Ph.D. Courses of PHYSICS

DEPARTMENT OF PHYSICS

Amaravati 522502, Andhra Pradesh

INDIA

CURRICULUM AND SYLLABI

(For students admitted from the academic year 2020)

CURRICULUM

University Mandatory Course

Course Category	Course Code	Course Name	L	T	P	L+T+P	C
Core	RM001	Research Methodology	4	0	0	4	4

Any One – Department Mandatory Common Course

Course Category	Course Code	Course Name	L	T	P	L+T+P	C
Core	PHY 701	Foundation in Experimental Physics	3	1	0	4	4
Core	PHY 704	Foundations in Theoretical Physics	3	1	0	4	4

Course nature				Theory		
Assessment Method – Theory Component (Weightage 100%)						
In-semester	Assessment tool	Mid Term I	Mid Term II	CLA I	CLA II	Total
	Weightage	15%	15%	10%	10%	50%
End semester examination Weightage :						50%

Minimum One for the list (Direct Courses)

Course	Course Code	Course Name	L	T	P	L+T+P	C
Elective	PHY 702	Introduction to Photonics	3	1	0	4	4
Elective	PHY 703	Computational Materials Science	3	1	0	4	4
Elective	PHY 705	Thin films, Surfaces and Interfaces	3	1	0	4	4
Elective	PHY 706	Nanotechnology in Energy Conversion and Storage	3	1	0	4	4
Elective	PHY707	Physics and Technology of Nanomaterials and Nanostructures	3	1	0	4	4
Elective	PHY 708	Solid State Ionics	3	1	0	4	4
Elective	PHY 709	Quantum Computation	3	1	0	4	4
Elective	PHY710	Introduction to Solid State and Modern Physics	3	1	0	4	4
Elective	PHY711	Introduction to Soft Matter Physics	3	1	0	4	4

Department of Physics, SRM University AP

Course Name – **Foundation in Experimental Physics**

SUBJECT CODE	SUBJECT TITLE	CORE/ ELECTIVE	CREDITS			
			L	T	P	C
PHY 701	**Foundation in Experimental Physics**	**PhD CORE (EXP)**	3	1	0	4

UNIT – I: Basics of Electronics

Semiconductor device physics, including diodes, junctions, transistors, field effect devices, homo and heterojunction devices, device structure, device characteristics, frequency dependence and applications; Optoelectronic devices, including solar cells, photodetectors, and LEDs; High-frequency devices, including generators and detectors; Operational amplifiers and their applications; Digital techniques and applications (registers, counters, comparators and similar circuits); A/D and D/A converters; Microprocessor and microcontroller basics.

UNIT – II: Basics of Condensed Matter Physics

Bravais lattices; Reciprocal lattice, diffraction and the structure factor; Bonding of solids; Elastic properties, phonons, lattice specific heat; Free electron theory and electronic specific heat; Response and relaxation phenomena; Drude model of electrical and thermal conductivity; Hall effect and thermoelectric power; Diamagnetism, paramagnetism, and ferromagnetism; Electron motion in a periodic potential, band theory of metals, insulators and semiconductors; Superconductivity, type – I and type - II superconductors, Josephson junctions; Defects and dislocations; Ordered phases of matter, translational and orientational order, kinds of liquid crystalline order; Conducting polymers; Quasicrystals.

UNIT-III: Experimental techniques

Data interpretation and analysis; Precision and accuracy, error analysis, propagation of errors, least squares fitting, linear and nonlinear curve fitting, chi-square test; Transducers (temperature, pressure/vacuum, magnetic field, vibration, optical, and particle detectors), measurement and control; Signal conditioning and recovery, impedance matching, amplification (Op-amp based, instrumentation amp, feedback), filtering and noise reduction, shielding and grounding; Fourier transforms; lock-in detector, box-car integrator, modulation techniques.

UNIT – IV: Materials Characterization Techniques

Metallography, microstructural characterization using Optical microscopy;

Diffraction techniques; Production of X-rays, crystal Structure determination using X-rays, Neutrons and Electrons; Thermal analysis using DSC, DTA, TGA; Phase transitions;

Electron Microscopy: SEM, TEM, STM; Compositional characterization using EDAX, WDS

UNIT –V: Vacuum & Cryogenic techniques

Vacuum Pumps, pressure gauges; Thin films & applications: Methods of deposition, measurement of thickness.

