SEMESTER - IV			
CORE X	**NANO SCIENCE AND TECHNOLOGY**		
Code :17PPCC41	**Hrs/Week: 6**	**Hrs/Semester:90**	**Credits: 4**

Course Outcomes

CO No.	Upon completion of this course, students will be able to	PSOs addressed	CL
CO 1	Recall a thorough knowledge of the basic concepts of nanoscience and nanotechnology	PSO1	R
CO 2	Explain the preparation, characterization and properties of nanomaterials	PSO4	U
CO 3	Analyze the types and properties of carbon nanotubes	PSO4	An
CO 4	Assimilate existing and new concepts, methodology and researches and apply them in their academic research environment	PSO5	E
CO 5	Aware of challenges, risks and promises of magneto electronics and nano technological development	PSO6	C
CO 6	Discuss the preparation of Quantum Nano structures	PSO1,4	U

Unit I-Introduction

History of Nanotechnology- Nano structures- importance of nano materials- Synthesis of nanomaterilas- physical methods(Laser Ablation, Evaporation,Sputtering and solvated metal Dispersion)- Chemical methods- Thermolysis, Sonochemical approach, reduction of metal ions by hydrogen and Methanol- Biosynthesis (Elementary idea only)

Unit II-Preparation and characterisation

Structural Characterisation (X- ray diffraction, Scanning Tunneling Microscopy, Atomic force microscopy) - Properties of nanomaterials(Optical,Electrical and magnetic properties) – Synthesis of semiconductor nanomaterials (Precipitation methods, Thermal decomposition of complex precursors) -Synthesis of Ceramic nanomaterials - Physical methods (Gas condensation & Laser methods)- Chemical method(Sol-gel synthesis)

Unit III- Carbon nanotube

Carbon nanotube - Carbon allotropes (Diamond ,Graphite, Carbon nanotubes) - Types of Carbon nanotubes – Graphene sheet to single walled nanotube - Synthesis of carbon nanotubes(Electric arc -Discharge method, Laser method, Fluidised bed CVD method, Solar production of Carbon nanotubes) - Purification and properties of Carbon nanotubes – Fullerenes - Purification and properties of Fullerenes.

Unit IV-Quantum well, Quantum wire and Quantum dots

Introduction - preparation of Quantum nanostructures - Fermi gas and Density of states – Calculation of the density of states in 1,2 and 3 dimension- Infrared detector -Quantum wire(Production ,Structure, Use), Quantum dot-Fabrication Techniques - Application of Quantum dots – Quantum dot information storage, Infrared photodetectors, Lasers.

Unit V-Magneto electronics and Applications of Nanotechnology

Magneto electronics: Nano crystalline soft magnetic materials-Permanent magnetic materials-Theoritical background-Super para magnetism-Coulomb blockade-Single electron transistor-Spintronics-Giant magneto resistance-Quantum Hall Effect-fractional Quantum Hall Effect

Applications of Nanotechnology:Chemistry and Environment - Energy applications of Nanotechnology -Information and Communication- Heavy industry - Consumer goods - Nano medicine - medical applications of molecular nanotechnology (Nanorobots, Cell repair machines, nanonephrology)

Book for Study:

1.Nano Physics, Dr.Sr.GeraldinJayam

Unit	Book no.	Page No
III	1	2.1-2.7,2.14-2.20,2.26-2.29
IV	1	4.1-4.10,4.15-4.30
V	1	5.1-5.5,5.10-5.30

Book for Reference

1. Shanmugam.S, Nanotechnology, MJP Publishers, Chennai(2011)
2. Parthasarathy. B.K, Nanostructure and Nanomaterials, Isha Books, Delhi(2007)
3. Fahrner.W.R (Ed), Nanotechnology and Nanoelectronics- materials, Devices, measurement techniques, Spinger(2004)
4. Charles.P. Poole Jr Frank J. Owens;John Wiley & Sons inc.Publication(2003)
5. Massimiliano Di ventra, Stephane Evoy, James R. Heflin Jr(Editors) , Introduction to Nanoscale science and Technology Springer(2009)
6. Guozhong Cao, Nanostructures and Nanomaterials – Synthesis, Properties and Applications, Imperial College Press, London(2004).

