

SRI VENKATESWARA UNIVERSITY:: TIRUPATI
SVU COLLEGE OF SCIENCES
DEPARTMENT OF PHYSICS



Syllabus for M.Sc. PHYSICS

Choice Based Credit System (CBCS)

Amended as per NEP-2020

(w.e.f. the Academic Year 2021-2022)

Vision

To inculcate certain specific enabling skill sets to prepare the students to take up challenges in any one or more functional domains viz. (i) Academics; (ii) Basic and Applied Research; (iii) Research & Development; (iv) Engineering & Technology and (v) Industry.

Mission

To bring out professionals having knowledge of basic laws of nature together with strong fundamentals in the core area of physics viz. Classical Mechanics, Quantum Mechanics, Condensed Matter Physics, Electromagnetism, Computational Physics, Statistical Physics, Spectroscopy, Photonics, Thin film Technology and Solar Energy Physics, Electronics, Atomic and Nuclear Physics and advanced level topics such as High Energy Physics, Nanotechnology, Nonlinear Optics, etc.

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

PEO1	Apply principles of basic scientific concepts in understanding, analysis, and prediction of physical systems.
PEO2	Develop human resource with specialization in theoretical and experimental techniques required for career in academic, research and industry.
PEO3	Engage in lifelong learning and adapt to changing professional and societal needs.

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

PO1	Apply the scientific knowledge to solve the complex physics problems.
PO2	Identify, formulate, and analyze advanced scientific problems reaching substantiated conclusions using first principles of mathematics, physical, and natural sciences.
PO3	Design solutions for advanced scientific problems and design system components or processes that meet the specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal consideration.
PO4	Use research-based knowledge and methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	Create, select, and apply appropriate techniques, resources, and modern scientific tools to complex physics problems with an understanding of the limitations.
PO6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues, and the consequent responsibilities relevant to the professional scientific practice.
PO7	Understand the impact of the scientific solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for, sustainable development.
PO8	Apply ethical principles and commit to the norms of scientific practice.

PO9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	Communicate effectively on scientific activities with the Scientific/Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	Demonstrate knowledge and understanding of the scientific principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of scientific and technological change.

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

PSO1	Understand the basic and advanced concepts of different branches of physics.
PSO2	Perform and design experiments in the areas of electronics, atomic, nuclear, Condensed matter, and computational physics.
PSO3	Apply the concepts of physics in specialized areas of condensed, nuclear, renewable energies, particle physics, etc. in industry, academia, research and day-to-day life.

SRIVENKATESWARAUNIVERSITY::TIRUPATI
DEPARTMENT OF PHYSICS
TWO YEAR M.Sc. COURSE IN PHYSICS (2021-2022) SCHEME

Semester -I

S.No	Components of Study	Title of the Course	Title of the Paper	Credit Hrs /Week	No. of Credits	IA Marks	Sem End Marks	Total
1.	Mandatory Core	PHY101	1. Classical Mechanics and Theory of Relativity	6	4	20	80	100
2.		PHY102	2. Solid State Physics	6	4	20	80	100
3.	Compulsory Foundation	PHY103(a)	1. Analog and Digital Electronics	6	4	20	80	100
		PHY103(b)	2. Computational Methods & C Language					
		PHY103(c)	3. Sensors and Transducers					
4.	Elective Foundation	PHY104(a)	1. Atomic and Molecular Physics	6	4	20	80	100
		PHY104(b)	2. Optical, Microwave and Satellite Communications					
		PHY104(c)	3. Computer Architecture and Networking					
5.	Practical-I	PHY105	Paper 1 & 3 (General Lab)	6	4	--	100	100
6.	Practical-II	PHY106	Paper 3 & 4 (Electronics Lab)	6	4	--	100	100
	Total			36	24	80	520	600
7.	Audit Course			0	0	100	0	0

*All core papers are Mandatory

- Compulsory Foundation choose one paper.
- Elective Foundation – Choose one paper.
- Audit course - 100 Marks (Internals) Zero Credits under self-study.
- Interested students may register for MOOC with the approval of the concerned DDC but it will be considered for the award of the grade as open elective only giving extra credits.

S.No	Components of Study	Title of the Course	Title of the Paper	Credit Hrs/Week	No. of Credits	IA Marks	Sem End Marks	Total
1.	Mandatory Core	PHY201	1. Statistical Mechanics	6	4	20	80	100
2.		PHY202	2. EM Theory, Lasers & Modern Optics	6	4	20	80	100
3.	Compulsory Foundation	PHY203(a)	1. Nuclear Physics	6	4	20	80	100
		PHY203(b)	2. IC fabrication Techniques					
		PHY203(c)	3. Advanced Microprocessors and its Applications					
4.	Elective Foundation	PHY204(a)	1. Mathematical Physics	6	4	20	80	100
		PHY204(b)	2. Introduction to VLSI design					
		PHY204(c)	3. Material Science For Industrial Applications					
5.	Practical-I	PHY205	Paper 1 & 3 (General Lab)	6	4	--	100	100
6.	Practical-II	PHY206	Paper 3 & 4 (Electronics Lab)	6	4	--	100	100
	Total			36	24	80	520	600
7.	Audit Course			0	0	100	0	0

*All core papers are Mandatory

- Compulsory Foundation choose one paper.
- Elective Foundation – Choose one paper.
- Audit course-100 Marks (Internals) Zero Credits under self-study.
- Interested students may register for MOOC with the approval of the concerned DDC but it will be considered for the award of the grade as per elective only giving extra credits.

S.No	Components of Study	Title of the Course	Title of the Paper	Credit Hrs/ Week	No. of Credits	IA Marks	Sem End Marks	Total
1.	Mandatory Core	PHY301	1.Introductory Quantum Mechanics	6	4	20	80	100
2.		PHY302	2.Physics of Semiconductor Devices	6	4	20	80	100
3.	Generic Elective	PHY303(a)	1.Applied Spectroscopy	6	4	20	80	100
		PHY303(b)	2.Condensed Matter Physics					
		PHY303(c)	3.Embedded Systems					
4.	Practicals	PHY304	Elective Lab	6	4	--	100	100
5.	Skill Oriented Course	PHY305	Advances in Physics	6	4	10	90(T40 +P50)	100
6.	Open Elective	PHY306(a)	1.Basic Spectroscopic Techniques	6	4	20	80	100
		PHY306(b)	1. Nanomaterials and Devices					
	Total			36	24	90	510	600

*All core papers are Mandatory

- Generic Elective – Choose two
- Core papers and Generic Electives opted paper held Practical-I
- Skill Oriented Course is Mandatory.
Relevant society along with practical (10 marks internal 40 final theory & 50 for practical's).
- Open Electives are for the students of other Departments. Minimum one paper should be opted. Extra credits may be earned by opting for more number of open electives depending on the interest of the student through self-study.
- Interested students may register for MOOC with the approval of the concerned DDC.

S.No	Components of study	Title of the Course	Title of the Paper	Credit Hrs/ Week	No. of Credits	IA Marks	Sem End Marks	Total
1.	Mandatory Core	PHY401	1. Advanced Quantum Mechanics	6	4	20	80	100
2.		PHY402	2. Physics of Advanced Materials	6	4	20	80	100
3.	Generic Elective	PHY403(a)	1. Photonics	6	4	20	80	100
		PHY403(b)	2. Solar Energy- Thermal and Photovoltaic Properties					
		PHY403(c)	3. Vacuum and Thin Film Technology					
4.	Practicals	PHY404	Elective Lab	6	4	--	100	100
5.	Multi Disciplinary Course/Project Work	PHY405	Advanced Characterization Techniques	6	4	10	90(T 40+P 50)	100
6.	Open Elective	PHY406(a)	1. Wireless Communications	6	4	20	80	100
		PHY406(b)	2. Vacuum Technology & Applications					
	Total			36	24	90	510	600

*All core papers are Mandatory

- Generic Elective – Choose two
- Core papers and Generic Electives opted paper held Practical-II.
- Project Work- Collaboration with various firms/companies/societies.
- Multi-Disciplinary Course is Mandatory. Circle formation with other subjects/Dept. of Arts/Commerce.
- Open Electives are for the students of other Departments. Minimum one paper should be opted. Extra credits may be earned by opting for more number of open electives depending on the interest of the student through self-study.
- Interested students may register for MOOC with the approval of the concerned DDC.

(Mandatory Core)

PHY-101	CLASSICAL MECHANICS AND THEORY OF RELATIVITY					L-5,T-1,P-0	4Credits					
Pre-requisite: Understanding of graduate level physics												
Course Objectives: The aim and objective of the course on Classical Mechanics and theory of relativity is to train the students of M.Sc. in the Lagrangian and Hamiltonian formalisms and relativity theory so that they can use these in the modern branches of physics such as Quantum Mechanics, Quantum Field Theory, Condensed Matter Physics, Astrophysics, etc.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Understand the necessity of Action, Lagrangian, and Hamiltonian formalism.											
CO2	Used' D'Alembert principle and calculus of variation to derive the Lagrange equations of motion.											
CO3	Describe the motion of a mechanical system using Lagrange-Hamilton formalism.											
CO4	Apply essential features of a relativity problem (like motion under central force, periodic motions) to set up and solve the appropriate physics problems.											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	-	1	1	-	2	2	-	1
CO2	3	2	2	2	-	1	1	-	2	2	1	2
CO3	3	3	2	-	2	1	1	-	2	2	-	-
CO4	3	2	3	2	-	1	1	-	2	2	1	-

PHY101: Classical Mechanics and Theory of Relativity

UNIT-I: Lagrangian Mechanics and Hamiltonian Mechanics

Newtonian mechanics of one and many particle systems: Conservation laws: Constraints and their classification: Degrees of freedom: Generalized coordinates: Principle of virtual work, D'Alembert's principle: Lagrange's equations of motion.

Applications: Inclined plane, Linear harmonic oscillator and simple pendulum: Hamiltonian principle: Lagrange's equation from Hamilton's principle: Hamilton's equation of motion: Applications: Simple pendulum, Compound pendulum.

UNIT-II: Canonical Transformations and Hamilton – Jacobi Theory

Canonical Transformations; generating function; properties: Condition for transformation to be canonical; Illustration of canonical transformation: Poisson - Brackets; Canonical equations in terms of Poisson - Bracket notation. Lagrange-Brackets and their properties.

The Hamiltonian - Jacobi equation; one dimensional harmonic oscillator; Action Angle variables:

Kepler problem in action-angle variables

UNIT–III: Motion in a Central Force Field

Reduction to the equivalent one body problem; Motion in a central force field: Conditions for closed orbits; Inverse square law of forces; Kepler's laws of planetary motion; Rutherford scattering.

Rotations – Space and body fixed axes: Angular momentum and Torque; Eulerian angles – Euler's equations of a rigid body: Motion of symmetrical top; Expression for slow and fast precessions; Larmor precession; Examples of Gyroscope.

UNIT–IV: Special Theory of Relativity

Introduction – Postulates of Special Theory of Relativity – The principle of constancy of light – The Lorentz transformations. Relativistic Kinematics: The velocity transformations – The transformations for the acceleration of a particle. Relativity Optics: The aberration of the light from stars – The Doppler effect.

Relativistic Mechanics: The mass of a moving particle – The relativistic dynamics of a single particle – Applications of relativistic dynamics of a single particle: Motion in electric field – Motion in a magnetic field – Experimental verification of the variation of mass with velocity – Bucherer's experiment – Transformation of momentum and force.

Books for Study

1. Classical Mechanics by N.C. Rana and P.S. Joag, Tata Mc-graw Hill (1991).
2. Classical Mechanics by H. Goldstein, Addison Wesley, (1980).
3. Classical Mechanics by J.C. Upadaya, Himalaya Publishing House (2014).
4. Classical Mechanics by Gupta, Kumar and Sharma, Pragati Edition, (2019).
5. Classical dynamics of particles and systems by J.B. Marion, Thomson Books/cole, (2004).
6. Introduction to Classical Mechanics by R.G. Takwale and P.S. Puranik, Tata Mc-graw Hill, (2008).
7. Theory of Relativity by W. Pauli, Dover Publications, (2013).
8. Introduction to the theory of relativity by P.G. Bergmann, Dover Publications (1977).
9. Introductory Relativity by W.G.V. Rosser, London Butterworths, (1967).

(Mandatory Core)

PHY-102	Solid State Physics				L-3,T-1,P-2				4Credits			
Pre-requisite: Understanding of graduate level solid state physics												
Course Objectives: The aim and objective of the course on Solid State Physics is to expose the students of M.Sc. class to the topics like elastic constants, lattice vibrations, dielectric properties, energy band theory and transport theory so that they are equipped with the techniques used in investigating these aspects of the matter in condensed phase.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Gain in-depth knowledge about the formation of various crystal structures and performing calculations on their elemental parameters.											
CO2	Differentiate between various lattice types based on their lattice dynamics and then explain thermal properties of crystalline solids.											
CO3	Understand the electron motion in periodic solids and origin of energy bands in semiconductors.											
CO4	To explain the basic transport theory for understanding the transport phenomenon in solids											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	2	1	-	2	-	1	-
CO2	2	3	2	2	2	2	2	-	-	-	1	2
CO3	3	3	2	2	1	2	2	-	1	-	1	-
CO4	3	3	2	2	2	2	1	-	-	-	1	2

PHY102:Solid State Physics

UNIT–I:Crystallography,LatticeEnergiesandLatticeVibrations

Bravaislattices–Reciprocal lattice –X-raydiffraction –structuralfactor.

Origin of chemical binding in ionic and van der Waals crystals – Elastic properties – Stress and strain –Elastic moduli - Lattice energy calculations for ionic and van der Waals crystals – Lattice vibrations:Mono anddiatomiconedimensionalinfinitelylonglattices–Quantizationoflatticevibrations–Phonons –Properties.

UNIT– II: TransportPhenomenaandBandTheory

Concept of electrical and thermal resistivity – Expression for thermal and electrical conductivities formetals – Lorenz number - Different scattering mechanisms – Matheissens rule- Distribution function -FormulationofBoltzmantransportequation– Relaxationtime approximation.

Sommerfeld model – its consequences – electron-lattice interaction (Quantitative only) – Bloch function -Motion of electron in periodic potential –Kronig - Penny model – Formation of energy bands in solids –Brillouinzones–Conceptofeffectivemass – Distinctionbetweenmetals,insulatorsandsemiconductors.

UNIT–III:SemiconductorPhysics

Intrinsicandextrinsicsemiconductors–ExpressionforpositionofFermilevelsandcarrier concentrations – Variation of Fermi level with temperature – np product – Carrier mobility, conductivity and theirvariation with temperature – Direct and indirect band gap semiconductors – Differences and examples –Hall effect - Continuity equation – Drift and Diffusion – Einstein relation – Generation, Recombinationand life time of non-equilibrium carriers – Heyness-Schockley experiment – Determination of life time,diffusionlength of minoritycharge carriers.