Cryogenic fluids, cryostats, feed-throughs, temperature control to low temperatures, Properties at low temperatures

Reference Books:

- Experimental Physics: Modern Methods by R. A. Dunlap (1997 Ed.) – Oxford University Press
- Advanced practical physics by Worsnop and Flint
- Building Scientific Apparatus by Moore, Davis, Coplan and Greer
- Experimental Techniques for Low-Temperature Measurements - Jack Ekin(2006)

Course Name – Foundations in Physics

SUBJECT CODE	SUBJECT TITLE	CORE/ ELECTIVE	CREDITS			
	Foundations in	PhD ELECTIVE	L	T	P	C
PHY 704	Theoretical Physics	(EXP)	3	1	0	4

Unit I

Heisenberg uncertainty principle and Problems, Ehrenfest theorem, Problems on Hermitian Operator, Problems on Commutation, Eigen Value Equation, Linear Vector Space, Hilbert Space, Schrödinger's time dependent and time independent wave equations, Scattering states, Reflection and transmission of particles, Problems on Delta function potential well, Problems on Spherical Harmonic oscillator in one dimension, Energy Eigen functions and Eigen values coordinates precession, Problems on Infinite square well and finite square well potential

Unit II

Angular momentum (L_x, L_y, L_z), Generalized Angular momentum (J_x, J_y, J_z), Addition of Angular Momentum, Eigen values of angular momentum, Spin ½ and 1 system, Problems on Angular momentum, Principle of Variational method, Proof of Variational method and problems, Energy Eigen value in case of Time independent perturbation theory for non-degenerate energy levels, Eigen Function in case of Time independent perturbation theory for non-degenerate energy levels, problems on perturbation theory, problems on Fermi's golden rule and selection rule

Unit III

Two particle system's Schrödinger equation, Transformation to center of mass frame from laboratory frame, Exchange operator, Symmetrization of wave function, Bosons and Fermions, spin-statistics connection, Spin-orbit coupling, fine structure, WKB approximation, Elementary theory of scattering and numerical, phase shifts, partial waves, Born approximation, Klein-Gordon and Dirac equations.

Unit IV

Thermodynamical laws and their consequences; Thermodynamic potentials, Maxwell relations; Chemical potential, phase equilibria; Phase space, micro- and macrostates of thermodynamic systems; Various ensembles (microcanonical, canonical and grand canonical) and partition functions; Free energies and connection with different thermodynamic quantities;

Unit V

First- and higher-order phase transitions with examples; Classical and quantum statistics of particles, ideal Fermi and Bose gases; detailed balance; Blackbody radiation and Planck's distribution law; Bose-Einstein condensation; Random walk and Brownian motion; Introduction to nonequilibrium processes; Classical Linear Response Theory, Brownian Motion, Master Equation, Fokker-Planck Equation, Fluctuation-Dissipation Theorem.

Reference Books

1. David J. Griffiths, "Introduction to Quantum Mechanics", Second Edition, Pearson, 2009
2. AjoyGhatak and S. Lokanathan, "Quantum Mechanics", Fifth Edition, Macmillan, 2009
3. M. Plischke and B. Bergersen, Equilibrium Statistical Physics, World Scientific
4. Principles of Condensed Matter Physics, P. M. Chaikin, T. C. Lubensky, CambridgeUniversity Press

PHY702	Introduction to Photonics	L	T	P	C
		3	1	0	4
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category					
Course designed by	Department of Physics				
Approval	-- Academic Council Meeting -- , 2018				

PURPOSE	The purpose of this course is to introduce students about the basics of optical principles and the ways to develop the photonic devices such as lasers and detectors.

LEARNING OBJECTIVES	STUDENT OUTCOMES
At the end of the course, student will be able to	
1. To provide a comprehensive background of optical principles	

2.	To provide a comprehensive background of quantum mechanical description of light							
3.	To discuss the various analytical techniques for analyzing the optical signals							

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I –Introduction to photonics	**9**			
1.	Introduction to light ~ wave vs particle I	1	C		3
2.	Introduction to light ~ wave vs particle II	1	C		3
3.	Polarization of electromagnetic waves	1	C		1,3
4.	Polarization ellipse	1	C		1,3
5.	Mueller and Jones matrices	1	C,O		1,3
6.	Fresnel and Fraun-hoffer diffraction of light	1	C		3
7.	Coherence of light I	1	C		3
8.	Coherence of light II	1	C		3
9.	Van-Cittert Zernike theorem	1	C,O		3
	UNIT II – Interaction of light with matter	**9**			
10.	Interaction of radiation with matter – threshold conditions	1	C		5
11.	2-level and 3-level laser systems	1	C		5
12.	Einstein's theory for lasers	1	C.D		5
13.	CW and Pulsed operations in lasers	1	C		5
14.	Characteristics of laser beam	1	C		5
15.	Non-linear materials – higher harmonic generations	1	C		5
16.	Optical resonators I	1	C		5
17.	Optical Resonators II	1	C		5
18.	Q-switching and Mode locking of lasers	1	C		5
	UNIT III – Introduction to Fibre Optics	**9**			
19.	Introduction to fibres	1	C		6