SEMESTER - III			
CORE - VII	**QUANTUM MECHANICS-I**		
Code :17PPHC31	**Hrs/Week: 6**	**Hrs/Semester: 90**	**Credits: 5**

Course Outcomes

CO No.	Upon completion of this course, students will be able to	PSOs addressed	CL
CO 1	Develop a knowledge and understand the meaning of uncertainty principles, energy eigen function and boundary conditions	PSO1	C
CO 2	Able to numerically solve the linear harmonic oscillator and describe fundamentals	PSO2	A
CO 3	Compile the knowledge of role of angular momentum and the Pauli spin matrices using ladder operators	PSO1	C
CO 4	Relate the matrix formalism to the use of basic states and solve simple problems in that formalism	PSO2	U
CO 5	Make use of the perturbation theory and variation methods in applications of ground state of He atom	PSO2	A
CO 6	Have a deep understanding of the mathematical foundations of quantum mechanics	PSO1	U

Unit I: Formalism of Quantum Mechanics

Inadequacy of classical Physics - Uncertainty Principle – Interpretation of wave function – Statistical Interpretation – Normalisation of Ψ – Probability current density – Expectation value – Ehrenfest's theorem – Energy eigen functions – separation of wave equations – Boundary and continuity condition – Energy eigen values in one dimension – discrete energy level – continuous energy eigen functions – discrete and continuous eigen values in 3D – 1D square well potential.

Unit II: Eigen functions and eigen values

Normalisation – Orthonormality – Momentum eigen functions – The Dirac function.

Discrete Eigen Values: Bound state - Linear Harmonic Oscillator – Spherical symmetric potential in 3D - Hydrogen atom.

Unit III: Angular Momentum

Angular momentum operator – Eigen values and eigen functions of L^2 – commutation relations – Angular momentum and rotations – Ladder operators – the constants C_+ and C_- - Angular

momentum corresponding to j = ½ and the Pauli spin matrices, wave function and equations – combination of two angular momenta – C.G coefficient.

Unit IV: Matrix formulation

Transformation theory – Unitary matrix – Transformation of Hamiltonian with W, U, V – Hilpert space – Dirac bra and ket notation - Schrodinger's picture – Hisenberg's picture – Interaction picture – Matrix theory of harmonic oscillator.

Unit V: Approximation methods

Perturbation theory in non-degenerate cases – Applications to ground state of He atom, Harmonic oscillator – Stark effect in Hydrogen – Variation method – Application to ground state of He atom - WKB Approximation.

Books for Study:

1. L.I.Schiff, Quantum Mechanics , IIIEdition,McGraw Hill,1968
2. Ajoy Ghatak, S.Lokanathan, Quantum Mechanics Theory and Applications, 5th Edition, Macmillan India Ltd, NewDelhi.
3. Quantum Mechanics ,Chatwal Anand, Fourth Edition,1993,Himalaya Publishing house,Bombay,

Unit	Book no.	Sections / Page No
I	1	2-3, 7-8,24-32, 34-44
II	1	47-50, 53-55, 66-83, 88-98
III	2 3	212 – 221, 309 – 318 653 - 659
IV	1	155-159, 163-166, 168-173, 180 - 185
V	3 2	405-410, 505 – 508 380 - 384

Books for Reference:

1. Richard L.Liboff , Introductory Quantum mechanics, Fourth edition, Pearson Education 2003.
2. SathyaPrakash, Advanced Quantum Mechanics, Reprint 2013,Keda Nagth and Ram Nath Publications, Meerut.
3. P.M.Mathews and K.Vengatesan, A text book of Quantum Mechanics, 38 reprint 2007, Tata Mc Graw Hill Publishing Company Ltd, NewDelhi.
4. S.N.Biswas, Quantum Mechanics, 2011 Reprint, Books and Allied P Ltd, Kolkata.
5. Ajoy Ghatak, S.Lokanathan, Quantum Mechanics Theory and Applications, 5th Edition, Macmillan India Ltd, NewDelhi.
6. Vimal Kumar Jain, Introduction to Quantum Mechanics, 2010 Edition, Narosa publishing P Ltd, NewDelhi.

SEMESTER - III			
CORE VIII THERMODYNAMICS AND STATISTICAL MECHANICS			
Code : 17PPHC32	**Hrs/Week: 6**	**Hrs/Semester: 90**	**Credits:5**

Course Outcomes

CO No.	Upon completion of this course, students will be able to	PSOs addressed	CL
CO 1	Acquire working knowledge of the zeroth, first, second and third law of thermodynamics	PSO1	C
CO 2	Apply statistics in different systems containing atoms and molecules	PSO2	A
CO 3	Construct the partition function for calculations about the microcanonical, canonical, grand canonical ensemble	PSO2	An
CO 4	• Recover the loss of thermodynamics and equipartition theorem from the statistical description using microstates • Uses Fermi Dirac and Bose Einstein statistics according to the spin of the particles	PSO6	E
CO 5	Acquire knowledge about phase transitions and fluctuations in ensembles	PSO1	C
CO 6	Analyse energy changes in chemical reaction using the first law of thermodynamics	PSO1	An

Unit I: Thermodynamics

Zeroth, First, Second and Third law of thermodynamics – Entropy – Maxwell's thermodynamic relations – Thermodynamic potentials – Chemical potential.