UNIT–IV:Superconductivity

Conceptofzeroresistance–Magneticbehavior–

Distinctionbetweenaperfectconductorandsuperconductor–Meissnereffect–Isotopeeffect–

Specificheatbehavior–Two-fluidmodel–Expression for entropy difference between normal and superconducting states – London’s equations –Penetration depth – BCS theory –Josephson junctions – SQUIDS and its applications - Applications ofsuperconductors –High T_c superconductors–Preparation– Properties.

BooksforStudy

1. SolidStatePhysics, C.Kittel, Edition:8th 2012,JohnWiley&Sons.
2. SolidStatePhysics,A.J.Dekkar, Edition: 1st,2000.MacmillanIndiaLtd.
3. SolidStateElectronicDevices,B.G.Streetman.Edition7th,2018,PearsonEducationIndia
4. ElementarySolidStatePhysics,M.Ali Omar,1993,Addison-Wesley.
5. SolidStatePhysics,M.A.Wahab, Edition:3rd, 2020,NarosaPublishingHouse.
6. High T_c Superconductivity,C.N.R.RaoandS.V.Subramanyam,worldscientificpublishingcompany,1989
7. SolidStatePhysics,S.O.Pillai. Edition:6th,2009,NewAcademicScienceLtd
8. SolidStatePhysics,S.L.Kakani and C.Hemarajan, Edition: 4th,2005,Sultan Chand andSons
9. ElectronsInSolids,RichardH.Bube, Edition3rd,1992Elsevier,
10. SolidState PhysicsbyR.K. PuriV.K. BabbarEdition: 1st 2017. S.Chand.

(Compulsory Foundation)

PHY-103(a)	Analog and Digital Electronics	L-5,T-1,P-6	4Credits									
Pre-requisite: Basic knowledge about electronics												
Course Objectives: The aim and objective of the course on Analog and Digital Electronics is to introduce the students of M.Sc. class to the formal structure of the subject and to equip them with the knowledge of semiconductor physics, basic circuit analysis, first-order nonlinear circuits, OPAMP based analog circuits and introduction to digital electronics so that they can use these in various branches of physics as per their requirement.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Understand working of Different Semiconductor devices (Construction, Working Principles and V-I characteristics) and their applications.											
CO2	Explain the construction and working of Operational amplifiers and applications											
CO3	Design Digital circuits and their applications.											
CO4	Understand the working of various analog communication techniques											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	2	1	-	1	-	1	-
CO2	3	3	2	1	2	2	1	-	-	2	1	-
CO3	2	2	3	2	2	2	1	-	1	-	1	-
CO4	3	3	2	2	2	2	1	-		2	1	-

PHY103(a): Analog and Digital Electronics**UNIT-I: Introduction to Electronic Devices:**

Field Effect Transistor (FET): Structure and working of JFET, Characteristics, and parameters of JFET. Advantages of FET over BJT. FET as switch and Amplifier- Application of FET as voltage variable resistor. Structure of MOSFET, depletion type and enhancement type, MOSFET Characteristics, MOSFET as variable resistor, Concept of CMOS. Structure, working and Characteristics of UJT. Application of UJT as a Relaxation oscillator.

UNIT-II: Operational Amplifiers:

Block diagram of a typical Op-Amp, differential Amplifier, Comparator open loop configuration, inverting and non-inverting amplifiers. Op-amp with negative feedback, voltage shunt feedback, effect of feedback on closed loop gain, input resistance, output resistance, CMRR, frequency response, slew rate. Instrumentation Amplifier, integrator and differentiator. Waveform generators (Square and triangle). Filters (Low pass, high pass and Band pass). Analog to Digital data converters (ADC) and Digital to Analog conversion (DAC).

UNIT-III: Digital Electronics

(Compulsory Foundation)

Combinational Logic: Multiplexers, Decoder, Demultiplexer, Data selector, Multiplexer, Encoder . Sequential Logic: Flip-Flops, A 1-bit memory, The RS Flip-Flop, JK Flip – Flop, JK Master Slave Flip-Flops, T Flip-Flop, D Flip-Flop, Shift Registers, Serial-in Serial-out, Serial-in Parallel-out, Parallel-in Serial-out, Parallel-in Parallel-out Registers. Asynchronous and Synchronous Counters.

UNIT–IV: Communication Electronics

Introduction to Modulation (AM & FM), Sampling Theorem, Low pass and Band pass signals, PAM, Channel BW for a PAM signal. Natural sampling, Flat-top sampling. Signal recovery through holding. Quantization of signals, PCM transmission, Quantization of noise, Differential PCM, Delta Modulation, Adaptive Delta modulation CVSD. Signal to noise ratio in PCM and Delta Modulations.

Books for Study

1. Micro Electronics by Milliman and Halkias. TMH Publications
2. OP- Amps & Linear Integrated Circuits, by Ramakanth A. Gayakwad, PHI, 2nd Edition, 1991.
3. Digital Systems by Ronald J. Tocci, 6th Edition, PHI, 1999.
4. Digital Principles and Applications by A.P. Malvino and Donald P. Leach, Tata McGraw-Hill, New Delhi, 1993.
5. Principles of Communications by Taub and Schilling, Mc-Graw Hill Publication.
6. Electronic Devices and Circuit Theory by Robert Boylested and Louis Nashdsky – Jose Kanedy & Division. PHI, New Delhi, 1991
7. Electronic Principles by Malvino, 6th Ed. TMH, 2017
8. Linear Integrated circuits by Roy Choudhry, Pearson, 2018
9. Op-Amps – D.K. Mahesh, PHI

(Compulsory Foundation)

PHY-103(b)	Computational Methods and C language	L-5,T-1,P-0	4Credits									
Pre-requisite: Understanding of graduate level physics												
Course Objectives: The aim and objective of the course on Computational Methods and C language is to familiarize the students of M.Sc. students with the numerical methods used in computation and programming using any high level languages such as C, etc., so that they can use these in solving simple physics problems.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Apply basic knowledge of computational physics in solving the physics problems.											
CO2	Program with the C or any other high-level language.											
CO3	Use various numerical methods in solving physics problems.											
CO4	Analyze the outcome of the algorithm/program graphically.											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	1	1	-	1	2	-	1
CO2	3	3	3	1	2	1	-	-	3	2	-	1
CO3	3	3	3	2	2	1	1	-	1	2	-	1
CO4	3	3	3	-	-	2	-	-	2	2	-	1

PHY103(b): Computational Methods & C Language**UNIT-I:(a) Fundamentals of C language**

C character set – Identifiers and keywords – Constants – Variables – Data types – Declaration of variables – Declaration of storage class – Defining symbolic constants – Assignment statement. Operators: Arithmetic operators – Relational operators – Logic operators – Assignment operators – Increment and decrement operators – Conditional operators.

(b) Expressions and I/O statements: Arithmetic expressions – Precedence of arithmetic operators – Type converters in expressions – Mathematical (library) functions – Data input and output - Getchar and putchar functions – scanf – printf – Simple programs.

(c) Control statements: If-Else statement – Switch statement – The? operator – GO TO – While, Do-while, FOR statements – BREAK and CONTINUE statements.

UNIT-II:(a) Arrays

One dimensional and two-dimensional arrays – Initialization – Type declaration – Inputting and outputting of data for arrays – Programs of matrices addition, subtraction and multiplication.

(b) User Define functions: The form of C functions – Return values and their types – Calling a function – Category of functions. Nesting of functions. Recursion. ANSI C functions – Function declaration. Scope and lifetime of variables in functions.

(c) Pointers: Accessing the address of variable. Declaration and Initialization of pointer variables. Accessing the value of the variable through its pointer. Pointer Expressions – Pointers and Arrays – Pointers and structures.

UNIT– III: Linear and non-linear equations

(a) Solution of Algebraic and transcendental equations – Bisection, Falsi position and Newton-Raphson methods – Basic principles – Formulae – Algorithms.

(b) **Simultaneous equations:** Solutions of simultaneous linear equations – Gauss elimination and Gauss-Seidel iterative methods - Basic principles – Formulae – Algorithms

UNIT–IV:(a) Interpolations

Concept of linear interpolation – Finite differences – Newton's and Lagrange's interpolation formulae – Principles and Algorithms Curve fitting – regression – Least square fitting – Linear and quadratic.

(b) **Numerical differentiation and integration:** Numerical differentiation – algorithm for evaluation of first order derivatives using formulae based on Taylor's series – Numerical integration – Trapezoidal and Simpson's 1/3 rule – Formulae – Algorithms.

(c) **Numerical solution of ordinary differential equations:** Euler method, Fourth order Runge-Kutta Method.

Books for Study

1. Programming with 'C' – Byron Gottfried, 4th Edition, Tata McGraw Hill, 2010.
2. Programming in 'C' – Balaguruswamy, 8th Edition, Tata McGraw-Hill, 1990.
3. Numerical Methods, E. Balaguruswamy, Tata McGraw Hill, 1999.
4. Computer oriented numerical methods – Raja Raman, 4th Edition, PHI Learning, 2018.
5. Let Us C, Yeswanth Kanetkar, 17th Edition, Infinity Science Press, 2008.

(Compulsory Foundation)

PHY-103©	Sensors and Transducers	L-3,T-1,P-2	4Credits									
Pre-requisite: Understanding of graduate level physics												
Course Objectives: The aim and objective of the course on Sensors and Transducers is to familiarize the students of M.Sc. students with the various electronic sensors used in the industry and to understand the working principles of the sensors so that they can design and use them in industry or in real time applications.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Apply basic knowledge of sensors and transducers in understanding the measurement systems.											
CO2	Study and understanding of various types of sensors											
CO3	Study and understanding of various types of Transducers											
CO4	Analyze the outcome of the signal conditioners like filters, detectors and amplifiers											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	1	-	1	2	1	1
CO2	3	3	3	1	2	1	1	-	-	-	1	1
CO3	3	3	3	2	2	1	1	-	-	-	1	1
CO4	3	3	3	3	2	2	2	-	2	-	1	1

PHY103(c): Sensors and Transducers

UNIT-I: General Introduction to sensors/transducers

Definition of a transducer/sensor. Role of a transducer in a generalized measurement system. Classification of transducers. Significant parameters of transducer. Temperature scales. Mechanical temperature sensors. Platinum resistance thermometer. Thermistors. Thermocouples.

UNIT-II: Displacement and strain transducers

Displacement transducers-

Variable resistance, inductance and capacitance. Linear voltage differential Transformer (LVDT) Strain- Definition, Principle of working of strain gauges. Gauge factor. Types of strain gauges. Materials for strain gauges. Temperature compensation. Application

UNIT-III: Opto-electronic transducers

Photoemission tube. Photomultiplier cell. Photoconductive cell. Photovoltaic cell (solar cell). Photodiode, Photo-transistor, PhotoFET, Light emitting diode. Liquid crystal display. Optoelectronic couplers. Laser

diode.

UNIT–IV: Single conditioners (Filters, Detectors & Amplifiers)

Filters – Integrators, Differentiators and active filters. Detectors Peak Detectors sample and hold circuits. Phase sensitive detector and precision rectifiers, Amplifiers– chopper stabilized DC amplifiers. Instrumentation amplifiers. Logarithmic and anti-logarithmic amplifiers Isolation amplifiers, Lock in amplifiers.

Books for Study

1. Instrumentation Measurement Analysis, Nakra and Chaudary, 4th Edition, Tata McGraw-Hill, 1985.
2. Instrumentation- Devices and Systems, Rangan, Mani and Sharma, 2nd Edition, Tata McGraw Hill, 1983.
3. A course in Electrical and Electronic Measurements and Instrumentation, AK Sawhney, 4th Edition, Dhanpat Rai & Company, 2016.
4. Instrumental Methods of Analysis, Willard, Meritt, Dean and Seattle, 7th Edition, Van Nostrand, 1981.
5. Handbook of Biomedical Instrumentation, RSK Handpur, 3rd Edition, Tata McGraw-Hill, 1987.
6. Fundamentals of Electronic Devices, David A. Bell, 5th Edition, Oxford University Press, 2008.
7. An introduction to Operational amplifiers, SV Subramanyam, 2nd Edition, Macmillan India, 1980.

PHY-104(a)	Atomic and Molecular Physics (Elective Foundation)							L-5, T-1, P-0			4 Credits		
Pre-requisite: Understanding of graduate level spectroscopy													
Course Objectives: The aim and objective of the course on Atomic and Molecular Physics for the students of M.Sc. Physics is to equip them with the knowledge of Atomic, Rotational, Vibrational, Raman, and Electronic spectra.													
Course Outcomes: At the end of the course, the student will be able to													
CO1	Have the basic knowledge of different atomic models, quantum nos and atomic spectra.												
CO2	Understand the classical/quantum description of effect of magnetic field and Electric field on spectral lines.												
CO3	Know the different types of rotation of the molecules and rotational constants and intern structure of the molecules.												
CO4	Study the vibrational spectra of molecules and applications of vibrational spectra of molecules and applications of vibrational spectra												
Mapping of course outcomes with the program outcomes													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	
CO1	3	2	3	2	2	2	-	-	2	1	-	1	
CO2	3	2	3	3	-	2	2	-	2	1	-	1	
CO3	3	2	3	3	2	2	-	-	2	-	-	1	
CO4	3	2	3	3	-	2	2	-	2	-	-	1	

PHY104(a): Atomic and Molecular Physics

UNIT-I: Atomic Spectra

Introduction: Hydrogen atom (one electron atom) - quantum numbers- Spectra of hydrogen atom- Spectra of alkali elements- Fine structure- Elements with more than one valence electron- Forbidden transitions and selection rules- Vector atom model- Spin-orbit interaction energy- Stern-Gerlach experiment- Experimental setup to demonstrate S-G - Coupling schemes- Spectral terms and term symbols based on electron configuration - LS coupling - JJ coupling- Interaction energies in LS and JJ couplings - Hund's rule of multiplicity- Pauli's exclusion principle- Equivalent and non-equivalent electronic systems.

UNIT-II: Zeeman and Stark Effects

Introduction: Zeeman effect- Normal and anomalous Zeeman effects - Experimental details - Magnetic moment of atom and Lande's 'g'-factor - Zeeman effect in sodium atom - Lande g-formula for LS and JJ couplings- Paschen-Back effect- Splitting of sodium lines and selection rules- Stark effect- Experimental details - Weak and strong field effects - linear and quadratic Stark effects- Width of spectral lines.