20.	Description of fibres – Numerical aperture	1	C		6
21.	Propagation of light through fibre	1	C		6
22.	Preparation of fibres	1	C,D		6
23.	Fibre couplers and connectors	1	C,D		6
24.	Optical detectors	1	C		6
25.	Fibre Amplifiers	1	C		6
26.	Fibres for different spatial modes of light	1	C		6
27.	Integrated fibre optics	1	C		6
	UNIT IV: Photon Statistics	**9**			
28.	Introduction	1	C		4
29.	Photon statistics of laser light	1	C,D		4
30.	Derivation of Poissonian statistics	1	C		4
31.	Description of thermal light – Bunching of photons	1	C		4
32.	Anti-bunching of light	1	C		4
33.	Sub and super Poissonian statistics	1	C		4
34.	Description of Quantum light	1	C		4
35.	Ideal single photon sources	1	C		4
36.	Heralded single photon sources	1	C		4
	UNIT V: Holography and Optical Imaging	**9**			
37.	Introduction to Holography	1	C		3
38.	Computer generated holography	1	C		3
39.	Generation of structured light using holography	1	C		3
40.	Review of Imaging	1	C		3

41.	Fourier transforms for imaging	1	C		3
42.	Reconstruction of phase using holography	1	C		3
43.	Bio-imaging	1	C		3
44.	Optical Trapping and tweezers	1	C		3
45.	Optical Coherence tomography	1	C		3
	Total contact hours	45			

LEARNING RESOURCES	
	TEXT BOOKS/REFERENCE BOOKS/OTHER READING MATERIAL
1	Polarized light by Goldstein
2	Nonlinear Optics, 3rd Ed. by Robert Boyd
3	Introduction to Optics by Hecht
4	Quantum optics by Mark Fox
5	Lasers by Silfvast
6	Fibre Optics by Ajoy Ghatak

SUBJECT CODE	SUBJECT TITLE	CORE/ ELECTIVE	CREDITS			
			L	T	P	C
PHY 703	**Computational Material Science**	**PhD ELECTIVE (EXP)**	**3**	**1**	**0**	**4**

Introduction

Computational Materials Science, Goals and Approach, Basic Procedure of computational Materials Science Finite Element Analysis (FEA), Monte Carlo Methods, Schrödinger's Wave Equation, Energy Operator: Hamiltonian $\hat{H}$, Plane Wave, Standing Wave, Superposition principles of waves, Indistinguishability of electrons, Infinite and Finite Well Problems, Hydrogen Atom, Degenerate States.

First-Principles Methods

Born–Oppenheimer (BO) approximation, n-Electron Problem, Hartee method: One-electron model, Hartee-Fock method: Expression for $\Psi(r)$, Orthogonality of wave functions, Expression for E, Variational Principles, Variational approach to the search for the ground-state energy, Self-Consistent procedure, First-Principles Methods.

Density Functional Theory – I

Reduced Density Matrices; Gilbert Theorem; Role of electron density; The problem of v-representability and N-representability; Hohenberg-Kohn Theorems; Kohn-Sham (KS) Equation; KS Orbitals & KS Eigenvalues

Density Functional Theory – II

Exchange-Correlation (XC) Hole; Local Density Approximation (LDA); Generalized Gradient Approximation (GGA); Jacob's Ladder for improved XC Functional; Practical aspects of solving KS Equations: Self-consistency, Iterative Diagonalization, DOS, Bands, Total Energy and other Properties, Spin-polarized DFT; Limitations and cautionary remarks in using DFT. Quasiparticle Representations, Quasiparticle System Replacing n-electron System, DFT for Excited States, Finite-temperature DFT, Time Dependent DFT

Molecular Dynamics

Atomic Model in MD, Classical mechanics, Molecular dynamics, Pair Potentials, Embedded atom method potentials, Tersoff potential, Potential for ionic solids, N-atom system, Verlet algorithm, Velocity Verlet algorithm, Predictor-corrector algorithm, Potential cutoff, Periodic boundary conditions, Number of atoms, Initial position and velocities, Timestep, Total simulation time, Type of ensembles, Energies, Structural Properties

Reference Books:

1) June Gunn Lee, *Computational Materials Science*, CRC Press 2015 © 2012 by Taylor & Francis Group, LLC.

