hrs.**

Introduction, Absorption and Scattering, States of a System and Hooke's Law, The Nature of Polarizability and the Measurement of Polarization, The Basic Selection Rule, Number and Symmetry of Vibrations, the Mutual Exclusion Rule, The SERS-surface Plasmon resonances, electromagnetic and chemical enhancement, Enhancement factor (EF).

Textbooks:

1. Femtosecond laser pulses –principals and experiments - Claude Rulliere, Springer-Verlag Berlin and Heidelberg GmbH, ISBN: 978-3540636632
2. Fundamentals of photonics, Bahaa E. A. Saleh , Malvin Carl Teich, Wiley–Blackwell, ISBN: 978-0471358329
3. Modern Raman Spectroscopy – A Practical Approach, Ewen Smith, Geoffrey Dent, Wiley, ISBN: 978-0471496687

Course outcomes:

- Students procure knowledge on ultrashort pulses. obtained exposure on generation mechanisms of ultrashort laser pulses. Understand the basic properties of ultrashort pulses.
- Understand how time domain and frequency domain information of pulses is related. Acquired exposure on time resolved studies.
- To know how micro level information of molecules will be probed by ultrashort pulses. Understood the intensity role of ultrashort pulses in determining optical nonlinearities.
- Learn nonlinear optical phenomenon which gave birth to many advanced laser systems. Raman scattering and its basic idea.
- Learn techniques such as SERS.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	3	3		2		3	3	2	2	2	
CO2	3	3		2		3	3	2	2	2	
CO3	3	3		2		3	3	2	2	2	
CO4	3	3		2		3	3	2	2	2	
CO5	3	3		2		3	3	2	2	2	

Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation

M.Sc. PHYSICS

IV - SEMESTER

SPH 850: MATERIALS SCIENCE

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessional: 40 Marks

Preamble: Aims to understand the different phenomena of materials science.

Objective: To impart knowledge in understanding crystal structures, classification, synthesis, and phase transitions in different types of materials.

Unit- I Applied Crystallography in Materials Science 9 hrs.

Nanocrystalline and semicrystalline states, Lattice, Crystal systems, unit cells. Indices of lattice directions and planes. Coordinates of position in the unit cell, Zones, and zone axes. Crystal geometry. Symmetry classes and point groups, space groups. Glide planes and screw axes, space group notations, Equivalent points. Systematic absences, Determination of crystal symmetry from systematic absences. Stereographic projections. Standard projection of crystals.

Unit- II Introduction to Materials Classification of Materials 9 hrs.

Crystalline & amorphous materials, high Tc superconductors, alloys & composites, semiconductors, solar energy materials, luminescent and optoelectronic materials, Polymer, Liquid crystals and quasi- crystals, Ceramics.

Unit- III Preparation Techniques of Materials 9 hrs.

Preparation of materials by different techniques: Single crystal growth, zone refining, epitaxial growth. Melt-spinning and quenching methods, sol-gel, polymer processing. Preparation of ceramic materials; Fabrication, control, and growth modes of organic and inorganic thin films: different technique of thin film preparations: Basic principles.

Unit-IV Synthesis of Nanomaterials **9 hrs.**

Top-down and bottom-up approaches of synthesis of nano-structured materials, nanorods, nanotubes/wire, and quantum dots. Fullerenes and tubules, Single wall, and multiwall nanotubes

Unit- V Phase Transition in Materials **9 hrs.**

Solid solutions, Phases, Thermodynamics of solutions, Phase rule, Binary phase diagrams, Binary isomorphous systems, Binary eutectic systems, ternary phase diagrams, kinetics of solid reactions. Order disorder phenomenon in binary alloys, long range order, super lattice, short range order.

Reference Books

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

Course outcomes:

1. Enable to understand the realization of crystals with crystallographic parameters. Introduces the symmetry of crystals, point, and space groups of crystals. Introduces the classifications of materials.
2. Concept of liquid crystals and its classification are understood. Aims in preparation of materials with different methods.
3. Fabrication and growth modes of thin films are understood. Helps to understand the synthesis of nanomaterials.
4. Idea of fullerenes and nanotubes were understood.
5. Helps to understand the phase diagrams of importance. Understands the ordering phenomena of binary alloys.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**3**	**3**		**2**		**3**	**3**	**2**	**2**	**2**	
CO2	**3**	**3**		**2**		**3**	**3**	**2**	**2**	**2**	
CO3	**3**	**3**		**2**		**3**	**3**	**2**	**2**	**2**	
CO4	**3**	**3**		**2**		**3**	**3**	**2**	**2**	**2**	
CO5	**3**	**3**		**2**		**3**	**3**	**2**	**2**	**2**	

Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation

M.Sc. PHYSICS

IV - SEMESTER

SPH 852 INTRODUCTION TO PHOTONIC QUANTUM COMPUTING

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessional: 40 Marks

Course Objectives:

Develop a foundational understanding of quantum optics, including its principles and applications.