UNIT-III: Diatomic Molecular Spectroscopy- Rotational Energies

Introduction- Rotational, vibrational, electronic spectra of diatomic molecules- types of molecules- Linear, symmetric top, asymmetric top and spherical top molecules - Rotational spectra of a diatomic molecule as rigid rotator- Energy levels and spectra of non-rigid rotor - Intensity of

rotational lines-Rotational spectra (Elective Foundation) polyatomic molecule-
Rotational analysis of electronic spectra-Evaluation of rotational constants-Effect of
isotopic substitution on rotational levels-Stark splitting of rotational lines-
Stark modulated microwave spectrometer – Applications of rotational spectroscopy

UNIT-IV: Diatomic Molecular Spectroscopy – Vibrational Spectra

Introduction-Vibrational spectra of diatomic molecule-Diatomic molecule as
simple harmonic oscillator-An harmonic oscillator-Energy levels and spectrum- Molecule as vibrating
rotator – PQR branches – progressions and sequences –Vibrational analysis of electronic spectra-
Deslander's stable-Evaluation of vibrational constants-Morse potential energy curve
– Frank-Condon principle – Intensity distribution in absorption and emission spectra -
Effect of isotopic substitution on vibrational bands-IR spectrometer-FTIR spectroscopy-Principle-
Interferometer arrangement-advantages-Applications of vibrational spectroscopy

Books for Study

1. Introduction to Atomic Spectra, H.E. White, McGraw-Hill Kogakusha Ltd., New Delhi (1934).
2. Elements of Spectroscopy by Gupta, Kumar, Sarma, Pragati Prakasan, (2012).
3. Fundamentals of Molecular Spectroscopy, C.N. Banwell and E.M. McCash, Tata McGraw-Hill Publishing Company Ltd., New Delhi. (1994).
4. Spectroscopy, Volume I and III, B.P. Straughan and S. Walker, John Wiley & Sons Inc., New York. (1976).
5. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw-Hill Book company, Inc., New York. (1962).
6. Spectra of Diatomic Molecules, G. Herzberg, D. Van Nostrand Company Inc, New York, (1950).
7. Molecular Spectroscopy, J.M. Brown, Oxford Science Publications, Oxford. (1998).
8. Molecular Structure and Spectroscopy, G. Aruldas, Prentice-Hall of India, Pvt., New Delhi, (2005).

PHY-104(b))	Optical, Microwave and Satellite Communications					(Elective Foundation) L-3, T-1, P-2			4Credits			
Pre-requisite: Understanding of graduate level Basic Electronics												
Course Objectives: The aim and objective of the course on Optical, Microwave and Satellite Communications for the students of M.Sc. Physics is to equip them with the knowledge of Optical, microwave and satellite Communications.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	understand microwave communication system											
CO2	Understand functioning of Radar systems											
CO3	Study different digital modulation techniques											
CO4	Differentiate losses in optical fiber link and state transmission characteristics of optical fiber											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	1	1	-	2	-	-	-
CO2	3	3	3	3	2	1	2	-	1	2	-	-
CO3	3	3	3	3	2	1	2	-	1	-	-	-
CO4	3	3	3	3	2	1	2	-	2	2	-	-

PHY104(b): Optical, Microwave and Satellite Communications

UNIT- I: Microwave Communications

Advantages and Disadvantages of microwave transmission, loss in free space, propagation of microwaves, atmospheric effects on propagation, Fresnel zone problem, ground reflection, fading Sources, Detectors, components, antennae used in MW communications systems.

UNIT-II: Radar Systems

Radar block diagram and operation, radar frequencies, pulse considerations. Radar range equation, derivation of the radar range equation, minimum detectable signal, receiver noise, Signal to noise ratio, Integration of radar pulses, Radar cross section, Pulse repetition frequency, Antenna parameters, System Losses and propagation losses, Radar transmitters, receivers, Antennas, Displays.

UNIT-III: Digital Communications

Digital Communications: Principles of digital communications, digital radio, frequency shift keying, phase shift keying, quadrature amplitude modulation.

UNIT-IV: Optical and Satellite Communications

Optical Communications: Optical transmitter and receiver for analog and digital communications,

coherent and non-coherent detection, signal-to-noise ratio, error rate, coding, synchronization and equalization in optical data transmission.

Satellite Communications: Orbital satellites, geostationary satellites, orbital patterns, look angles, orbital spacing, satellite systems, Link modules.

Books for Study

1. Microelectronics by Jacob Millman, 2nd Edition, McGraw-Hill International Book Co., New Delhi, 1990.
2. Optoelectronics: Theory and Practice, edited by Allen Chappel, 11th Edition, McGraw Hill, International Book Co., New York, 1978.
3. Microwaves by K.C. Gupta, 2nd Edition, Wiley Eastern Limited, New Delhi, 1979.
4. Advanced Electronics Communications Systems by Wayne Tomasi, 6th Edition, Prentice Hall, 1998.

(Elective Foundation)

PHY-104(C)	Computer Architecture and Networking	L-5,T-1,P-0	4Credits									
Pre-requisite: Understanding of graduate level Basic Physics and Electronics												
Course Objectives: The aim and objective of the course on Computer Architecture and Networking for the students of M.Sc. Physics is to equip them with the knowledge of Computer architecture and working and also various networking protocols.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Understand basics of logic circuits and computer functional blocks											
CO2	Know machine instructions and assembly languages											
CO3	Comprehend I/O organization											
CO4	Appreciate differences between different memory devices											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	2	2	1	1	-	2	1	-	-
CO2	3	2	-	3	2	1	2	-	2	1	-	-
CO3	3	2	-	3	2	1	2	-	2	1	-	-
CO4	3	2	-	3	2	1	2	-	2	1	-	-

PHY104(c): Computer Architecture and Networking

UNIT– I: Logic Circuits

Logic functions – synthesis of logic functions – Minimization of logic - Synthesis with NAND and NOR gates – Implementation of Logic gates – Flip-Flops – Registers and shift registers – counters – decoders – multiplexers – PLDs – sequential circuits. Basic structure of computers: Functional units – Basic operational concepts – Bus structures performance – Multiprocessors and multi computers.

UNIT–II: Machine Instructions and programs

Numbers, arithmetic operations and characters – memory locations and address, operations – Instructions and instruction sequencing – addressing modes – assembly language – basic input/output operations – subroutines – encoding of machine instruction. Instructions – assembly languages – O/I operations – registers and addressing – instructions – assembly language – instructions of 68000 and Intel Pentium.

UNIT–III:Input/outputorganization

Accessing I/O devices – interrupts – direct memory access – buses 240 interface circuits – standard I/O interface.

UNIT– IV:Memory System

Concepts semiconductor RAM memories – Randomly memories - cache memories performanceconsiderations – virtual memories – memory management requirements – secondary storagearithmetic: addition and subtraction of signed numbers – design of fast adders – multiplication ofpositivenumbers–signedoperandmultiplication–fastmultiplication–integerdivision
–floatingpointnumbers andoperations.

BooksforStudy

1. HamacherCVranesicZandZakyS.ComputerOrganization,5thEdition,McGrawHill2002.
2. StallingsW.ComputerOrganizationandArchitecture6thEdition,PearsonEducation2003
3. ManoMM, Computer SystemArchitecture3rdEditionPhi 1993
4. YarbroughJ.M.Digital LogicApplicationsand Design,Thomas Learning1997
5. HeuringVPandJordan
HFComputerSystemsDesignandArchitecture,PearsonEducation
1977

(Mandatory Core)

PHY201	Statistical Mechanics				L-5,T-1,P-0				4Credits			
Pre-requisite: Understanding of graduate level statistical mechanics												
Course Objectives: The aim and objective of the course on Statistical Mechanics is to equip the M.Sc. student with the techniques of statistical ensemble theory so that he/she can use these to understand the macroscopic properties of the matter in bulk in terms of its microscopic constituents.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Use ensemble theory to explain the behavior of Physical systems											
CO2	Understanding											
CO3	Explain the statistical behavior of Bose-Einstein and their applications.											
CO4	Fermi –Dirac Statistics & Fluctuations											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	-	3	2	1	-	1	-	1	-
CO2	3	3	3	1	3	-	1	-	-	1	-	-
CO3	3	3	3	-	2	-	1	-	-	-	-	-
CO4	3	3	3	-	2	2	1	-	-	-	1	-

PHY201: Statistical Mechanics

UNIT-I: Ensembles

Phase space – Concept of ensembles – Types of ensembles - Ensemble average - Liouville's Theorem – Microcanonical ensemble: ideal gas – Gibb's paradox and its resolution – Entropy and probability – Canonical ensemble – Ideal gas in canonical ensemble – Grand canonical ensemble – Ideal gas in grand canonical ensemble – Comparison of various ensembles.

UNIT-II: Partition Functions

Canonical partition function – Molecular partition function – Transnational partition function – Rotational partition function – Vibrational partition function – Electronic and Nuclear partition functions – Applications of Rotational partition function – Applications of vibrational partition function to solids

UNIT–III:Maxwell –BoltzmannandBose –Einstein Statistics

Maxwell-Boltzmann distribution-Distributionofvelocities–Experimentalverification-
Calculationofmeanvalues–Equipartitionenergy-Bose–Einstein distribution,Bose–Einstein
condensation, Black body radiation and the Planck’s radiation law - Dulong and Petit’s law -
Einstein and Debye’s theories of heat capacities - Liquid helium – Two fluid model
of liquid helium II– Super fluid phase of ^3He .

UNIT–IV:Fermi –DiracStatistics& Fluctuations

Fermi - Dirac distribution – Electrons in metals – Thermionic emission – Magnetic
susceptibility of free electrons – White dwarfs – Fluctuations in ensembles, Onsager’s one
dimensional and reciprocal rotations and their application to thermoelectric
phenomena, Kelvin’s first and second equations: One dimensional random walk–Random
walk and Brownian motion.

BooksforStudy

1. Statistical Mechanics by B.K. Agarwal, Melvin Eisner-Publisher John Wiley & Sons, 1988
2. Statistical Mechanics and properties of Matter by ESR Gopal–
Publishers Ellis Horwood, 1974
3. Statistical and Thermal Physics by F. Reif-Publisher Waveland Press, 2009
4. Elementary Statistical Mechanics by C. Kittel-Dover Publications, 2012
5. Statistical Physics by Bhattacharjee, Allied Publishers Limited, 2000
6. Thermal Physics by Kittel and Kremer –W.H. Freeman and Company, 1980

(Mandatory Core)

PHY- 202	Electromagnetic Theory, Lasers and Modern Optics	L-3,T-1,P-2	4 Credits									
Pre-requisite: Understanding of graduate level optics and Lasers												
Course Objectives: The aim and objective of the course on Electromagnetic Theory, Lasers and Modern Optics is to expose the M.Sc. students to the basics of the challenging research field of optical fibres and their use in nonlinear optics.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Understand the electro statistics and magneto statistics and also the properties of propagation of electromagnetic radiation in different media											
CO2	Know about the properties of laser beam and the working of different lasers and applications											
CO3	Describe the fourier analysis in optics problems and to understand the concept of holography											
CO4	Analyze the propagation of light in optical fibers and to know the various applications of optical fibers											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	-	2	1	1	-	1	1	-	-
CO2	3	2	2	1	2	1	-	-	1	1	-	-
CO3	3	3	3	-	2	1	2	-	1	1	-	-
CO4	3	2	3	2	3	-	2	-	1	1	-	-

PHY202: Electromagnetic Theory, Lasers and Modern Optics

UNIT– I: Electromagnetic Theory

Electromagnetic radiation; Introduction to electrostatics and magnetostatics – Electrostatics: emf – electromagnetic induction – Maxwell’s equations in differential and integral forms – Retarded potentials – Radiation from moving point charge and oscillating dipoles – Linear antenna – Radiation resistance – electric quadrupole radiation – Lienard – Wiechert potentials.

General wave equation – Propagation of light in isotropic dielectric medium – Dispersion – Propagation of light in conducting medium – skin depth – Reflection and refraction at the boundary of a dielectric interface – Fresnel’s equations – Propagation of light in crystals – Double refraction.

UNIT–II: Lasers and Non-Linear Optics

Introduction to lasers – Spontaneous and stimulated emission – Laser beam properties – Einstein coefficients – Population inversion – Pumping schemes – Losses in laser radiation – Threshold condition for laser oscillation – Laser cavity - Q factor – different experimental methods – Ruby laser - GaAs laser - He-Ne laser – Argon ion laser – CO₂ laser – Laser applications. Basic Principles – Origin of optical nonlinearity - Harmonic generation – Second harmonic generation – Phase matching condition – Third harmonic generation – Optical mixing – Parametric generation of light – Parametric light oscillator – Frequency up conversion – Self focusing of light - Guided wave optics - Pulse compression - Optical solutions.

UNIT–III:HolographyandFourierOptics

Introduction to Holography – Basic theory of Holography – Recording and reconstruction of Hologram–Diffuse object illumination–Speckle pattern–

Frenel and Fourier transform Holography– Applications of Holography.

Introduction to Fourier optics – Two dimensional Fourier transforms – Transforms of Dirac-delta function – The convolution integral – convolution theorem- Spectra and correlation –

Parseval's formula–Apodization–Array theorem–Fourier methods in diffraction-

Fraunhofer diffraction of single slit, double slit and transmission grating using Fourier method.

UNIT–IV:FiberOptics

Total internal reflection - Optical fiber modes and configuration – Single mode fibers – Graded index fiber structure – Fiber materials and fabrication – Mechanical properties of fibers – Fiberoptic cables – Attenuation – Signal distortion on optical wave guides - Erbium doped fiber amplifiers – Solitons in optical fibers - Block diagram of fiber optic communication system - Applications of optical fibers in communication and medicine.

BooksforStudy

1. Introduction to Electrodynamics, D.J. Griffiths, Prentice-Hall, India, 2015
2. Electromagnetics, B.B. Laud, Wiley-Eastern, New Delhi, 2011
3. Introduction to Modern Optics, G.R. Fowles, 2012
4. Lasers and their Applications, M.J. Beesly, Taylor and Francis, 1976
5. Lasers and Non-Linear Optics, B.B. Laud, Wiley Eastern Ltd., 1983
6. Optics, E. Hecht, Addison Wiley, 1974
7. Optical Fiber Communications, G. Keiser, McGraw Hill Book, 2000

(Compulsory Foundation)

PHY-203(a)	Nuclear Physics				L-5,T-1,P-0				4Credits			
Pre-requisite: Understanding of graduate level physics												
Course Objectives: The aim and objective of the course on Nuclear Physics is to familiarize the students of M.Sc. class to the basic aspects of Nuclear Physics like static properties of nuclei, radioactive decays, nuclear forces, nuclear models, and nuclear reactions so that they are equipped with the techniques used in studying these things.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Understand the basics of nuclear forces and their characteristics and also about various nuclear models											
CO2	Know the various types of nuclear reactions and nuclear decay system											
CO3	Understand the basic principles in nuclear accelerators and reactors and also their applications											
CO4	Describe the various elementary particles and their conservation laws.											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	2	1	1	-	-	2	2	-
CO2	3	3	2	1	2	1	1	-	1	-	2	-
CO3	3	3	2	1	2	1	1	-	-	-	2	-
CO4	3	3	2	1	2	1	1	-	-	2	2	-

PHY203 (a): Nuclear Physics**UNIT– I: Nuclear Forces and Models**

Nuclear Forces: Characteristics of nuclear forces – Ground state of Deuteron – Proton – Proton scattering – Neutron – Proton scattering – Meson theory of nuclear forces.

Nuclear Models: Introduction – The liquid drop model – Bethe-Weizacker semi-empirical binding energy equation and its applications – Nuclear shell model – Energy levels and calculation of angular momentum – Collective model.

UNIT–II: Nuclear Reactions and Decays

Nuclear Reactions: Types of nuclear reactions – Compound nuclear reactions – Nuclear cross section – Resonance theory – Briet Wigner formula.