2) Richard M. Martin, *Electronic Structure – Basic Theory and Practical Methods*, © 2004, Cambridge University press, ISBN 0 521 78285 6 hardback.

3) David S. Sholl, Janice A. Steckel, *Density functional theory, A Practical Introduction*, Copyright © 2009 by John Wiley & Sons.

Course Name – Thin Film, Surface and Interfaces

SUBJECT CODE	SUBJECT TITLE	CORE/ ELECTIVE	CREDITS			
			L	T	P	C
PHY 705	**Thin Film, Surface and Interfaces**	**PhD ELECTIVE (EXP)**	**3**	**1**	**0**	**4**

UNIT – I: Introduction

What is the surface? Why is it important? Historical importance and achievements, Future prospects.

Role of ultra-high vacuum (UHV) in surface science, vacuum techniques, preparation of a clean surface, in-situ experiment

UNIT-II: Surface Growth Processes

Basic theory of epitaxial growth – observation and method of atomic steps, 2D-island nucleation and step flow growth modes, morphological instability of atomic steps.

Thin Film Deposition Methods – brief discussions on major thin-film growth techniques like PLD, MBE, MOCVD, ALD, Sputtering and thermal evaporation.

UNIT – III: Surface Characterization Techniques

Surface chemical composition: AES, XPS, RBS, SIMS, XAS

Surface atomic structure: surface tension, relaxation, reconstruction, defects surface lattice, LEED, RHEED, PEEM, SPM , SEM, TEM, SEXAFS, PED

Surface electronic structure: Surface potential and work function, surface states, band bending, surface, plasmons, PES (XPS, UPS), Inverse Photoemission, EELS, Kelvin Probe

UNIT – IV: Properties of Surface

Mechanical properties: Choice of substrate and epitaxiality, compressive and tensile strain on film growth, role of interface.

Electrical Properties: Conduction in metallic thin-films, superconducting, semiconducting and dielectric thin-films.

Magnetic Properties: Magnetism in thin-films and hetero-structures, Important length scales, Domains and hysteresis, Role of interfaces, Interaction of magnetism and superconductivity in oxide hetero-structures.

UNIT –V: Applications:

Semiconductor industry – Application of semiconductor and dielectric thin-films and hetero-structures, FINFET etc.

Magnetic thin-film application in spintronics, MRAM.

Defence and space applications:

Self-cleaning, lubrication and microfluidic application using wettability study of thin-film surfaces.

Recommended textbooks

1. H. Lüth: Surface and Interfaces of Solids, Springer-Verlag 2001

2. M. C. Desjonquères, D. Spanjaard: Concepts in Surface Physics, Springer, 1998.

3. M. Prutton: Introduction to Surface Physics, Oxford Science Publications, 1994

4. A. Zangwill: Physics at Surfaces, Cambridge University Press 1988

5. N. V. Richardson, S. Holloway: Handbook of Surface Science, North-Holland, 1996

6. R. I. M.Hohn, Principles of Adsorption and Reaction on Solid Surfaces,Wiley & Sons, Inc. 1996

7. D. P. Woodruff, T. A. Delchar: Modern Techniques of Surface Science, Cambridge University Press, 1994

8. G. Attard, C. Barnes: Surfaces, Oxford University Press, 1998

9. D.Briggs, J.T. Grant: Surface Analysis by Auger and X-ray Photoelectron Spectroscopy, IM Publications, 2003

10. D.Briggs, M. P. Seah: Practical Surface Analysis: Auger and X-ray photoelectron spectroscopy, Wiley, 1990

Course Name – Nanotechnology in Energy Conversion and Storage

SUBJECT CODE	SUBJECT TITLE	CORE/ ELECTIVE	CREDITS			
			L	T	P	C
PHY 706	Nanotechnology in Energy Conversion and Storage	PhD ELECTIVE (EXP)	3	1	0	4

UNIT I - INTRODUCTION (9 hours) Nanotechnology for sustainable energy- Energy conversion process, indirect and direct energy conversion-Materials for light emitting diodes-batteries-advanced turbines-catalytic reactors-capacitors-fuel cells.