Gain knowledge of quantum optical states and its use in photonic quantum computing, exploring its theoretical framework and potential.

Learn about quantum entanglement in continuous variables.

Get an overall idea about cluster state photonic quantum computing.

Unit-I Introduction to Quantum Optics 6 hrs.

Classical vs. Quantum description of light, Quantum harmonic oscillator, Quantum harmonic oscillator in optical systems.

Unit-II Quantum States of Light 9 hrs.

Generation of non-classical light states, Coherent state and their properties, Squeezed Coherent states, Gottesman-Kitaev-Preskill State, Orbital Angular Momentum Modes.

Unit-III Quantum Computing with Light 9 hrs.

Basics of continuous variable quantum mechanics, Discrete vs Continuous variables quantum computing, Qubit vs Qumodes, Qumode Gates, Photonic quantum computing, Gaussian Operations, Measuring Quadratures, Single Photon Sources, Spontaneous Parametric Down-Conversion (SPDC), Quantum Dots, Photon Detectors.

Unit-IV : Quantum Entanglement **9 hrs.**

Continuous variable entanglement and its characterization, Density Matrix, Partial Trace, Reduced Density Matrix, Schmidt Decomposition, Schmidt Number, Linear Entropy, Von-Neumann Entropy. Experimental ways to detect quantum entanglement, Heterodyne Detection, Homodyne Detection, Photon counting and quantum state tomography.

Unit-V Cluster State Quantum Computing **12 hrs.**

Phase space representation of Coherent State, Hussimi distribution of coherent states, Wigner function, Glauber-Sudarshan P representation, Gottesman-Kitaev-Preskill State, Hex-GKP State, Gottesman-Kitaev-Preskill Code, Cluster State, Optical Cluster state generation. Optical cluster-state quantum computation overview.

Textbooks:

1. Gerry, C. C., & Knight, P. L. (2005), Introductory Quantum Optics.
2. Scully and Zubairy (2001), Quantum Optics, Cambridge University Press.
3. S. L. Braunstein and A. K. Pati (2003), Quantum Information with Continuous Variables, Springer Publishers.
4. Nicolas J. Cerf, Gerd Leuchs, Eugene S. Polzik (2007), Quantum Information With Continuous Variables of Atoms and Light, Imperial College Press.

References:

- C. Weedbrook, S. Pirandola et. al., Gaussian quantum information, Rev. Mod. Phys.84, 621 (2012).
- Samuel L. Braunstein and Peter van Loock, Quantum information with continuous variables, Rev. Mod. Phys. 77, 513 (2005).
- Jacquiline Romero and Gerard Milburn, Photonic Quantum Computing, arXiv:2404.03367
- E. Bourassa, et al. , “Blueprint for a Scalable Photonic Fault-Tolerant Quantum Computer”, Quantum 5, 392 (2021).
- Quantum computing with continuous-variable clusters, Phys Rev A 79, 062318 (2009).

Course Outcomes:

At the end of this course, the students will be able to:

- Understand the fundamentals of Quantum Optics.
- Learn Continuous Variable Quantum Optical States.
- Learn Continuous Variable Quantum Entanglement.
- Learn Photonic Quantum Computing.
- Learn Cluster State Quantum Computing.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	2	2		2		2	2	2	2	2	2
CO2	2	2		2		2	2	2	2	2	2
CO3	2	2		2		2	2	2	2	2	2
CO4	2	2		2		2	2	2	2	2	2
CO5	2	2		2		2	2	2	2	2	2
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

IV - SEMESTER

SPH 854 TOPOLOGY IN QUANTUM MATERIALS

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessional: 40 Marks

Course Description:

This course introduces the concepts of topology and its applications in condensed matter physics. Topics include fundamentals of topology, basics of band theory and topological bands, topological insulators, superconductors, quantum Hall effects, and introduction to topological quantum computing. The course will cover both theoretical foundations and experimental realizations.