Nuclear Decays: Nuclear transformations – Radioactive decay – Alpha decay – Gamow's theory – Beta decay – Fermi theory – Selection rules – Interaction of gamma radiation with matter – Photoelectric effect – Compton scattering – Pair production.

UNIT–III:NuclearAcceleratorsandReactors

Nuclear Accelerators:Introduction – Linear accelerators – Drift tube and Wave guideaccelerators – Lowenergycircularaccelerators–CyclotronandBetatron–Highenergycircularaccelerators– SynchrotronandMicrotron.

Nuclear Reactors: Nuclear fission and fusion reactions – Nuclear chain reactions – Four factor formula –The critical size of a reactor – General aspects of reactor design – Classification of reactors – Powerreactors(elementaryaspects only).

UNIT–IV:ElementaryParticles

Discovery andclassificationofelementary particles–Typesofinteractions –Conservation laws–Iso-spin, parity, charge conjugation – Time reversal – CPT theorem – Properties of leptons, mesons andbaryons – Elementary particle symmetries (SU_2 and SU_3 symmetries) – Quark model – Search for Higg’sparticle –elementaryideas.

Bookfor Study

1. NuclearPhysics,IrvingKaplan,NarosaPub.(1998).
2. NuclearPhysics,Theoryandexperiment–P.R.RoyandB.P.Nigam,NewAgeInt.1997.
3. AtomicandNuclearPhysics(Vol.2), S.N.Ghoshal,S. Chand&Co.(1994).
4. NuclearPhysics,D.C.Tayal,HimalayaPub.(1997).
5. AtomicandNuclear Physics,R.C. Sharma,K. Nath&Co.,Meerut(2007).
6. NucleiandParticles,E.Segre,WABenjamin. Inc.,(1965).
7. IntroductiontoNuclearPhysics,H.A.Enge,AddisonWesley(1975).
8. IntroductiontoNuclearPhysics,K.S.Krane,JohnWiley&Sons(1988).

(Compulsory Foundation)

PHY-203(b)	IC fabrication Techniques	L-5,T-1,P-0	4Credits									
Pre-requisite: Understanding of graduate level physics												
Course Objectives: The aim and objective of the course on IC fabrication Techniques is to familiarize the students of M.Sc. class to the basic aspects of IC fabrication, different techniques in preparing and processing of IC technology and deposition techniques.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Understand and compare crystal growth and Epitaxial deposition techniques											
CO2	Understand structure and process of oxidation											
CO3	Study the diffusion processes											
CO4	Understand vacuum deposition techniques											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	-	2	1	1	-	-	2	2	-
CO2	3	3	2	1	2	1	1	-	1	2	2	1
CO3	3	3	2	-	-	1	1	-	-	2	2	-
CO4	3	3	2	1	2	1	1	-	1	2	2	1

PHY 203 (b): IC Fabrication

Techniques UNIT – I: IC Fabrication Technology

Wafer preparation: Silicon crystal growth, Wafer orientation, Sawing and polishing, Crystal orientation, Doping of crystals during growth.

Epitaxial deposition: Introduction theory, Growth of an Epitaxial layer, evaluation of Epitaxial layers.

UNIT – II: Oxidation

Introduction, equipment for thermal oxidation, oxidation process, oxide evaluation, recent advances in oxidation technology, oxide thickness determination, oxidation function, redistribution of dopant atoms during thermal oxidation, anodic oxidation.

UNIT-III: Impurity

Introduction and redistribution, the idea of diffusion, diffusion process, diffusion analysis,

ion implementation,

UNIT–IV:Photomasking

Introduction – generation of photomask. Metallization: Metallization of requirements, vacuum deposition, deposition techniques, vacuum deposition cycle.

Books for Study

1. Instrumentation Measurement and Analysis by Nakra and Choudary, 4th Edition, Tata McGraw-Hill, 1985.
2. Instrumentation – Devices and Systems by Rangan, Sarma and Mani, 2nd Edition, Tata McGraw-Hill, 1997.
3. Measurement of Systems Applications and Design by Earnest O. Doebelin, 7th Edition, McGraw-Hill, 1990.
4. A course in Electrical; and Electronic Measurements and Instrumentation by A.K. Sawhney, 3rd Edition, Dhanpat Rai & Company, 2016.
5. Electronic Instrumentation and Measurements Techniques, Cooper and Albert D. Helfriek, 3rd Edition, Pearson India Education, 2016.
6. Applied Electronics by G.K. Mithal, 20th Edition, Khanna Publishers, 1997.
7. Principles of Industrial Instrumentation by D. Patranabis, Tata McGraw-Hill, 1976.

(Compulsory Foundation)

PHY-203(c)	Advanced Microprocessors and Its Applications	L-3,T-1,P-2	4Credits									
Pre-requisite: Understanding of graduate level physics												
Course Objectives: The aim and objective of the course on Advanced Microprocessors and Its Applications is to familiarize the students of M.Sc. class to the basic aspects of microprocessors and different programming and interfacing techniques.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Understanding of microprocessor architecture and evaluation											
CO2	Develop skill of writing programs in ALP for various applications of 8085 & 8051											
CO3	Interface various peripherals with 8085 & 8051.											
CO4	Understanding interrupts and direct memory access											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	1	-	1	2	-	-
CO2	3	3	-	2	2	1	1	-	-	2	2	-
CO3	3	3	2	1	2	1	1	-	-	2	-	-
CO4	3	3	1	-	2	1	1	-	1	2	2	-

PHY203(c): Advanced Microprocessors and Its Applications

UNIT-I: Microprocessors and its Architecture

Internal microprocessor architecture, Real mode and protected modes of memory addressing, Memory paging.

Addressing modes-Data addressing modes, program memory – addressing modes, Stack - memory addressing modes.

Instruction Set - Data movement instruction, Arithmetic and logic Instruction, Program control instructions, Assembler details.

UNIT-II: Programming the Microprocessor

Modular programming, using the keyboard and video display, Data conversions.

Hardware Specifications - Pin - outs and the pin functions, clock - generator (8284A), Bus buffering and latching, Bus timing, Ready and Wait state, Minimum mode versus maximum mode.

UNIT-III: Memory Interface

(Compulsory Foundation)

Memory devices, Address decoding, 8088 and 80188 (8-bit) memory interface, 8086, 80186, 80286 and 80386 (16-bit) memory interface.

Basic I/O Interface - Introducing to I/O interface, I/O port address decoding, 8255, 8279, 8254, ADC and DAC (excluding multiplexed display & keyboard display using 8255).

UNIT-IV: Interrupts

Basic interrupt processing, Hardware interrupts, expanding the interrupt structure, 8259 APIC.

Direct Memory Access - Basic DMA operation, 8237 DMA controller.

Bus Interface - PCI bus.

Book for Study

1. B.B. Brey, "The Intel Microprocessors 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium and Pentium pro processor architecture, programming and interfacing", 4/e, PHI, 1999.
2. K.J. Ayala, "The 8086 Microprocessor: Programming & Interfacing the PC" Penram International Publishing (India) Pvt. Ltd., 1995.
3. Douglas V. Hall, "Microprocessors and Interfacing, Programming and Hardware", 2/e, McGraw Hill, International Edition, 1992.
4. Muhammad Ali Mazidi and Janice Gillispie Mazidi, "The 80x86 IBM PC and Compatible Computers, (Volumes I & II)". 2/e, Prentice-Hall, Inc., 1998.
5. Walter A. Triebel and Avatar Singh, "Software, Hardware and Applications" PHI, 1995.
6. Yu Cheng Lin and Glenn A. Gibson, "Microcomputer systems: The 8086/8088 Family Architecture, Programming and Design", PHI, 1992.

(Elective Foundation)

PHY204(a)	Mathematical Physics				L-5,T-1,P-0				4Credits			
Pre-requisite: Understanding of graduate level mathematics												
Course Objectives: The aim and objective of the course on Mathematical Physics is to equip the M.Sc. Students with the mathematical techniques that he/she needs for understanding theoretical treatment in different courses taught in this class and for developing a strong background if he/she chooses to pursue research in physics as a career.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Understand the basics and applications of special functions in all the branches of Physics.											
CO2	Use Fourier series and transformations as an aid for analyzing physical problems.											
CO3	Apply integral transform to solve mathematical problems of Physics interest.											
CO4	Formulate and express a physical law in terms of complex variables and simplify it by use of coordinate transforms.											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	-	-	-	-	2	-	1	1
CO2	3	3	2	2	-1	-	1	-	2	-	1	-
CO3	3	3	2	-	1	1	1-	-	2	-	1	-
CO4	3	3	2	2	2	1	1	-	2	-	1	2

PHY204(a): Mathematical Physics**UNIT-I: Special Functions**

Beta and Gamma Functions – Definitions and properties – Evaluation of integrals, Legendre, Bessel and Hermite differential equations – Solutions – Generating functions – Orthogonal properties of Legendre, Bessel and Hermite Functions (Proof not necessary) – Recurrence relations – (Proof for Legendre polynomials only).

UNIT-II: Integral Transforms

Fourier Transforms: Properties of Fourier transforms – Fourier sine and cosine transforms – Power in Fourier series – Modulation theorem, Fourier transform of impulse function, Constants, Unit step function and Periodic functions.

Laplace Transforms: Definition and notation – Properties of Laplace transforms – Laplace transforms of Dirac delta function and periodic functions (Square wave, sawtooth wave and triangular wave) – Inverse Laplace transforms – properties – Solution of linear differential equations with constant coefficients - Applications to LCR circuits and resonance of simple pendulum.

UNIT-III: Numerical Techniques

(Elective Foundation)

Solution of an equation – Bisection method, Regular False method, Newton – Raphson method
Solutions of simultaneous – Gauss elimination method and Gauss-Seidel method – Interpolations

- Newton's interpolation and Lagrange's interpolation, Curve fitting – Method of Least squares. Numerical differentiation and integration – Trapezoidal rule and Simpson's 1/3 rule – Solutions of differential equations – Euler's method and Runge-kutta Methods.

UNIT–IV:Complex Variables

Functions – Complex differentiation - Analytic function - Cauchy – Riemann equations
– Derivatives of elementary functions – Singular points and classification. Complex integration - Cauchy's theorem – Integrals of special functions – Cauchy's integral formula – Taylor's and Laurent's theorem (statements only) – Residues, calculations of residues - Residue theorem – evaluation of definite integrals.

Books for Study

1. Mathematical physics, B.D. Gupta, 4th edition, Vikas publishing house, 2010
2. Mathematical physics, B.S. Rajput, Pragati Prakashan Meerut, 2017
3. Special Functions for Scientists and Engineers, W.W. Bell, Dover Publications, 2013
4. Laplace Transforms, Murray Spigle, Schaum's outline series, McGraw Hill, International Book Company, NY, 2005
5. Applied Mathematics for Engineers, Louis A. Pipes, Lawrence R. Harvill, Courier Corporation, 2014
6. Theory and Properties of Complex Variables, Schaum's outline series, Murray R. Spiegel, Seymour Lipschutz, John J. Schiller, Dennis Spellman, McGraw-Hill, 1976
7. Complex Variables and Applications, Brown and Churchill, McGraw-Hill, 2013
8. Applied Fourier analysis, Hweipiao Hsu, Unitech Division, 1984
9. An Introduction to Mathematical Physics, Suresh Chandra, Mohit Kumar Sarma Alpha Science International, 2013.

(Elective Foundation)

PHY204(b)	Introduction to VLSI design				L-5,T-1,P-0				4Credits			
Pre-requisite: Understanding of graduate level mathematics												
Course Objectives: The aim and objective of the course on is to equip the M.Sc. Students with the Introduction to VLSI design that he/she needs for understanding theoretical treatment in different courses taught in this class and for developing a strong background if he/she chooses to pursue research in physics as a career.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Demonstrate a clear understanding of CMOS fabrication flow and technology scaling.											
CO2	Analyze CMOS based logic circuit											
CO3	Realize logic circuits with different design styles											
CO4	Understand Front & Back end design aspects of simple VLSI Digital circuits											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	1	-	2	1	-	-
CO2	3	3	2	2	2	1	1	-	2	1	-	-
CO3	3	3	2	2	2	1	1	-	2	1	-	-
CO4	3	3	2	2	2	1	1	-	2	1	-	-

PHY 204 (b): Introduction to VLSI

Design UNIT-I: An Overview of

VLSI and Logic Design with MOSFET

Complexity and Design, Basic concepts, Ideal switches and Boolean operations, MOSFETs as switches, Basic logic gates in CMOS, Complex logic gates in CMOS, Transmission Gate circuits, Clocking and data flow control.

UNIT-II: Physical Structure and Fabrication of CMOS ICs

Integrated Circuit layers, MOSFETs, CMOS layers, Designing FET arrays, Overview of silicon processing, Material growth and deposition, Lithography, The CMOS process flow, Design rules.

UNIT-III: Elements of Physical Design and Electrical Characteristics of MOSFETs

Basic concepts, Layout of basic structures, Cell concepts, FET sizing and the unit

transistor, Physical design of logic gates, Design hierarchies, MOS physics, nFET current-voltage equations, FET RC model, pFET characteristics, Modeling of small MOSFETs.

UNIT-IV: Electronic analysis of CMOS logic gates

DC characteristics of the CMOS inverter, Inverter switching characteristics, Power dissipation, DC characteristics: NAND and NOR gates, NAND and NOR transient response, Analysis of complex logic gates, Gate design for transient performance, Transmission gates and pass transistors.

Designing High-speed CMOS Logic Networks- Gate delays, Driving Large capacitive loads, Logical effort, BiCMOS drivers.

Book for Study

1. John P. Uyemura, "Introduction to VLSI Circuits and Systems", John Wiley & Sons (Asia) Pte Ltd., 2003.
2. S.K. Ghandhi, "VLSI Fabrication Principles", 2/e, John Wiley & Sons (Asia) Pte. Ltd., 2003.
3. S.M. Sze, "VLSI Technology", 2/e, McGraw-Hill, 1988.
4. N.H.E. Weste and K. Eshraghian, "Principles of CMOS VLSI Design", Pearson Education, Inc., 1999.
5. Yuan Taur and T.H. Ning, "Fundamentals of Modern VLSI Devices", Cambridge University Press, 1998.
6. R.L. Geiger, P.E. Allen and N.R. Strader, "VLSI Design Techniques for Analog and Digital Circuits", McGraw-Hill, 1990.

(Elective Foundation)

PHY -204 (c)	Materials Science for Industrial Applications	L-5,T-1,P-0	4Credits									
Pre-requisite: Course on Particle Physics												
Course Objectives: The aim and objective of the course on Materials Science for Industrial Applications is to expose the students of M.Sc. students to experimental aspects of different equipment and methods used in the fields of Industrial applications												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Understand various experimental techniques for describing interaction of organic materials											
CO2	Use error analysis for experimental data.											
CO3	Knowledge about the different types of the Liquid crystals											
CO4	Apply the knowledge of phase transformations for various applications											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	1	-	-	-	-	1	1	-
CO2	3	2	2	3	2	-	-	-	1	-	1	-
CO3	3	2	1	2	3	-	1	-	2	2	-	-
CO4	3	2	1	3	3	1	1	-	2	-	2	-

PHY 204 (c): Materials Science for Industrial

Applications UNIT– I: Organic materials and their properties

Introduction - polymerization mechanism. Structure and properties of polymers. Strengthening of polymers. Behavior of polymers. Deformation of polymers and their industrial use. Ceramic Materials: Introduction – Classification of ceramic. Structure of ceramics. Polymorphism. Properties of ceramic and their applications.