UNIT II - RENEWABLE ENERGY TECHNOLOGY (9 hours) Energy challenges, development and implementation of renewable energy technologies- nanotechnology enabled renewable energy technologies -Energy transport, conversion and storage- Nano, micro, and poly crystalline and amorphous Si for solar cells, Nano-micro Si-composite structure, various techniques of Si deposition.

UNIT III - MICRO FUEL CELL TECHNOLOGY (9 hours) 26 SRM-M.Tech.-Nano-2015-16 Micro-fuel cell technologies, integration and performance for micro-fuel cell systems - thin film and microfabrication methods - design methodologies - micro-fuel cell power sources.

UNIT IV - MICROFLUIDIC SYSTEMS (9 hours) Nano-electromechanical systems and novel microfluidic devices - nano engines - drivingmechanisms - power generation - microchannel battery - micro heat engine (MHE) fabrication - thermocapillary forces -Thermocapillary pumping (TCP) - piezoelectric membrane.

UNIT V - HYDROGEN STORAGE METHODS (9 hours) Hydrogen storage methods - metal hydrides - size effects - hydrogen storage capacity -hydrogen reaction kinetics - carbon-free cycle-gravimetric and volumetric storage capacities- hydriding/dehydriding kinetics -high enthalpy of formation - and thermal management during the hydriding reaction.

REFERENCES

1. Twidell. J. and Weir. T "Renewable Energy Resources", E & F N Spon Ltd, 1986.

2. Martin A Green, "Solar cells: Operating principles, technology and system applications", Prentice Hall Inc, Englewood Cliffs, 1981.

3. Moller. H J "Semiconductor for solar cells", Artech House Inc, 1993.

4. Ben G Streetman, "Solid state electronic device", Prentice Hall of India Pvt Ltd.,1995.

5. Kettani. M.A "Direct energy conversion", Addision Wesley Reading, 1970.

6. Linden , "Hand book of Batteries and fuel cells", Mc Graw Hill, 1984.

7. Hoogers , "Fuel cell technology handbook". CRC Press, 2003. 8. Vielstich, "Handbook of fuel cells: Fuel cell technology and applications", Wiley, CRC Press, 2003.

Course Name – Physics and Technology of Nanomaterials and Nanostructures

SUBJECT CODE	SUBJECT TITLE	CORE/ ELECTIVE	CREDITS			
			L	T	P	C
PHY 707	Physics and Technology of Nanomaterials and Nanostructures	PhD ELECTIVE (EXP)	3	1	0	4

UNIT – I: Introduction

What are nanostructures? What makes nanostructures unique and interesting?

Schrödinger equation and free particle, Potential well, quantization, and bound states, Quantum well, wire and dot, Density of states, Tunnelling.

UNIT – II: Physical properties of Nano-structures

Finite-size effects on physical properties

Transport properties: 2D electron gas (2DEG), Coherent quantum transport, 2DEG in a magnetic field and quantum Hall effect, Quantum dots: Coulomb blockade and resonant tunneling.

Optical Properties: Optoelectronics of quantum wells and superlattices, Optical properties of quantum dot systems, Luminescence from Si-based nanostructures.

Magnetic Properties: Magnetism at the nanoscale, Spin-based electronics, GMR

Properties of Special Nanostructures: Quantum dots, Quantum wells, Nano-clusters, Nanotubes & Nanowires (SWCNT, MWCNT), Graphene & other layered materials (2D-TMDC).

UNIT-III: Fabrication of nano-structures

Top-down and bottom-up approaches of nanomaterial synthesis; Physical and Chemical Vapor deposition, Vapour-liquid-solid synthesis, Chemical synthetic protocols; Sol-gel; Hydrothermal synthesis; Mechanical milling; Nanocluster deposition; Other novel methods of nanomaterial synthesis.

Lithographic techniques: electron beam lithography, x-ray lithography, nanoimprint lithography, dip-pen lithography.

UNIT – IV: Characterization of nano-structures

Scanning probe and tunneling microscopy: Scanning tunneling microscopy (STM), Atomic force microscopy (AFM), Variants of STM/AFM, Near-field scanning optical microscopy (NSOM), Scanning electron microscopy (SEM) & transmission electron microscopy (TEM).

X-ray diffraction; Electron Microscopy; scanning near field optical microscopy; X-ray photoelectron spectroscopy;

Photoluminescence and Raman spectroscopy with emphasis on information that can be extracted about nanomaterials such as size and shape of particles, crystal structure.