Prerequisites: Solid state physics, Quantum mechanics.

Course Objectives:

- Provide a thorough understanding of basic topology concepts, including manifolds, homotopy, and homology.
- Enable identification and explanation of topological invariants like winding numbers, Chern numbers, and Z2 invariants.
- Familiarize with topological phases of matter, including band theory, Berry phase, and time-reversal symmetry in Z2 insulators.
- Provide comprehensive understanding of IQHE and FQHE, including edge states and bulk-boundary correspondence.
- Examine properties and significance of topological insulators, superconductors, and semimetals, and analyze advanced models and Berry phase implications.

Unit -I Introduction to Topological concepts 8 hrs.

Basics of topology: manifolds, homotopy, homology. Topological invariants: winding numbers, Chern numbers, Z2 invariants. Topological spaces and maps.

Learning outcome: By the end of this unit, students will be able to:

- Understand the foundational concepts in topology, including manifolds, homotopy, and homology.
- Identify and explain various topological invariants such as winding numbers, Chern numbers, and Z2 invariants.
- Define and work with topological spaces and maps.

Unit -II Topological phases of matter 9hrs.

Overview of topological phases, Band theory and topological band structures, Berry phase , Berry connection and Berry curvature. Example: two level system (eg. spin-½ particle in a magnetic field) Time-reversal symmetry and Z2 topological insulators.

Learning Outcomes: By the end of this unit, students will be able to:

- Understand the fundamental concepts of topological phases of matter and their significance in condensed matter physics.
- Explain band theory and identify topological band structures.
- Describe Berry phase, Berry connection, and Berry curvature and their physical implications.
- Analyze a two-level system, such as a spin-½ particle in a magnetic field, in the context of Berry phase.

Unit-III Quantum Hall Effects 6 hrs.

Integer Quantum Hall Effect (IQHE), Fractional Quantum Hall Effect (FQHE), Edge states and bulk-boundary correspondence.

Learning Outcomes: By the end of this unit, students will be able to:

- Understand the physical principles and experimental observations underlying the Integer Quantum Hall Effect (IQHE).
- Describe the Fractional Quantum Hall Effect (FQHE) and its theoretical foundation.

- Explain the concept of edge states and the bulk-boundary correspondence in the context of quantum Hall effects.

Unit- IV Topological materials and models 12 hrs.

Topological Insulators: 2D and 3D topological insulators, Kane-Mele model, Experimental realizations. Topological Superconductors: Majorana fermions, p-wave superconductors, Experimental signatures. Topological Semimetals: Weyl and Dirac semimetals, Fermi arcs and surface states, Experimental observations. Berry phase and electric polarization, Su Schriffer Heeger Model: domain wall states and Jackiw Rabbi problem, Thouless charge pump, TKNN effect, edge states, chiral dirac fermions, Hofstadter model, SSH Model, Kitaev model, Majorana\fermions.

Learning outcome: By the end of this unit, students will be able to:

- Understand the properties and significance of 2D and 3D topological insulators.
- Recognize the characteristics and experimental signatures of topological superconductors and Majorana fermions.
- Explain the properties of topological semimetals, including Weyl and Dirac semimetals, and identify their experimental observations.
- Analyze the role of Berry phase and electric polarization in topological systems.

Unit-V Topological Quantum Computation 10 hrs.

Basics of quantum computation, topological quantum bits (qubits), anyons and braiding, Fibonacci anyon model, non-Abelian anyons, Yang-Baxter equation, Fusion rules.

Learning Outcomes: By the end of this unit, students will be able to:

- Understand the basic principles of quantum computation and the significance of topological quantum computation.
- Describe anyons, braiding operations, and their role in topological quantum computation.
- Understand the Yang-Baxter equation and its role in topological quantum computation.
- Describe fusion rules and their application in the context of anyons and quantum computation.

Textbooks:

1. F. Ortmann, Topological Insulators: Fundamentals and Perspectives, Wiley-VCH (2015), 1st Ed.

2. Ed. by G. Tkachov, Topological Insulators: The Physics of Spin Helicity in Quantum Transport, CRC press (2016), 1st Ed

3. János K. Asbóth, László Oroszlány, András Pályi, A Short Course on Topological Insulators: Band Structure and Edge States in one and two dimensions, Springer (2016), 1st Ed.