UNIT–II: Liquid Crystals

Introduction – classification, oriental order, Elasticity, magnetic effects, optical properties – applications.
Ferroelectrics: General properties of ferroelectric materials. Theories of ferroelectricity. Thermodynamic of Ferroelectric transitions. Magnetic Materials: Classification. The domain structure. Soft and hard magnetic materials, Ferrites, ceramic magnets.

UNIT–III: Phase diagrams and phase transformation

The Phase rules.Unary and binary phase diagrams.Typical phase diagrams- copper-zinc systems.Iron-carbon system.Other applications of phase diagrams.Phase transformation.Nucleation and growth.Nucleation kinetics.Martensitic transformation.

UNIT-IV:Thin films

Theories of thin film nucleation and growth.Thin film preparation – Rf sputtering.Chemical vapor deposition.Thickness measurements.Electrical and optical properties of thin films Applications.

Superconductivity:Meissner Effect.The critical field.Theories of superconductivity.Tunneling and Josephson effect.High T_c superconductors.Application of superconductors.

Books for Study

1. Introduction to Solid State Physics, Charles Kittel VII edition, John Wiley & Sons.
2. Solid State Physics, A.J. Dekker, McMillan Publications.
3. Solid State Physics, M.A. Wahab, Narosa Publishing House.
4. Fundamentals of Solid State Physics, Saxena, Gupta, Saxena, Pragathi Publications, Meerut.
5. Solid State Physics, R.L. Singhal, Kedar Nath Ram Nath & Co. Pub.
6. Science of Engineering Materials, C.M. Srivastava and C. Srinivasan, New Age Inter. Pub.
7. Crystal Growth, B.R. Pamplin, Pergamon Press.
8. Crystal Growth from High Temperature Solutions, D. Elwell and H.J. Scheel, Academic Press.

(MandatoryCore)

PHY-301	Introductory Quantum Mechanics	L-5,T-1,P-0	4Credits									
Pre-requisite: Basic knowledge of wave mechanical quantum Mechanics												
Course Objectives: The aim and objective of the course on Introductory Quantum Mechanics is to introduce the students of M.Sc. class to the formal structure of the subject and to equip them with the techniques of vector spaces, angular momentum, perturbation theory, and scattering theory so that they can use these in various branches of physics as per their requirement.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Understand the need for quantum mechanical formalism and its basic principles.											
CO2	Appreciate the importance and implication of vector spaces, Dirac Ket Bra notations, eigen value problem.											
CO3	Understand the need of approximate methods in solving problems											
CO4	Understanding scattering theory and its importance.											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	2	1	-	2	1	-	-
CO2	3	2	2	2	2	2	1	-	-	2	2	-
CO3	3	2	2	2	2	2	1	-	-	-	-	-
CO4	3	2	2	2	2	2	2	-	2	2	-	1

PHY

301:

Introductory Quantum Mechanics UNIT-I: Formulation and

Simple Problems

Wave particle duality – Wave functions in coordinate and momentum representation- Postulates of quantum mechanics -Linear vector space: Hilbert space - Dirac's Bra and Ket notations-Hermitian operators and their properties-Matrix representation of an operator- Unitary operators- Unitary transformation - The Kronicker Delta and Dirac delta functions- Eigen values and Eigen functions for finite potential well and step barrier- Quantum mechanical tunneling.

UNIT-II: Quantum Dynamics and Simple Problems

Equations of motion - Schrodinger Picture- Heisenberg Picture- Interaction Picture- Equivalence of various Pictures-Poisson and Commutation brackets- Their Properties- Eigen values and Eigen functions for Simple harmonic oscillator- Polynomial method and abstract operator method in one dimension- Eigen values and Eigen functions for a free particle and particle in a box in three dimensions.

UNIT-III: Approximate Methods

Time independent perturbation theory for non-degenerate levels: Perturbed harmonic oscillator, Normal Helium atom, Stark effect of the planar rotator. First order perturbation theory for degenerate levels: First order Stark effecting in hydrogen atom; Time dependent perturbation theory: Transition to continuum (Fermi Golden rule).

WKB approximation – Turning points and connecting formulae: Application to potential barrier. Variational methods.

UNIT-IV: Scattering Theory

Introduction: classical theory of scattering - Quantum theory of scattering - Method of partial wave analysis - Scattering by a perfectly rigid sphere - Green's function in scattering theory - Born approximation - Validity of Born approximation - optical theorem.

Books for Study

1. Quantum Mechanics: Concepts and Applications by Nouredine Zettili, Wiley, Ed., 2021
2. Introduction to Quantum Mechanics by David J. Griffiths and Darrell F. Schroeter, Third Ed., Cambridge University Press India Pvt Ltd., 2018.
3. Quantum Mechanics: G. Aruldas PH learning private limited Second edition, 2018
4. Quantum Mechanics: S.L. Kakani and H.M. Chandalia Sultan Chand and, Sons First Edition, 2004
5. Advanced Quantum Mechanics: B.S. Rajput, Pragati prakasan, 2019
6. Quantum Mechanics: V.K. Thankappan, New Age International (P) Ltd., Publishers, 1993
7. A Textbook of Quantum Mechanics: P.M. Mathews and K. Venkatesan, Tata McGraw Hill Publishing Company, 2008
8. Quantum Mechanics: S.L. Gupta, V. Kumar, H.V. Sharma and R.C. Sharma, Jai Prakash Nath and Company, 2007
9. An Introduction to Quantum Mechanics, P.T. Mathews McGraw Hill Publishing Company, 1974

(MandatoryCore)

PHY -302	Physics of Semiconductor devices	L-5,T-1,P-0	4Credits									
Pre-requisite: CourseongeneralPhysics												
CourseObjectives: Theaimandobjectiveofthecourseon Physics of Semiconductor devices is to expose the students of M.Sc. students to experimental aspectsofdifferent semiconductor devise technologies, characterization and fabrication.												
CourseOutcomes: At theend ofthe course, thestudent willbe ableto												
CO1	Understandvariousexperimentaltechniquesforsemiconductor junctions and interfaces											
CO2	UseI-V characteristics to understand the function of devices											
CO3	Apply the knowledge of Junction transistors for various applications											
CO4	To get familiarization with Power Devices and Semiconductor Technology											
Mappingofcourseoutcomeswiththeprogramoutcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	1	2	2	-	1	1	1	-
CO2	3	2	1	3	2	1	-	-	1	1	-	1
CO3	3	2	1	2	3	2	1	-	2	2	-	-
CO4	3	2	1	3	3	1	1	-	-	2	2	2

PHY302:PhysicsofSemiconductorDevic

esUNIT-I: Junctions and Interfaces

p-nJunctions:Descriptionofp-nJunctionaction–Junctioninequilibrium-applicationofbias– energy band diagrams.Abrupt junction – calculation of the built-in Voltage- electric field andpotential distributions – Expression for Depletion layer capacitance, Static I-V characteristics ofp-n junction diodes: Ideal diode model- Derivation of ideal diode equation. Real diodes –Carrier generation – recombination in the junction depletion region, I-V characteristics of RealDiodes.

Electricalbreakdowninp-njunctions:ZenerandAvalanchebreakdowninp-njunctions,Distinctionbetween theZenerand Avalanchebreakdown.

UNIT-II:JunctionDiodes

Majority carrier diodes: Tunnel diode- I-V characteristics, equivalent circuits as an oscillator andamplifier.Backward diode, Schottkybarrierdiode-operation and applications.

Microwave devices:Varactor diode- basic principle, equivalent circuit,Figure of merit andapplications.p-i-ndiodeoperationanditsapplications.Transferred-electrondevices-Gunneffect devices- domain formation- modes of operation. Avalanche Transit devices: IMPATTdiode,TRAPATT diode, BARITT diode.

UNIT-III: Junction Transistors

Bipolar junction transistors: Principle of operation- Analysis of the ideal diffusion transistor – Calculation of terminal currents, DC parameters. Ebers-Moll Equations – Four regions of operation of a bipolar transistor. Real transistors -- carrier recombination in the Emitter-Base junction depletion region – Effect of collector bias variation, avalanche multiplication in the collector – base junction and base resistance. Basic Structures and the operating principle of MOSFET, I-V characteristics of an ideal MOSFET, Charge Coupled Devices (CCD) - principle of operation.

UNIT-IV: Power Devices and Semiconductor Technology

Power rectifiers and Thyristors: Power rectifiers, Thyristors, Some special thyristor structures, Bidirectional thyristors, Field-controlled thyristor. Technology of Semiconductor Devices: Crystal growth and Wafer preparation, Methods of p-n junction formation, Growth and deposition of dielectric layers, Planar technology, Masking and lithography, Pattern definition, Metal deposition techniques.

Books for Study

1. Introduction to Semiconductor Materials and Devices by M.S. Tyagi, John Wiley & Sons (Asia) Pte. Ltd., Singapore, 2000.
2. Microwave Devices and Circuits by SAMUELY. LIAO, Prentice-Hall of India, 1999.
3. Microwave and Radar Engineering by M. Kulkarni, UMESH publications, New Delhi, 1999.
4. Physics of Semiconductor Devices by S.M. Sze, 3rd Edition, Oct. 2006, John Wiley
5. Solid State Electronic Devices by B.G. Streetman, PHI, New Delhi, 2006

(Generic Elective)

PHY-303 (a)	Applied Spectroscopy	L-3,T-1,P-2	4 Credits									
Pre-requisite: Understanding of graduate level spectroscopy												
Course Objectives: The aim and objective of the course on Applied Spectroscopy for the student of M.Sc. Physics is to equip them with the knowledge of Atomic, Rotational, Vibrational, Raman, and Electronic spectra.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Understand the rotational and vibrational spectra of diatomic molecules and their applications in structure determinations.											
CO2	Know the Raman effect and its use in the structural analysis of various molecules.											
CO3	Have the knowledge about various spectrophotometer and the functioning of various parts in SPECTROPHOTOMETER.											
CO4	Understand the basic concepts of fluorescence and phosphorescence their applications in different fields											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	1	1	-	2	1	-	-
CO2	3	2	3	3	-	1	2	-	2	1	-	-
CO3	3	2	3	3	2	-	2	-	2	1	-	-
CO4	3	2	3	3	-	-	2	-	2	1	-	-

PHY303(a): Applied Spectroscopy

UNIT-I: Molecular Spectroscopy

Introduction – Rotational and vibrational structure of electronic bands of diatomic molecules – Fortrat diagram – General relations – Combination relations for $^1\Sigma$ - $^1\Sigma$ and $^1\Sigma$ – $^1\pi$ bands – Evaluation of rotational constants with reference to above transitions. Isotope effect in electronic spectra of diatomic molecules – Vibrational effect and rotational effect. Potential energy curves -Dissociation energy and pre-dissociation energy - Vibrations of polyatomic molecules: CO₂ and H₂O.

UNIT-II: Raman Spectroscopy

Introduction – Theory of Raman Scattering – Rotational Raman Spectra – Vibrational Raman Spectra – Mutual Exclusion Principle Laser Raman Spectroscopy Sample Handling Techniques – Polarization of Raman Scattered Light – Single Crystal Raman Spectra – Raman Investigation of Phase Transitions – Resonance Raman Scattering – Structure Determination using FTIR and Raman Spectroscopy. Fourier Transform (FT) Raman Spectroscopy and its additional advantages over the conventional Raman Spectroscopy - Surface enhanced Raman Scattering-Coherent Anti-Stokes Raman Spectroscopy.

UNIT-III: Spectrophotometry

Introduction – Beer's law – Absorptivity – UV and visible absorption – Instrumentation –

(Generic Elective)

Essential parts of spectrophotometer – Gratings and prisms – Radiant energy sources – Filters – Photosensitive detectors – Barrier layer cells – Photo emissive cells – Photomultiplier tubes – Relationship between absorption in the visible and UV region and molecular structure – IR Spectrophotometry – Fourier Transform Infrared (FTIR) Spectrometer – Molecular structure – Qualitative and Quantitative analysis – Importance of photography in the spectrochemical analysis.

UNIT-IV: Fluorescence and Phosphorescence Spectroscopy

Introduction – Normal and Resonance Fluorescence – Intensities of Transitions – Non-radiative decay of fluorescent molecules – Phosphorescence and the nature of the triplet state – Population of the triplet state – Delayed Fluorescence – Excitation spectra – Experimental methods – Emission lifetime measurements – Time resolved emission spectroscopy – Applications of Fluorescence and Phosphorescence.

Books for Study

1. Molecular spectra and Molecular Structure Vol. I, G. Herzberg, 2nd Ed, Van. Nostrand (1950).
2. Fundamentals of Molecular Spectroscopy, C.N. Banwell, Tata McGraw-Hill, (1983).
3. Spectroscopy Straughan and Walker (Vol. 2 & 3), John Wiley & Sons, (1976).
4. Molecular Structure and Spectroscopy G. Aruldas, Printice-Hall Pvt. Ltd. (2001).
5. Instrumental Methods of Analysis Willard, Merritt, Dean & Settle, CBS Pub, (2001).
6. Spectrochemical Analysis, L.H. Ahrens and S.R. Taylor, Addison-Wesley, London, Pergamon, 1961.
7. Elements of Spectroscopy, Gupta, Kumar and Sharma Pragati Prakasan, New Delhi (2012).
8. Elements of Diatomic Molecular Spectra, H. Dunford, Addison Wesley Publishing company, 1965.
9. Problems in Spectroscopy, S.V.J. Lakshman, ICSU, Costed, 1988.
10. Basic Principles of Spectroscopy by R. Chang, McGraw Hill, 1971.
11. Principles of Fluorescence Spectroscopy, Joseph R. Lakowicz-Plenum Press, (1983).

(Generic Elective)

PHY-303(b)	Condensed Matter Physics	L-3,T-1,P-2	4Credits									
Pre-requisite: Understanding of graduate level solid state physics												
Course Objectives: The aim and objective of the course on Condensed Matter Physics is to expose the students of M.Sc. class to the topics like elastic properties, thermal properties, Fermi surface studies and photoluminescence so that they are equipped with the knowledge on the matter in condensed phase.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	They gain knowledge on elastic properties of solids and its importance.											
CO2	Differentiate they gain knowledge on specific heat and Thermal importance.											
CO3	Understand the importance of Fermi surface in electrical properties of Solids.											
CO4	Gain knowledge on photoconductivity and its origin											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	1	2	1	-	-	2	-	-
CO2	3	2	2	2	2	2	2	-	2	-	2	-
CO3	3	2	2	2	1	2	2	-	-	2	-	-
CO4	3	2	2	2	2	2	1	-	1	-	2	-

PHY303(b): Condensed Matter Physic

csUNIT-I: Elastic Properties of Solids

Lattice as a homogeneous and continuous medium - Analysis of stress and strain tensors – Hooke's law - Elastic compliances and stiffness constants – Elastic energy density – Reduction in the number independent elastic constants in cubic crystals – Cauchy's relations – Bulk modulus and compressibility – Elastic waves in cubic crystals – Formulation and solution of wave equations along [100], [110] and [111] directions – Experimental determination of elastic constants – Pulse-echo technique.