UNIT –V : Applications of NSs:

Single electron devices; sensors; resistive memories; nano-electro mechanical systems; plasmonics; drug delivery; therapy and diagnostics; energy harvesting, storage and generation; superhydrophobic surfaces.

Molecular electronics: Electronic properties and device function of molecules, Assembly of molecule-based electronic devices

Recommended textbooks

Introduction to Nanotechnology , by Charles Poole and Frank Owens (Wiley publishers)
Nanotechnology: Principles and Practices by Sulabha K. Kulkarni, (Springer)
Fabrication Engineering at the Micro- and Nanoscale (The Oxford Series in Electrical and Computer Engineering) 4th Edition by Stephen A. Campbell

Course Name – Solid State Ionics

SUBJECT CODE	SUBJECT TITLE	CORE/ ELECTIVE	CREDITS

PHY 708	Solid State Ionics	PhD ELECTIVE (EXP)	L	T	P	C
			3	1	0	4

UNIT – I: Crystallography

Crystalline and amorphous solids, Glasses, Bonding in solids: ionic, covalent, and metallic bonding, Fundamental concepts of crystals, Lattice points and space lattice, Crystal systems, Bravais lattices, Crystal directions, Miller indices, Interplanar spacing, Bragg's law, Crystal structure of NaCl, Diamond, sodium beta alumina, $BaTiO_3$, CaF_2, AgI, $PbSnF_4$, $RbAgI_4$

UNIT-II: Basic concepts underlying the ionic conductivity in solids

Imperfections in solids, Kröger-Vink Notation for Point Defects, Point Defect Formation and Equilibrium, Law of Mass-action

Basic Concepts of Diffusion, Tracer Diffusion, Self Diffusion, Chemical Diffusion, Ambipolar Diffusion, Ionic Conduction in Crystalline Solids, Intrinsic and Extrinsic Ionic Conduction, Transference Number, Nernst-Einstein Relationship, and Conductivity-Diffusion Relationship

UNIT – III: Fast ion conductors

Difference between fast ion conductors and normal ion conductors, Advantages of fast ion conductors

Classification of solid electrolytes based on the type of the mobile ion

Classification of solid electrolytes based on phase and microstructure: (a) Framework Crystalline/Polycrystalline materials, (b) Glassy electrolytes, (c) Polymer electrolytes, (d) Dispersed phase solid electrolytes/Composites (e) ionic liquids

UNIT – IV: Experimental Techniques

Structural analysis: X-ray Diffraction, Neutron diffraction

Microstructural analysis: Field Emission Scanning Electron Microscopy (SEM), High Resolution-Transmission Electron Microscopy (HRTEM), Atomic Force Microscopy (AFM)

Thermal analysis: Differential Scanning Calorimetry (DSC), Differential Thermal Analysis (DTA), Thermogravimetric Analysis

Transport studies: Complex impedance spectroscopy, Ionic transport number determination, Nuclear Magnetic Resonance (NMR)

UNIT –V : Solid State Ionic Devices

Batteries and its types, Li-ion batteries, Thermodynamics and mass transport in all solid state batteries, Fuel cells, Sensors, Supercapacitors, Electrochromic devices.

Recommended textbooks

1. Joachim Maier, Physical Chemistry of Ionic Materials: Ions and Electrons in Solids, Wiley, 2004.
2. A.L. Laskar and S. Chandra (eds), Superionic Solids and Solid electrolytes -Recent Trends, , Academic Press, 1989.
3. Anthony R West, Solid State Chemistry and Its applications, Wiley

PHY 709	Quantum Computation		L	T	P	C
			3	1	0	4
Co-requisite:	NIL					
Prerequisite:	PHY213 Quantum Mechnics					
Data Book / Codes/Standards	NIL					
Course Category		Elective				
Course designed by	Department of Physics					
Approval	Academic Council Meeting, 2019 (**Regulation - 2019**)					

PURPOSE	The course represents a comprehensive survey on the concept of quantum computing with an exposition of qubits, quantum logic gates, quantum algorithms and Implementation. Starting with the main definitions of the theory of computation, the course mostly deals with the application of the laws of quantum mechanics to quantum computing and quantum algorithms.						
LEARNING OBJECTIVES		**STUDENT OUTCOMES**					
At the end of the course, student will be able to							
4.	know the definition of qubit, quantum logic gates, quantum circuits and quantum algorithms						
5.	understand how quantum parallelism is used in the simplest quantum algorithms such as Deutsch, period finding and quantum Fourier transform						
6.	know the basic requirements for implementation of quantum computers and classify the schemes for implementation of quantum computers						