4. B. Andrei Bernevig, Topological Insulators and Topological Superconductors, Princeton University Press (2013) 1st Ed.

5.Topological Insulators and Topological Superconductors by B. Andrei Bernevig and Taylor L. Hughes.

6. Topology and Condensed Matter Physics, Somendra M. Bhattacharjee and Manas K. Chattopadhyay.

7. Berry Phase in Electronic Structure Theory: Electric Polarization, Orbital Magnetization and Topological Insulators, David Vanderbilt.

8. Quantum Field Theory and Condensed Matter: An Introduction, Ramamurti Shankar.

References:

1. A.M. Turner, V. Ashwin, Beyond band insulators: Topology of semi-metals and interacting phases, (arXiv 1301.0330(V2))
2. Colloquium: Topological insulators, M. Z. Hasan and C. L. Kane, Reviews of Modern Physics.
3. Topological phases of matter, Xiao-Liang Qi and Shou-Cheng Zhang, Reviews of Modern Physics.

Course Outcomes:

At the end of this course, the students will be able to:

• Understand the fundamentals of topology

• Learn quantum hall effects.

• Learn Topological Insulators, Semi-metals and Topological superconductors.

• Learn basics of Topological quantum computing

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	3	3		3		3	3		2		2
CO2	3	3		3		3	3		2		2
CO3	3	3		3		3	3		2		2
CO4	3	3		3		3	3		2		2
CO5	3	3		3		3	3		2		2
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

IV - SEMESTER

SPH 856 PHYSICS OF STRONGLY CORRELATED QUANTUM MATTER

L	T	P	S	J	C
3	0	0	0	0	3

Hours per week: 3 End Examination: 60 Marks

Credits: 3 Sessional: 40 Marks

Prerequisites: Students will have the necessary linear algebra, solid state physics, quantum physics, and computational foundation to effectively engage with the advanced topics covered in the Physics of Strongly Correlated Quantum Materials course.

Course Objective:

The objective of this course :

- Provide an in-depth understanding of strongly correlated electronic systems,
- Explore theoretical frameworks, experimental techniques, and applications.
- Students will gain knowledge of the physical phenomena and mathematical models that describe these systems
- Develop an ability to apply this knowledge to current research topics in condensed matter physics.

Unit- I Introduction to Strong Correlations 9 hrs.

Overview of strongly correlated materials, historical context and significance in condensed matter physics, Basic concepts: electrons, spin, and lattice structure Theoretical Foundations: Hubbard Model, Single-band Hubbard model, Multi-band Hubbard model, Anderson Model, Heisenberg Model

Unit-II Techniques in Theoretical Analysis 9 hrs.

Mean-field theory, Perturbation theory, Variational methods, Numerical techniques: Exact diagonalization, Quantum Monte Carlo

Unit-III Novel Properties of Strongly Correlated Materials 9 hrs.

Metal-Insulator Transitions, Magnetic Properties of Strongly Correlated Systems, Superconductivity in Correlated Systems, Quantum Hall Effect and Topological Phases, Heavy Fermion Systems, Low-Dimensional Systems

Unit-IV Experimental Techniques to probe strongly correlated system 9 hrs.

Angle-resolved photoemission spectroscopy (ARPES), Neutron scattering, Scanning tunnelling microscopy (STM), Resonant inelastic X-ray scattering (RIXS)

Unit-V Current Research and Emerging Topics 9 hrs.

Quantum information and entanglement in correlated systems, non-equilibrium dynamics, Novel materials and heterostructures

Textbooks and References:

1. Quantum Theory of Many-Particle Systems, Alexander L. Fetter and John Dirk Walecka, Dover Publications Inc.

2. The Theory of Quantum Liquids, David Pines and Philippe Nozieres, CRC Press, ISBN: 978-0367319090

3. Introduction to Many-Body Physics, Piers Coleman, Cambridge University Press, ISBN: 978-0521864886

4. Electronic Structure: Basic Theory and Practical Methods (v. 1), Richard M. Martin, Cambridge University Press, ISBN: 978-0521534406

5. Research papers and review articles from journals such as Physical Review Letters, Physical Review B, and Journal of Physics: Condensed Matter

Course Outcomes:

- Understand fundamental concepts and historical significance of strongly correlated materials.
- Apply theoretical models to analyze the behavior of strongly correlated systems.
- Utilize theoretical analysis techniques to solve problems in strongly correlated systems.
- Analyze novel properties of strongly correlated materials and their implications.
- Employ experimental techniques to investigate and interpret data from strongly correlated systems.