UNIT-II: Thermal Properties of Solids

Quantum theory of lattice vibrations – Properties of phonons – Lattice specific heat at low temperatures – Einstein and Debye models – Born cut-off procedure – Inelastic scattering of neutrons by phonons – Experimental study of dispersion curves – Inadequacy of harmonic model – Anharmonicity – Thermal expansion – Gruneisen parameter - Lattice thermal conductivity – Elementary kinetic theory – Role of U and N processes.

UNIT-III: Energy bands and Fermi Surfaces

Energy band calculations: Plane Wave method and Augmented Plane Wave (APW) method. Importance of Fermi surface – Characteristics of Fermi surface – Construction of

(Generic Elective)

Fermi surface -Quantization of electron orbits - Experimental study of Fermi surface: Anomalous skin effect – Cyclotron resonance – de Haas van Alphen effect.

UNIT-IV: Photoconductivity and Luminescence

Excitons: Weakly bound and tightly bound – Photoconductivity – Simple model – Influence of traps – Space charge effects – Determination of photoconductivity. Luminescence – Various types – Thermoluminescence, Electroluminescence, Photoluminescence, Cathodoluminescence and Chemiluminescence – Excitation and emission – Decay mechanisms – Applications

Books for Study

1. Solid State Physics, C. Kittel, Edition: 8th 2012, John Wiley & Sons.
2. Solid State Physics, A.J. Dekkar, Edition: 1st, 2000. Macmillan India Ltd.
3. Solid State Physics, M.A. Wahab, Edition: 3rd, 2020, Narosa Publishing House.
4. Fundamentals of Solid State Physics, Saxena, Gupta, Saxena, Edition: 31st, 2019, Pragathi
5. Solid State Physics, R.L. Singhal, Kedar Nath, Ram Nath & Co. Publications, Meerut, 2018.

(Generic Elective)

PHY-303 (c)	Embedded Systems	L-3,T-1,P-2	4Credits									
Pre-requisite: Understanding of graduate level spectroscopy												
Course Objectives: The aim and objective of the course on Embedded Systems for the students of M.Sc. Physics is to equip them with the knowledge of microcontrollers and other processors used in the industry.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	understand about the basic functions and structure of embedded systems											
CO2	Get familiarized with Embedded system Design Tools and Hardware											
CO3	understand about the basic programming concepts of embedded systems											
CO4	know about the applications of PIC microcontrollers											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	1	-	-	2	1	1	-
CO2	3	2	3	3	2	1	2	-	2	-	1	-
CO3	3	2	3	3	2	-	-	-	2	1	1	-
CO4	3	2	3	3	2	1	2	-	2	1	1	-

PHY303(c): Embedded Systems

msUNIT-I: Introduction to Embedded Systems

Embedded systems in today's world – examples of Embedded systems – Microprocessors and Microcontrollers – Microchip and PIC microcontroller – Introduction to PIC microcontrollers using the 12 series.

Architecture of 16F84A – Memory organization – in 16F84A – Timing generation – Power-up and Reset functions in 16F84A.

UNIT-II: Hardware Details of 16F84A

Parallel ports: Basic idea – Technical challenge – connecting to the parallel port – Parallel ports of PIC16F84A – Clock oscillator – Power supply – Interrupts – Timers and counters – watch dog timer – Sleep mode.

UNIT-III: Assembler and Assembler Programs

Basic idea – PIC 16 series instruction set and ALU – Assemblers and Assembler format –

(Generic Elective)

creating simple programs – Adopting a development environment – Building structured programs –
Flow control: Branching and Subroutines – Generating time delays and intervals –
Logical instruction – Arithmetic instructions.

UNIT-IV: PIC Microcontroller PIC16F873A

Block diagram and CPU – Memory and memory maps – Interrupts –
Oscillator, Reset and Power supply – Parallel ports. PIC16F87XA Timer0 and Timer1 –
16F87XA Timer2, Comparator and PR2 register – capture/Compare/PWM (CCP) Module – Pulse
width modulation – ADC module.

Interface: LED displays – Liquid crystal displays – Sensors – Actuators.

Books for Study

1. Designing Embedded Systems with PIC Microcontrollers: Principles and Applications by Tim Wilmshurst, First Edition, 2007, Newnes – Elsevier – Publishers.
2. Microcontrollers: Theory and Applications by Ajay V. Deshmukh, Tata McGraw-Hill, New Delhi, 2005.
3. Designing with PIC Microcontrollers by John B. Peatman, Pearson Education, Inc., 1998.
4. The 8051 Microcontroller and Embedded Systems, by Mahammad Ali Mazidi and Janice Gillispie Mazidi, Pearson Education Asia, Pvt. Ltd., 2000.

(Skill Oriented Course)

PHY – 305	Advances in Physics	L-3,T-1,P-2	4Credits									
Pre-requisite: Understanding of graduate level physics												
Course Objectives: The aim and objective of the course on Advances Physics for the students of M.Sc. Physics is to equip them with the knowledge of Nanotechnology, MEMS and remote sensing.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Understand the concepts of nanotechnology											
CO2	Physical and chemical techniques of nanomaterial synthesis											
CO3	Concepts of Nano materials and Nano devices											
CO4	Basics of remote sensing and understanding the concepts of Geographical Information system											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	-	1	-	-	2	2	-	-
CO2	3	2	3	3	2	1	2	-	2	2	-	-
CO3	3	2	3	3	-	1	-	-	2	2	-	-
CO4	3	2	3	-	2	1	2	-	2	2	-	-

PHY305: Advances in Physics

UNIT–I: Nano Technology

Introduction to Nanomaterials–Zero, One- and Two-Dimensional Nanostructures- Quantum confinement-Density of states and Dependence of dimensionality–Properties of Nanomaterials

–Carbon Nanotubes, Fullerenes, Graphene.

Synthesis of Nanomaterials–Physical Techniques: Ball Milling–Plasma Arc Deposition– Inert Gas Condensation –Pulsed Laser Deposition– Molecular Beam Epitaxy.

Chemical Techniques: Hydrothermal synthesis– Sol-Gel Process–

Chemical Vapor Deposition. Applications: Single Electron Transistor – Solar Cells–Light Emitting Diodes.

UNIT–II: Micro and Nanodevices

Microelectromechanical systems (MEMS): Introduction to MEMS, Basic MEMS structure. Applications of MEMS: Pressure sensors, Accelerometers Mass flow sensors.

Nanodevices: Quantum well and quantum dot devices: Infrared Detectors–

Quantum Dot Lasers. Carbon nanotube emitters-Photoelectrical cells - Plasmons propagation in wave guides.

UNIT–III: 8051 Microcontrollers

Introduction of Microprocessors and Microcontrollers, Microcontroller: 8051 Internal Architecture, Register Structure, I/O pins, Memory Organization, 8051 Addressing modes. 8051 Assembly Language Programming Tools. 8051 Instruction set: Data Transfer Instructions, Arithmetic instructions, Logical instructions, Boolean Variable Manipulation Instructions- Bit Addressability, Single-Bit instructions, Program Branching Instructions- Jump, Loop, and Call instructions, Rotate Instructions, Stack Pointer.

UNIT -IV: Remote Sensing

Definition of remote sensing; introduction to concepts and systems; Electromagnetic radiation; electromagnetic spectrum; image characteristics; remote sensing systems; remote sensing platform; Sources of remote sensing information; Advantages of remote sensing. Application of Remote sensing in Environmental Management, Natural resource management – forest resources, water resources, land resources and mineral resources.

Books for Study

1. Nano structures and Nanomaterials: Synthesis, Properties and Application by Guozhiong Cao
2. Introduction to Nanotechnology, By Charles P. Poole, Jr and Frank J. Owens, Wiley India (2006).
3. An Introduction to Microelectromechanical Systems Engineering by Nadim Maluf, Artech House Publishers, 2004
4. Nanomaterials Synthesis Properties and Applications, by Alen S. Edelstein and Robert C. Cammarata, 1998.
5. The 8051 Microcontroller and Embedded systems, by Mahammad Ali Mazidi and Janice Gillispie Mazidi, Pearson Education Asia, Pvt. Ltd., 2000.
6. Floyd F. Sabins Jr., Remote Sensing Principles and Interpretation, by W. H. Freeman and Company, 2nd Ed., New York, 1987.
7. T. M. Lillesand & R. W. Kiefer, Remote Sensing and Image Interpretation, by John Wiley & Sons, New York, 1994.
8. An Introduction to GIS by Ian Heywood et al., Addison Wesley, Longmont Limited, England, 2011.

(Open Elective)

PHY – 306 (a)	Basic Spectroscopic Techniques	L-3,T-1,P-2	4Credits									
Pre-requisite: Understanding of graduate level spectroscopy												
Course Objectives: The aim and objective of the course on Basic Spectroscopic Techniques for the students of M.Sc. Physics is to equip them with the knowledge of Atomic, Rotational, Vibrational, Raman, and Electronic spectra.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Have the basic knowledge of Bohr's-Sommerfeld Quantum theory of hydrogen like atom											
CO2	Understand classical/quantum description of electronic spectra of atom and molecules											
CO3	Use microwave and Raman Spectroscopy for analysis of known molecules											
CO4	Correlate infrared spectroscopic information of known molecules with their physical description											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	1	1	-	2	1	-	
CO2	3	2	3	3	2	1	2	-	2	1	1	-
CO3	3	2	3	3	2	1	2	-	2	1	-	-
CO4	3	2	-	3	2	1	2	-	2	1	-	-

PHY 306 (a): Basic Spectroscopic

Techniques

UNIT I: Fundamentals of Spectroscopy

Introduction - Interaction of Electromagnetic radiation with matter - Spectra of Hydrogen atom- quantum numbers - Forbidden transitions and selection rules- Spectroscopic transition between two stationary states - Absorption and emission of a photon - Einstein A and B coefficients - Line shape functions - Spectral broadening mechanisms- Spin orbit interaction energy- Stern-Gerlach experiment- L-S coupling- JJ coupling - Hund's rule of multiplicity - Pauli's exclusion principle - Rotational and vibrational spectra of different molecules- Energy expressions.

UNIT- II: Spectrophotometry

Introduction - Beer's law - Absorptivity - UV and visible absorption - Instrumentation - Essential parts of spectrophotometer - Gratings and prisms - Radiant energy sources - Filters - Photosensitive detectors - Barrier layer cells - Photo emissive cells - Photomultiplier tubes - Relationship between

absorption in the visible and UV region and molecular structure – IR Spectrophotometry – Fourier Transform Infrared (FTIR) Spectrometer – Molecular structure – Qualitative and Quantitative analysis – Importance of photography in the spectrochemical analysis.

UNIT–III: Colorimeters, spectrophotometers and microscopes

Colorimeter – Principle - Applications of colorimeters in analytical and biomedical purposes Spectrophotometer-Principle and working with block diagram – Salient features of individual blocks – Specifications and operation of spectrophotometers – Applications of spectrophotometers to chemical analysis Electron microscope – Transmission electron microscope - Principle and working with block diagram – Salient features of individual blocks – Scanning electron microscope - Principle and working with block diagram – Description of individual blocks – Applications of electron microscopes.

UNIT–IV: Resonance spectrometers and Mass Spectrometer

Electron spin resonance – theory – ESR spectrometer – Principle and working with block diagram – Experimental techniques – Salient features of individual blocks – Applications of ESR. Nuclear magnetic resonance – theory – NMR spectrometer – Principle and working with block diagram – Experimental techniques – Description of individual blocks – Applications of NMR. Mossbauer effect – theory – Mossbauer spectrometer – Principle and working of Mossbauer spectrometer – Experimental methods – Explanation of block diagram – Applications of Mossbauer studies.

Books for Study

1. Introduction to Atomic Spectra, H.E. White, McGraw-Hill Kogakusha Ltd., New Delhi (1934).
2. Elements of Spectroscopy by Gupta, Kumar, Sarma, Pragati Prakasan, 2012.
3. Spectrochemical Analysis, L. H. Ahrens and S.R. Taylor, Addison-Wesley, London, 1961.
4. Instrumental methods of Chemical analysis by Chatwal and Anand, Himalaya Publisher, 2003
5. Spectroscopy by B.K. Sarma, Goel publishing House, Meerut, 1993.
6. Spectroscopy Vol I by Straughan and Walker, John Wiley and Sons, 1976
7. Basic principles of Spectroscopy by Raymond Chang, McGraw Hill, 1971
8. Molecular Structure and Spectroscopy by G. Aruldas, Prentice Hall of India, 2001

(Open Elective)

PHY-306(a)	Nanomaterials and Devices	L-5,T-1,P-0	4Credits									
Pre-requisite: Condensed matter physics												
Course Objectives: The aim and objective of the course on Physics of Nano-materials is to familiarize the students of M.Sc. to the various aspects related to preparation, characterization and study of different properties of nanomaterials so that they can pursue this emerging research field as a career.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Understanding the basics of nanomaterials											
CO2	Acquire knowledge of basic approaches to synthesize the nanomaterials											
CO3	Understand the physical and chemical properties of carbon nano tubes and nano structured materials.											
CO4	Introduction to nanodevices											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2	1	2	-	1	2	1	-
CO2	3	2	2	2	3	2	2	-	1	2	-	-
CO3	3	3	-	2	3	2	2	-	1	2	1	-
CO4	3	2	3	2	3	2	2	-	1	2	-	-

PHY 306 (b): Nanomaterials and

Devices

UNIT-1: Introduction to Nanomaterials

Introduction to Nanomaterials-

Zero, One and Two Dimensional Nanomaterials Quantum confinement, Density of states, Dependence of dimensionality – Physical and chemical properties.

UNIT-II: Synthesis of Nanomaterials

Introduction to Bottom-up and Top-down approaches

Ball milling – Inert Gas condensation – Physical vapor deposition -, Molecular Beam Epitaxy – Sputtering – Pulsed laser Deposition – Chemical vapor deposition - Sol Gel – Hydrothermal Synthesis

UNIT-III: Nano – Carbon

Carbon molecules: Nature of the carbon bond –New Carbon structure –carbon clusters – Smallcarbon clusters –Discovery of C₆₀–Structure of C₆₀and its properties –Synthesis of buckyballsandApplications.

Carbon Nanotubes: Fabrication –Structure -Electrical Properties – Mechanical properties – Applicationsof carbonNanotubes

Graphene:Fabrication–Structure–ElectricalProperties–Mechanicalproperties–Applications.

UNIT–IV:NanoDevices

Introduction–Nanofabrication–Photo-Lithography–Patterntansfer–IntroductiontoMEMS –SingleElectronTransistor–SolarCells–LightEmittingdiodes–GasSensors-Microbatteries –Fieldemissiondisplaydevices –FuelCells.