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
Unit 1	**Matrix and Tensor**	**9**			1,2

1.	Basis vectors and orthogonality	1	C		1,2
2.	Matrices Hilbert spaces	1	C		1,2
3.	Tensors in index notation	1	C-D		1,2
4.	Inner and outer products	1	C		1,2
5.	Kronecker and Levi Civita tensors	1	C		1,2
6.	Contraction, symmetric and antisymmetric tensors, quotient law	1	C-D		1,2
7.	Metric tensors, covariant and contravariant tensors	1	C-D		1,2
8.	Unitary operators and projectors	1	C		1,2
9.	Dirac notation	1	C		1,2
Unit 2	**Introduction and Overview**				
10.	Qubits and pieces	1	C-D		1,2
11.	Bloch sphere	1	C-D		1,2
12.	Qquantum mechanical probabilities	1	C-D		1,2
13.	Quantum behaviors	1	C-D		1,2
14.	History of quanta	1	C-D		1,2
15.	Base states and superposition	1	C-D		1,2
16.	Structural randomness	1	C-D		1,2
17.	Measurement: how long is a qubit?	1	C-D		1,2
18.	Heisenberg's Uncertainty Principle	1	C-D		1,2
Unit 3	**Fundamentals of Quantumness and Quantum Circuit**	9			
19.	Abramsky-Coecke semantics	1	C-D		1,2
20.	no-cloning theorem	1	D-I		1,2
21.	quantum entanglement	1	D-I		1,2
22.	Bell states	1	D-I		1,2

23.	Bell inequalities	1	D-I		1,2
24.	Pauli, Hadamard gates	1	D-I		1,2
25.	phase, CNOT, Toffoli gates	1	D-I		1,2
26.	quantum teleportation	1	D-I		1,2
27.	universality of two-qubit gates	1	D-I		1,2
Unit 4	**Quantum Algorithms**	**9**			
28.	Deutsch-Josza algorithm	1	D-I		1,2
29.	Deutsch-Josza algorithm application	1	D-I		1,2
30.	Simon's problem	1	D-I		1,2
31.	quantum Fourier transform	1	D-I		1,2
32.	Shor's Algorithm - Periodicity	1	D-I		1,2
33.	Shor's period-finding algorithm	1	D-I		1,2
34.	Shor's Algorithm – Preparing and Data Modular Arithmetic	1	D-I		1,2
35.	Shor's Algorithm - Superposition Collapse, Entangelment and QFT	1	D-I		1,2
36.	Grover's searching algorithms	1	D-I		1,2
Unit 5	**Quantum Computer**	**9**			
37.	Quantum key distribution	1	I-O		1,2
38.	Physical realization of quantum computation: ion trap	1	I-O		1,2
39.	Physical realization of quantum computation: cavity QED	1	I-O		1,2
40.	Physical realization of quantum computation: nuclear magnetic	1	I-O		1,2
41.	Quantum Error Correction	1	I-O		1,2
42.	Quantum Error Correction Example	1	I-O		1,2
43.	physical qubits	1	I-O		1,2
44.	noise and decoherence	1	I-O		1,2

45.	Quantum cryptography	1	I-O		1,2
	Total contact hours		45		

LEARNING RESOURCES	
TEXT BOOKS/REFERENCE BOOKS/OTHER READING MATERIAL	
1	Phillip Kaye, Raymond Laflamme, and Michele Mosca (2007). An Introduction to Quantum Computing. Oxford University Press.
2	Michael A. Nielsen and Isaac L. Chuang (2000). Quantum Computation and Quantum Information. Cambridge University Press.

PHY 711M	**Introduction to Soft matter physics**		**L**	**T**	**P**	**C**
			3	**1**	**0**	**4**
Co-requisite:	NIL					
Prerequisite:	Mechanics I					
Data Book / Codes/Standards	NIL					
Course Category		CORE				
Course designed by	Department of Physics					
Approval	-- Academic Council Meeting -- , 2020					

PURPOSE	The purpose of this course is to introduce the students with the physics of membranes, polymers and structural stability in biological and other objects.							
LEARNING OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, students will be able to								
1	Understand the interactions and energy scales involved in soft matter physics							
2	Apply those concepts in understanding stability and fluctuations in biological cells and membranes							
3	Understand the concept of fluid flow and hydrodynamic instabilities							
4	Understand the concept of elastic properties of polymers							