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**3**	**3**		**3**		**3**	**3**		**2**		**2**
CO2	**3**	**3**		**3**		**3**	**3**		**2**		**2**
CO3	**3**	**3**		**3**		**3**	**3**		**2**		**2**
CO4	**3**	**3**		**3**		**3**	**3**		**2**		**2**
CO5	**3**	**3**		**3**		**3**	**3**		**2**		**2**
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

IV - SEMESTER

SPH 822 MATERIAL CHARACTERIZATION LAB

L	T	P	S	J	C
0	0	4	0	0	2

Hours per week: 4 Continuous Evaluation: 100 Marks

Credits: 2

Objective: Ability to understand the interpretation of various characterization data/spectra

1. Interpretation of Fourier transform infrared spectroscopy (FTIR) spectra
2. Interpretation of UV Vis spectra
3. Analysis of XRD pattern
4. Vibrational Raman spectra
5. TEM data -Average particle size measurement
6. SEM data Microstructure analysis
7. Electron Spin Resonance
8. Gamma ray spectrometer
9. Spectroscopic Ellipsometry
10. Identification of textures using Optical Polarizing Microscope

Course outcomes:

1. Ability of performing basic characterization of materials for morphological properties of materials.
2. Tests for the investigation of the thermal properties of materials
3. Tests for the identification of functional and fingerprint regions of molecules of interest.
4. Perform calculation of different parameters from database provided
5. Ability to grasp the physical properties form spectra

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**3**	**3**	**3**	**2**		**2**	**2**	**2**	**2**	**2**	**2**
CO2	**3**	**3**	**3**	**2**	**1**	**2**	**2**	**2**	**2**	**2**	**2**
CO3	**3**	**3**	**3**	**2**	**1**	**2**	**2**	**2**	**2**	**2**	**2**
CO4	**3**	**3**	**3**	**2**		**2**	**2**	**2**	**2**	**2**	**2**
CO5	**3**	**3**	**3**	**2**	**1**	**2**	**2**	**2**	**2**	**2**	**2**
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

M.Sc. PHYSICS

IV - SEMESTER

SPH 892 PROJECT WORK

Hours per week: 6 Continuous Evaluation: 200 Marks

Credits: 8

Course Outcomes

1. Students will be able to apply advanced research methodologies, including experimental design, data analysis, and interpretation, to investigate complex physical phenomena within their chosen project area.**(CO1)** , **Applying**
2. Students will acquire an in-depth understanding of the theoretical foundations and practical applications relevant to their specific research topic, demonstrating expertise in their chosen subfield of physics.**(CO2)** , **Analyzing**
3. Students will develop proficiency in communicating scientific findings effectively to both specialist and non-specialist audiences through written reports, oral presentations, and visual aids, demonstrating clarity, coherence, and persuasive argumentation.**(CO3)** , **Evaluating**
4. Students will cultivate the ability to critically evaluate existing literature, identify gaps in current knowledge, formulate research questions, and propose innovative solutions or avenues for further investigation within the realm of physics.**(CO4)** , **Applying**
5. Students will demonstrate a commitment to the highest standards of ethical conduct in research, including integrity, transparency, and respect for intellectual property rights, while adhering to relevant professional codes of practice and regulatory requirements.**(CO5)** , **Applying**

	PO 1	PO 2	PO3	PO 4	PO 5	PO6	PSO 1	PSO 2	PSO3	PSO4	PSO5
CO1	**3**	**3**	**3**	**2**	**3**	**2**	**2**	**2**	**2**	**3**	**3**
CO2	**3**	**3**	**3**	**2**	**3**	**2**	**2**	**2**	**2**	**3**	**3**
CO3	**3**	**3**	**3**	**2**	**3**	**2**	**2**	**2**	**2**	**3**	**3**
CO4	**3**	**3**	**3**	**2**	**3**	**2**	**2**	**2**	**2**	**3**	**3**
CO5	**3**	**3**	**3**	**2**	**3**	**2**	**2**	**2**	**2**	**3**	**3**
Note: 1 - Low Correlation 2 - Medium Correlation 3 - High Correlation											

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