BooksforStudy

1. Nanomaterials:Synthesis,opertiesandApplications– EditedbyA.S.EdelsteinandR.C.Cammarata, InstituteofPhysics Publishing, 2002.
2. IntroudctiontoNanotechnology– CharlesP.PooleJrandFrantJ.Owens,WileyInterscience,2003.
3. Nano practices from Theroyto Applications edited byGunter Schmid, WileyVCH, 2004.
4. Nanoelectronicsand Nanosystems byK. Glosekotterand J. Dienstuthi (Springer), 2004.

(Mandatory Core)

PHY- 401	Advanced Quantum Mechanics							5 Credits			4 Credits		
Pre-requisite: Preliminary course of Quantum Mechanics													
Course Objectives: The aim and objective of the course on Advanced Quantum Mechanics is to introduce the M.Sc. students to the formal structure of the subject and to equip him/her with the concept of identical particles, angular momentum. Relativistic quantum mechanics and Quantum field theory so that he/she can use these in various branches of physics as per his/her requirement.													
Course Outcomes: At the end of the course, the student will be able to													
CO1	Understand the concept of identifiable particles												
CO2	Understand the Orbital Angular momentum spin angular momentum and general angular momentum and their importance in spectroscopy												
CO3	Give the significance of Klein Gordon and Dirac equation and explain the existence of antiparticles.												
CO4	Apply the symmetries principles in calculating the conserved currents and charges.												
Mapping of course outcomes with the program outcomes													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	
CO1	3	2	2	-	1	1	1	-	2	1	2	-	
CO2	3	2	3	-	1	1	1	-	2	1	2	-	
CO3	3	2	2	2	1	1	1	-	2	1	2	-	
CO4	3	3	2	2	1	1	1	-	2	1	2	-	

PHY- 401: Advanced Quantum Mechanics

UNIT-I: Identical Particles and Molecules

Identical particles- Indistinguishability of Identical particles- Construction of Symmetric and Anti-symmetric wave functions for two and three particle systems - Pauli's Exclusion Principle- Hydrogen molecule- Spin-orbit interaction- Ortho and Para hydrogen- Spin statistics connection.

UNIT-II: Angular Momentum

Introduction: Motion in Central Potential, Orbital Angular momentum $-L_x, L_y, L_z, L^2, L^+$ and L^- Operators - Commutation rules for angular momentum - Eigen values and Eigen functions of L_z and L^2 - Angular momentum in general - Allowed values of angular momentum J - Eigen values of J_+ and J_- angular momentum matrices - Addition of angular momenta and Clebsch-Gordan coefficients: Clebsch-Gordan coefficient for $J_1=J_2=1/2$ and $J_1=1, J_2=1/2$ - spin angular momentum and Pauli's spin matrices.

UNIT-III: Relativistic Quantum Theory

(Mandatory Core)

Klein – Gordon Equation – K.G. equation in Co-variant form – Probability Density and Probability Current Density – Inadequacies of K.G. Equation – Dirac's Relativistic Equation for a Free Particle – Dirac's Matrices – Dirac's Equation in Co-variant form – Plane wave solution – Negative Energy States – Spin Angular Momentum – Existence.

UNIT-IV: Quantization of Wave Fields

Concept of Field-

Method of Canonical Quantization: Lagrangian Formulation of Field, Hamilton Formulation of Field – Second Quantization – Field equation – Quantization of Non-relativistic Schrodinger equation – Commutation and Anti-Commutation Relations, The N-representation-System of Fermions and Bosons – Creation and Annihilation.

Books for Study

1. Quantum Mechanics: Concepts and Applications by Nouredine Zettili, Wiley, Ed., 2021
2. Introduction to Quantum Mechanics by David J. Griffiths and Darrell F. Schroeter, Third Ed., Cambridge University Press India Pvt Ltd., 2018.
3. Quantum Mechanics: G. Aruldas PH learning private limited Second edition, 2018
4. Quantum Mechanics: S.L. Kakani and H.M. Chandalia Sultan Chand and Sons First Edition, 2004
5. Advanced Quantum Mechanics: B.S. Rajput, Pragati prakasan, 2019
6. Quantum Mechanics: V.K. Thankappan, New Age International (P) Ltd., Publishers, 1993
7. A Textbook of Quantum Mechanics: P.M. Mathews and K. Venkatesan, Tata McGraw Hill Publishing Company, 2008
8. Quantum Mechanics: S.L. Gupta, V. Kumar, H.V. Sharma and R.C. Sharma, Jai Prakash Nath and Company, 2007
9. An Introduction to Quantum Mechanics, P.T. Mathews McGraw Hill Publishing Company, 1974

(Mandatory Core)

PHY - 402	Physics of Advanced materials PHY402: Physics of Advanced Materials	L-3, T-1, P-2	4 Credits									
Pre-requisite: Understanding of graduate level solid state physics												
Course Objectives: The aim and objective of the course on Physics of Advanced materials is to expose the students of M.Sc. class to the topics like crystal growth, dielectric properties, ferromagnetic properties and functional materials, concepts and applications, so that they are equipped with the investigating the matter in the condensed phase.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Gain in-depth knowledge about the formation of various crystal Growth techniques											
CO2	Understand the properties dielectric and ferroelectric materials											
CO3	Understand different on Ferro and Anti ferro and ferro magnetism and their applications											
CO4	Study functional materials											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	1	2	1	-	2	2	1	-
CO2	3	2	2	2	2	2	2	-	2	2	2	-
CO3	3	2	-	2	1	2	2	-	1	2	1	-
CO4	3	2	-	2	2	2	1	-	1	2	2	-

PHY – 402: Physics of Advanced materials

UNIT-I: Crystal Growth and Imperfections in Crystals

Crystal growth: Nucleation and growth – Homogeneous and heterogeneous nucleation – Classification of crystal growth techniques – Melt growth: Bridgman, Czochralski techniques.

Imperfections: Classification of imperfections – Point defects – Schottky and Frenkel defects – Expressions for equilibrium defect concentrations – Colour centres – Production of colour centres – Line defects – Dislocations – Edge and Screw dislocations – Burger vector – Estimation of dislocation densities – Ordered phases of matter – Translational and orientational order

UNIT-II: Dielectrics and Ferroelectrics

Dielectrics: Introduction – Dipole moment – various types of polarization – Electronic, ionic and orientational polarization – Langevin's theory – Lorentz field – Clausius-Mosotti equation – Measurement of dielectric constant – Applications of dielectrics.

(Mandatory Core)

Ferroelectrics: Piezo-, Pyro- and ferroelectric crystals– Spontaneous polarization – Classification and properties of ferroelectrics– Ferroelectric domains – Oxygen ion displacement theory – Applications of ferroelectrics.

PHY 402: Physics of Advanced Materials

UNIT-III: Ferromagnetism and Anti-ferromagnetism

Ferromagnetism: Introduction – Weiss molecular field theory – Temperature dependence of spontaneous magnetization– Heisenberg model– Exchange interaction– Ferromagnetic domains– Magnetic bubbles– Bloch wall – Thickness and energy– Ferromagnetic spin waves– Magnons– Dispersion relations.

Anti-ferromagnetism: Introduction– Two sublattice model of anti-ferromagnetism– Ferrimagnetism– Ferrites – Structure– Applications– Multiferroics

UNIT- IV: Functional Materials

Amorphous semiconductors: Band structure – Electronic conduction – Optical absorption – Applications. Liquid crystals: Classification– Orientational order and intermolecular forces– Magnetic effect– Optical properties– Applications.

Polymers: Classification– Structural property correlation– Molecular weight– Crystalline in polymers– Applications.

Books for Study

1. Solid State Physics, C. Kittel, Edition: 8th 2012, John Wiley & Sons.
2. Solid State Physics, A.J. Dekkar, Edition: 1st, 2000. Macmillan India Ltd.
3. Solid State Physics, M.A. Wahab, Edition: 3rd, 2020, Narosa Publishing House.
4. Fundamentals of Solid State Physics, Saxena, Gupta, Saxena, Edition: 31st, 2019, Pragathi
5. Solid State Physics, R.L. Singhal, 2018, Kedar Nath, Ram Nath & Co. Publications, Meerut.
6. Science of Engineering Materials and carbon nanotubes, C.M. Srivastava and C. Srinivasan, Edition: 3rd, 2010 New Age Inter. Pub.
7. Crystal Growth, B.R. Pamplin, 1977, Pergamon Press.
8. Crystal Growth from High Temperature Solutions, D. Elwell and H.J. Scheel, 1975, Academic Press.

PHY -403 (a)		Photonics PHY403(a):Photonics					(Generic Elective) L-3,T-1,P-2			4Credits		
Pre-requisite: Understanding of graduate level optics and Lasers												
Course Objectives: The aim and objective of the course on Photonics is to expose the M.Sc. students to the basics of the challenging research field of optical fibers and their use in integrated optics and photonic crystals.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	In depth knowledge on different lasers and their application											
CO2	Importance of Fiber optics and their components in communication and sensors											
CO3	Significance and role of waveguides and optics in integrated optics											
CO4	Advances in photonic crystals, circuits and applications with respect to conventional devices.											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	2	1	1	-	-	3	-	1
CO2	3	2	1	1	1	1	-	-	-	3	-	1
CO3	3	2	2	1	2	1	-	-	-	3	-	1
CO4	3	2	1	1	1	2	-	-	-	3	-	1

PHY -403 (a): Photonics

UNIT-I: Lasers systems, Properties and Applications

General description, structure, excitation mechanism and working of CO₂, Argon ion, Free-electron, Dye, Nd:YAG, Optical parametric oscillator, semiconductor and erbium doped fiber lasers. Laser beam linewidth, frequency stabilization, divergence and coherence. Q-Switching and Methods of Q-switching. Mode locking and methods of mode locking. Frequency doubling and phase conjugation. Laser applications in isotopic separation, velocity measurements, interferometry and speckle metrology.

UNIT- II: Fiber Optic Components and Sensors

Connector principles, Fiber end preparation, Splices, Connectors, Source coupling, Distribution networks, Directional couplers, Star couplers, Switches, Fiber optical isolator, Wavelength division multiplexing, Time division multiplexing, Fiber Bragg gratings. Advantage of fiber optic sensors, Intensity modulated sensors, Mach-Zehnder interferometer sensors, Current sensors, Chemical sensors –Fiber optic rotation sensors. Optical biosensors: Fluorescence and energy transfer sensing, molecular beacons and optical geometries of bio-sensing, Bio-imaging, Biosensing.

UNIT- III: Integrated Optics

Introduction – Planar wave guide – Channel wave guide – Y-junction beam splitters and couplers –

(Generic Elective)
FTIR beamsplitters–Prism and grating couplers–Lens waveguide–Fabrication of integrated optical devices
- Integrated photodiodes – Edge and surface emitting laser – Distributed Bragg reflection and
Distributed feedback lasers -Wave guide array laser.
PHY403(a): Photonics

UNIT-IV: Photonic Crystals

Basics concepts, Theoretical modeling of photonic crystals, Features of photonic crystals, Methods of fabrication, Photonic crystal optical circuitry, Nonlinear photonic crystals, Photonic crystal fibers, Photonic crystals and optical communications, Photonic crystal sensors.

Books for Study

1. Lasers: Principles and applications by J. Wilson and J. F. B. Hawkes, Prentice, Hall of India, New Delhi, 1996.
2. Laser fundamentals, W. T. Silfvast, Foundation books, New Delhi, 1999.
3. Fiber Optic Communication, Joseph C. Palais, Pearson Education Asia, India, 2001
4. Introduction To Fibre Optics, A. Ghatak and K. Thyagarajan, Cambridge University Press, New Delhi, 1999
5. Optical Guided Wave Signal Devices, R. Syms and J. Cozens. McGraw Hill, 1993.
6. Optical Electronics, A. Ghatak and K. Thyagarajan, Cambridge University Press, New Delhi, 1991
7. Fundamentals of Photonics, B. E. A. Saleh and M. C. Teich, John Wiley and Sons, 1991
8. Nanophotonics, P. N. Prasad, Wiley Interscience, 2003.

(Generic Elective)

PHY- 403 (b)	Solar Energy– Thermal and Photovoltaic Properties	L-3,T-1,P-2	4 Credits									
Pre-requisite: Understanding of graduate level semiconductor physics												
Course Objectives: The aim and objective of the course on Solar Energy–Thermal and Photovoltaic Properties is to expose the M.Sc. students to the basics of solar energy.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Understand the thermal and light components of solar energy, basic concepts and measurement of solar radiation.											
CO2	Learn the theoretical aspects of solar collectors, performance evaluation and application.											
CO3	Know the concepts of solar cells, types and fabrication procedures of source solar cells.											
CO4	Provide knowledge on cell efficiency measurements.											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	-	1	-	1	2	-	2	3	-	-
CO2	2	2	1	2	1	1	1	-	1	-	-	-
CO3	3	2	-	2	1	1	2	-	1	3	-	-
CO4	2	2	-	2	1	1	2	-	1	-	-	-

PHY403(b): Solar Energy–Thermal and Photovoltaic Properties**UNIT-I: Basic Concepts of Solar Energy**

Introduction - Distribution of solar radiation – Solar Constant, Zenith Angle, Air Mass, Standard Time, Local Apparent Time, Equation of Time, Declination, Hour Angle, Azimuth Angles (all definitions only). Radiation Measurement using Pyranometer and Pyr heliometer–Principle and working. Kirchoff's law – Solar transmittance, absorptance, emittance and reflectance – Their relation. Selective coatings - Methods of Preparation of coatings - Measurement of solar absorptance and emittance of a selective surface.

UNIT- II: Solar Thermal Collectors

Introduction, Collector types - Flat plate collector (FPC), Evacuated tube collector – Energy balance equation and efficiency, Definitions of collector overall heat loss coefficient, collector efficiency factor, collector heat-removal factor and collector flow factor, Temperature distribution in FPC - Testing of FPC, solar water heating - natural and forced circulation type; Concentrating collectors, types, single axis and two-axis tracking – Performance of Linear parabolic trough concentrator, Applications - Space heating, Air heater - Configurations - Drier - Principle and working; Energy storage - Sensible heat storage- liquid and pebble-bed storage, Thermochemical storage.

UNIT–III: Solar Cells

Photovoltaic effect – Equivalent circuit of solar cell - Definitions of cell parameters, Type of cells, Crystalline silicon (c-Si), Float zone and Czochralski methods - Wafer to cell formation steps, Poly-Si wafer growth methods – EFG, Web, Heat exchange method, Amorphous Si cells. Thin film cells – Advantages and limitations – CdTe/CdS, CuInGaSe₂/CdS and GaAs cells –

(Generic Elective)

Configurations and structures

– Fabrication of these cells - I-V characteristics and spectral response - Multijunction cells - Quantum dot, Dye sensitized and Perovskite cells.

UNIT–IV: Solar Photovoltaic Systems

Photovoltaic (PV) Module assembly - Description of steps involved in the fabrication of solar module - Performance of module – I-V Characteristics, Modules design for different current and voltages – Module protection - Use of bypass and blocking diodes, Solar PV system - Components – PV Array, battery, inverter and load. Bifacial solar modules – Advantages over mono-facial cells; Applications of solar PV systems – Stand-alone system – Design methodologies, Hybrid system – Types and issues, Grid connected systems.