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT-I- Interactions in soft matters	**12**			
1.	What is soft matter?	1	C		1,2
2.	Forces, energies and time scales in soft matter	1	C		1,2
3.	Surface tension	1	C		1,2
4.	Surface energy	1	D		1,2
5.	Wetting phenomena: Young's equation and contact angle	1	D		1,2
6.	Hydrophobicity and hydrophilicity	1	C		1,2
7.	Capillarity	1	C		1,2
8.	Van der Waals interaction (molecules and colloids); stability and aggregation	1	C		1,2
9.	Entropy driven interactions	1	C		1,2
10.	Tutorial I	1	D-I		1,2
11.	Tutorial II	1	D-I		1,2
12.	Tutorial III	1	D-I		
	UNIT II – Elements of complex fluids motion	**12**			
13.	Random walks and diffusion equation	1	C		1,2
14.	Brownian motions of colloidal particles	1	C		1,2
15.	Langevin equation	1	C		1,2
16.	Fokker-Planck equation	1	C		1,2
17.	Hydrodynamics: Navier-Stokes equation	1	D		1,2
18.	Reynolds number	1	C		1,2
19.	Linearization: Stokes law	1	C		1,2
20.	Hard sphere suspension	1	D-I		1,2
21.	Linear viscoelasticity	1	D-I		1,2
22.	Tutorial IV	1	D-I		1,2
23.	Tutorial V	1	D-I		1,2
24.	Tutorial VI	1	D-I		1,2
	UNIT III – Self-assembly and membranes	**12**			
25.	Concept of self-assembly	1	C		1,2
26.	Aggregation of amphiphilic molecules; critical micelle concentration	1	C		1,2

27.	Self-assembly in viruses	1	C		1,2
28.	Self-assembly in colloidal systems	1	C-D		1,2
29.	Applications of self-assembly in nanotechnology	1	C-D		1,2
30.	Lipid bilayers and cell membranes	1	C		1,2
31.	Curvature elasticity in membranes	1	D		1,2
32.	Fluctuations in membranes	1	C-D		1,2
33.	Problems on Fluctuations in membranes	1	D		1,2
34.	Tutorial VII	1	D-I		1,2
35.	Tutorial VIII	1	D-I		1,2
36.	Tutorial IX	1	D-I		1,2
	UNIT IV: Polymers	**12**			
37.	Examples of polymers	1	D		1,2
38.	Polymers and biological macromolecules	1	C		1,2
39.	Polymer statistics: single polymer chain	1	C		1,2
40.	Self-avoiding walk	1	D		1,2
41.	Entropic forces and excluded volumes	1	C		1,2
42.	Persistence length	1	C		1,2
43.	DNA as polymer chain	1	C		1,2
44.	Phase transition and Flory theory of polymers	1	C		1,2
45.	Rubber elasticity	1	D		1,2
46.	Tutorial X	1	D-I		1,2
47.	Tutorial XI	1	D-I		1,2
48.	Tutorial XII	1	D-I		1,2
	UNIT V: Percolation theory	**12**			
49.	Concept of fractals; examples	2	D		2,3
50.	Fractal dimension	2	C		2,3
51.	Definition: site and bond percolation in regular lattices	1	C		2,3
52.	Percolation transition; order parameter	1	C		2,3

53.	Critical exponents in percolation; cluster statistics	1	C-D		2,3
54.	Lattice animals	2	C-D		2,3
55.	Application: Fluid flow through porous media	1	C-D		2,3
56.	Application: Cross-linking polymers; De Gennes' theory of polymer elasticity from percolation theory	1	D		2,3
57.	Rigidity percolation and fracture	1	D		2,3
58.	Tutorial XIII	1	D-I		2,3
59.	Tutorial XIV	1	D-I		2,3
60.	Tutorial XV	1	D-I		2,3
	Total contact hours	60			

LEARNING RESOURCES	
	TEXT BOOKS/REFERENCE BOOKS/OTHER READING MATERIAL
1	Principles of condensed matter physics, P. M. Chaikin, T. C. Lubensky, Cambridge university press (2000)
2	Intermolecular and surface forces, J. N. Israelachvili, Elsevier, ISBN: 978-0-12-375182-9 (2011)
3	Wineman. A.S & Rajagopal, K.R., Mechanical response of polymers- An Introduction, Cambridge University Press

Course nature				Theory		
Assessment Method (Weightage 100%)						
In-semester	**Assessment tool**	Mid Term I	Mid Term II	CLA1	CLA2	**Total**
	Weightage	**15%**	**15%**	**10%**	**10%**	**50%**
				End semester examination Weightage		**50%**