Books for Study

1. Solar Energy Utilization, G.D. Rai, Khanna Publishers, 1987.
2. Solar Energy - Fundamentals, Design, Modelling and Applications, G.N. Tiwari, Narosa Publications, 2005.
3. Solar Energy - Principles of Thermal Energy Collection & Storage, S.P. Sukhatme, Tata McGraw Hill Publishers, 1999.
4. Science and Technology of Photovoltaics, P. Jayarama Reddy, CRC Press (Taylor & Francis Group, Leiden, Netherlands) & BSP Publications, 2009.
5. Solar Photovoltaics - Fundamentals, Technologies and Applications, Chetan Singh Solanki, PHI Learning Pvt. Ltd., 2015.

(Generic Elective)

PHY-403 (c)	Vacuum and Thin Film Technology	L-3,T-1,P-2	4 Credits									
Pre-requisite: course in Condensed Matter Physics												
Course Objectives: The main objective of the course on vacuum and thin film technology is to introduce the basic and advanced concepts in the field of vacuum and thin films. The students are not only exposed to theoretical concepts but also have hands-on training in the preparation of thin films. The students also are exposed to various industrial applications of vacuum and thin films												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Basic theoretical concepts of the kinetic theory of gases applicable to vacuum technology and also the principles and construction of various vacuum pumps and gauges.											
CO2	Design and construction of various techniques for the preparation of thin films											
CO3	Theoretical aspects to understand the growth and properties of thin films											
CO4	Various industrial applications of thin films											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	3	1	2	-	3	2	3	-
CO3	3	3	3	-	3	1	-	-	3	-	3	-
CO3	3	2	-	2	2	1	1	-	1	2	1	-
CO4	3	3	-	3	-	1	1	-	3	-	3	-

PHY403(c): Vacuum and Thin Film Technology

UNIT-I: Basics of Vacuum

Fundamentals of kinetic theory applicable to vacuum technology - Vacuum pumps: Rotary pump - Roots pump - Sorption pump - Diffusion pump - Turbo molecular pump - Cryogenic pump - Vacuum Gauges: Pirani gauge - Penning gauge - Hot cathode ionization gauge - Bayard - Alpert gauge - Quadrupole mass spectrometer - Pump combinations - Design of vacuum systems - Leaks and Leak detection - Applications of vacuum.

UNIT-II: Preparation of Thin Films

Physical Methods: Vacuum evaporation - Resistive heating - Electron beam evaporation - Co-evaporation - Epitaxial deposition: Pulsed laser ablation - Molecular beam epitaxy - Sputtering - Glow discharge - DC and RF sputtering - Reactive sputtering - Magnetron sputtering - Chemical methods: Electroplating - Spray pyrolysis - Chemical vapor deposition (CVD) - Sol-gel - Spin coating.
Measurement of film thickness - Multiple beam interferometer (MBI) methods - Quartz crystal thickness monitor - Stylus profiler.

UNIT-III: Properties of Thin Films

(Generic Elective)

Transport Properties of Thin Films: Metallic Films: Sources of resistivity in metallic conductors – sheet resistance and temperature coefficient of resistance of thin films – Influence of thickness on the resistivity of structurally perfect thin films – Fuchs Sondheimer theory – Annealing and agglomeration - Optical Properties - Reflection and transmission by single film and multilayer films - Optical absorption – Determination of optical constants by Ellipsometry.

UNIT-IV: Applications of Thin Films

Photolithography - Pattern Generation - Thin film resistors – Thin film capacitors – Thin film diodes and transistors – Thin film solar cells - Thin film microbatteries – Thin film Gas sensors – Reflection and antireflection coatings - Optical filters - Transparent conducting oxide coatings - Hard coatings - Tribological coatings.

Books for Study

1. Vacuum Technology, A. Roth, North-Holland, 1986.
2. Vacuum Science and Technology, V. Vasudeva Rao, T. B. Ghosh and K. L. Chopra, Allied Publications, 1998.
3. Handbook of Thin Film Technology, L. I. Maissel and R. L. Glang, McGraw Hill Book Co., 1970.
4. Thin Film Phenomena, K. L. Chopra, McGraw Hill Book Co., New York, 1969.
5. Vacuum Deposition onto Webs, Films and Foils, Charles A. Bishop, Elsevier, London, 2011.
6. The Materials Science of Thin Films, M. Ohring, Academic Press, New York, 1992.
7. The User's Guide to Vacuum Technology, J. F. O'Henlon, John Wiley & Sons, 2003.

(Multidisciplinary Course)

PHY-405	Advanced characterization techniques	L-3,T-1,P-0	4Credits									
Pre-requisite: Understanding of graduate level chemistry and physics												
Course Objectives: The aim and objective of the course on Advanced characterization Techniques is to familiarize the M.Sc. students with the basics of the recently emerging research field of dynamics of Structures, Spectra and properties of various instruments												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Describe various Instrumentation – Essential parts of spectrophotometer.											
CO2	Understand theoretical techniques Resonance Spectrometers and Mass Spectrometer											
CO3	Understand use of various spectroscopic techniques and their application to the various fields of physics.											
CO4	Understand the Advanced Spectroscopic and Microscopic Techniques											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	2	1	2	-	2	-	-	-
CO2	3	2	1	2	2	2	2	-	2	-	1	2
CO3	3	2	1	2	1	2	2	-	2	-	-	2
CO4	3	3	1	2	2	2	2	-	2	-	1	-

PHY405: Advanced Characterization Techniques

UNIT-I: Spectrophotometry

Introduction – Beer's law – Absorptivity – UV and visible absorption – Instrumentation – Essential parts of spectrophotometer – IR Spectrophotometry – Fourier Transform Infrared (FTIR) Spectrometer – Molecular structure – Qualitative and Quantitative analysis – Raman Spectroscopy – Qualitative and Quantitative analysis. Fourier Transform (FT) Raman Spectroscopy and its additional advantages over the conventional Raman Spectroscopy,

UNIT-II: Resonance Spectrometers and Mass Spectrometer

Electron Spin Resonance (ESR) – Principle – ESR spectrometer – Working Principle with block diagram – Applications of ESR. Nuclear Magnetic Resonance (NMR) – Principle – NMR spectrometer – Working Principle with block diagram – Experimental techniques – Basic concepts of NQR spectra: Half integral and integral spins, Instrumentation, Superregenerative oscillator, application of NQR. Mossbauer effect – theory – Mossbauer spectrometer – Principle and working of Mossbauer spectrometer –

Experimental methods with block diagram – Applications of Mossbauer studies.

UNIT–III: Advanced Spectroscopic and Microscopic Techniques

Spectroscopic Techniques: Energy Dispersive Spectroscopy, X-ray Photo Electron Spectroscopy, X ray Fluorescence Spectroscopy and Auger Electron Spectroscopy, Secondary Ion Mass Spectrometry.
Imaging Techniques: Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy,
Diffraction Techniques: X-Ray diffraction – Laue method – Powder method.

Books for Study

1. Elements of X-ray Diffraction, B.D. Cullity, 3rd Ed., Pearson Education Ltd., 2014.
2. Methods of Surface Analysis, Techniques and Applications, J.M. Walls Cambridge University Press, 1990.
3. X-ray Structure Determination, H. Stout and L.H. Jenson, Macmillan, London, 1968.
4. Instrumental Methods of Analysis, Willard Merritt, Dean Settle, CBS publishers, New Delhi, 1986
5. Spectroscopy, B.P. Straughan and S. Walker, John Wiley & Sons Inc., New York, 1976.
6. Spectroscopy, G. Chatwal and S. Anand, Himalaya Pub., 2002.
7. Spectroscopy, B.K. Sharma, Goel Publishers House, Meerut, 1975.
8. Basic principles of Spectroscopy by Raymond Chang, MicGrawHill, 1971
9. Molecular Structure and Spectroscopy by G. Aruldas, Prentice Hall of India, 2001

(Open Elective)

PHY-406 (a)	Wireless Communications	L-3,T-1,P-2	4Credits									
Pre-requisite: Understanding of graduate level chemistry and physics												
Course Objectives: The aim and objective of the course on Wireless Communications is to familiarize the M.Sc. students with the basics of the recently emerging mobile technologies.												
Course Outcomes: At the end of the course, the student will be able to												
CO1	understand the basics of digital modulation techniques											
CO2	Understand various coding and error correction techniques											
CO3	Know GSM mobile communication standards, its architecture, logical channels, advantages and limitations.											
CO4	Familiarize with optical and satellite communication techniques											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	2	-	2	-	2	2	-	1
CO2	3	2	1	2	2	2	-	-	2	2	-	-
CO3	3	2	1	2	1	2	2	-	2	2	-	1
CO4	3	2	1	2	2	-	-	-	2	2	-1	-

PHY 406 (a): Wireless

Communications UNIT – I: Base Band Data Transmission

Digital Modulation techniques: BPSK, QPSK, DPSK, QASK, BFSK, MSK, M-ary techniques. Base band binary data transmission system – Inter symbol interference – Nyquist pulse shaping criteria – line coding, pulse shaping, and scrambling techniques, Detection of error probability.

UNIT – II: Codes for Error Detection and Correction

Linear block codes, Convolutional codes. Encoding, Decoding of convolutional codes, State, Tree and Trellis diagrams. Maximum likelihood – Viterby algorithm, Burst error correction – Interleaving techniques – Block and convolutional interleaving, Types of ARQ.

UNIT – III: Introduction to Wireless Communication Systems

Global system for mobile (GSM): cellular concept, system design. Transmission system, receiving system; frequency re-use; Spread spectrum modulation; Multiple access techniques as applied to wireless communications; 1G, 2G, 3G wireless networks.

(Open Elective)

UNIT–IV: Satellite and Optical Communications

Introduction to Satellite systems: Orbiting satellites, satellite frequency bands, communication satellite system-modulation and multiple access format- satellite systems in India, Satellite receiving systems, G/T ratio, satellite uplink and downlink analysis. Applications to communications and remote sensing. Introduction to Optical communications systems: Optical fibers, sources and detectors, analog and digital systems.

Books for Study

1. Modern Digital and Analog communication system by B.P. Lathi: Oxford 3rd ed., 2011
2. Digital Communications Fundamentals and Applications by Bernard Sklar, Sklar Person Education, 2008
3. Principles of Communication Systems: Taub & Schilling, Tata McGraw-Hill, 1991
4. Principles of Communication, R.E. Ziemer, W.H. Tranter Fifth Edition John Wiley (fifth module)
5. Wayne Tomasi: Modern Electronic Communication Systems. Person Education/PHI, 2014
6. John G. Proakis: Digital Communication. MGH
7. Digital Communication Techniques Simon, Hindey Lindsey PHI
8. Communication Systems: Simon Haykin, John Wiley & Sons. Pvt. Ltd.
9. Digital and Analog Communication System: K. S. Shanmugam. John Wiley
10. Communication Systems Engineering: Proakis, Pearson Education
11. Digital & Analog Communication System – Leon W. Couch, Pearson Education/PHI.
12. Introduction to Statistical Signal Processing with Applications M. Srinath, P. K. Rajasekaran, R. E. Viswanathan PHI
13. Analog and Digital Communication M. S. Roden PHI
14. Digital modulation and coding. Wilson, Pearson Education
15. Applied coding and information Theory for engineers, Wells, Pearson education.

(Open Elective)

PHY-406 (b)	Vacuum Technology and applications	L-3,T-1,P-2	4Credits									
Pre-requisite: course in Condensed Matter Physics												
Course Objectives: The main objective of the course on vacuum technology and applications is to introduce the basic and advanced concepts in the field of vacuum technology. The students are not only exposed to theoretical concepts but also have hands-on training in the construction of various vacuum pumps, vacuum measuring gauges, and thin film preparation techniques. The students also are exposed to various industrial applications of vacuum and thin films												
Course Outcomes: At the end of the course, the student will be able to												
CO1	Basic theoretical concepts of the kinetic theory of gases applicable to vacuum technology and also the principles and construction of various vacuum pumps and gauges for the production and measurement of vacuum											
CO2	Design and construction of various components for the construction of vacuum systems for the preparation of thin films											
CO3	Various techniques used for the growth of thin films											
CO4	Various industrial applications of vacuum technology and thin films											
Mapping of course outcomes with the program outcomes												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	3	-	2	-	3	1	-	-
CO3	2	3	3	3	3	1	-	-	3	2	-	-
CO3	2	2	2	2	2	-	1	-	1	1	-	-
CO4	3	3	3	3	3	-	-	-	3	3	-	-

406 (b) Vacuum Technology and

Applications UNIT-I: Basics of Vacuum

Vacuum – definition – Units of Vacuum – Vacuum ranges - Kinetic theory of gases related to vacuum - Physical parameters at low pressures – Vacuum components- Applications of vacuum – Vacuum metallurgy – Freeze drying – Vacuum in electrical applications – Space simulators – Leaks and detection of leaks – Pressure test – Halogen leak detector – Mass spectrometric leak detection.

UNIT-II: Production and Measurement of Vacuum

Classification of vacuum pumps – Rotary pump – Roots pump – Sorption pump – Diffusion pump – Turbo-molecular pump – Ion pump – Cryogenic pump.
Classification of vacuum gauges – McLeod gauge – Pirani gauge – Ionization gauges – Penning gauge – Bayard Alpert gauge – Measurement of partial pressure – Residual gas analyzer – Pump combinations – Construction of high vacuum coating system.

UNIT-III: Preparation of Thin Films

(Open Elective)

Physical Methods- Vacuum evaporation - Resistive heating - Electron beam evaporation - Co-evaporation.

Epitaxial deposition-Pulsed laser ablation-Molecular beam epitaxy.

Sputtering - Glow discharge - DC and RF sputtering - Reactive sputtering - Magnetron sputtering
Chemical methods: Electroplating – Spray pyrolysis – Chemical vapour deposition (CVD) -Sol-gel– Spin coating.

UNIT-IV: Applications of Thin Films

Photolithography-Pattern generation- Thin film resistors – Thin film capacitors – Thin film diodes and transistors – Thin film solar cells - Thin film microbatteries – Thin film gas sensors – Reflection and antireflection coatings - Optical filters - Transparent conducting oxide coatings -Hard coatings-Tribological coatings.

Books for Study

1. Vacuum Technology, A. Roth, 3rd Edition, North-Holland Publications, 2012.
2. Vacuum Science and Technology, V.V. Rao, T.B. Ghosh and K.L. Chopra, 3rd Editions, Allied Publications, 2008.
3. Handbook of Thin Film Technology, L.I. Maissel and R.L. Glang, McGraw Hill Book Co., 1970.
4. Thin Film Phenomena, K.L. Chopra, McGraw Hill Book Co., New York, 1969.
5. Vacuum Deposition onto Webs, Films and Foils, Charles A. Bishop, Elsevier, London, 2015
6. The Materials Science of Thin Films, M. Ohring, Academic Press, New York, 1992.
7. The User's Guide to Vacuum Technology, J.F. O'Henlon, John Wiley & Sons, 2003.