Unit II: Basis of Statistical Mechanics

Phase space – Ensemble – Liouville theorem – Conservation of extension in phase – Equation of motion – Equal a priori probability – Statistical Equilibrium – Microcanonical Ensemble – Quantisation of Phase space – Classical limit – Symmetry of wave functions – Effect of symmetry of counting – Various distributions using microcanonical ensemble.

Unit III: Ensemble

Gibbs paradox – Sackur-Tetrode equation – Entropy of a system in contact with a heat reservoir- Ideal gas in canonical ensemble – Grand canonical ensemble – Ideal gas in grand canonical ensemble – Comparison of various ensembles – Quantum distributions using other ensembles.

Unit IV: Statistical Thermodynamics

Macrostates and microstates – Bose-Einstein distribution function – Fermi-Dirac distribution function – Maxwell-Bolltzman distribution function – Partition function – Thermodynamic properties of a system - Bose-Einstein condensation – Einstein and Debye theories of the specific heat capacity of a solid – Blackbody radiation.

Unit V: Ising model and Fluctuations

Phase transitions of the second kind – Ising model – Bragg-Williams approximations – Fowler-Guggenheim approximation – One dimensional Ising model.
Fluctuations in ensembles – concentration fluctuations in quantum statistics - One dimensional random walk – Brownian motion.

Book for Study:

1. Heat and thermodynamics, V N Dass, First Edition, 2005, Dominant Publishers , Delhi.
2. Statistical Thermodynamics, M.C Gupta, Reprint 2009, New age international P Ltd, New Delhi.
3. Thermodynamics, Kinetic Theory and Statistical Thermodynamcis, Sears Salinger, Third edition, Narosa publishing house pvt Ltd, New Delhi.
4. Statistical Mechanics, B.K Agarwal, Melvin Eisner, Reprint 2002, New age international P Ltd, New Delhi.

Unit	**Book no.**	**Sections / Page No**
I	1	1-2, 14-19, 70-71, 76-77,154-160, 173-187
	2	5.5
	3	7.7
II	4	1.2,1.3,1.5-1.10, 2.2,2.4-2.7
III	4	3.5, 3.6, 4.2,4.3,4.6 - 4.9
IV	3	11.3,11.9,11.10, 11.13,11.14, 11.5,13.1,13.2,13.3
	4	6.2
V	4	11.1 -11.4, 11.6,10.3-10.6

Books for reference:

1. Kerson Huang, Statistical Mechanics, John Wiley & Sons, Inc., New York, Second edition, 1987.
2. A.K.Dasgupta, Fundamentals of Statistical Mechanics, New Central Book Agency (P) Ltd., Calcutta, 2000.
3. Sears and Zymanski, Statistical Mechanics, McGraw Hill Book Company, New York, 1961.
4. Federick Reif., Fundamentals of Statistical and thermal Physics, McGraw Hill International Editions, Singapore, 1985.

SEMESTER - IV			
CORE XI	**QUANTUM MECHANICS –II**		
Code :17PPHC41	**Hrs/Week: 6**	**Hrs/Semester:90**	**Credits: 4**

Course Outcomes

CO No.	Upon completion of this course, students will be able to	PSOs addressed	CL
CO 1	Understand time dependent perturbation theory in quantum mechanics	PSO1	U
CO 2	Interpret the wave functions and apply operators to its to obtain information about the particle's physical properties	PSO2	U
CO 3	Develop a knowledge and understand the scattering matrix and partial analysis	PSO1	A
CO 4	Relate the Einstein Coefficient using semi classical treatment	PSO6	R
CO 5	Interpret the form and construction of relativistic wave equations	PSO6	U
CO 6	Discuss the construction of Symmetric and anti-symmetric wave functions	PSO1	U

Unit I: Time Evaluation Process

Time dependent perturbation theory – first & second order – Application: Elastic scattering (first order) – Harmonic perturbation - Transition probability – The selection rules – Application: Elastic scattering (First order) - Adiabatic & Sudden approximations – Disturbance of an oscillator.

Unit II: Identical Particles and Spin

Symmetric and antisymmetric wavefunctions – construction – The exclusion principle – spin matrices and eigen functions – Collision of identity particles – Expectation value and projection operator – Density operator – Equation of motion - Density matrix.

Unit III: Scattering Theory

Definition and interpretation of scattering cross section – Quantum theory of scattering – Green's function – The Born approximation and its validity – Scattering by Yukawa potential – Ramsauer –Townsend effect – Scattering by a perfect rigid sphere - Scattering by a square well potential – Resonance scattering – Couloumb potential.

Unit IV:Semiclassical Treatment

Absorption and induced emission – Transition probability – Electric dipole transition – Einstein coefficient – Relation between Einstein coefficients – Selection rules for a single particle – Photoelectric effect.

Unit V: Relativistic Wave Equations

The Klein-Gordan equation – The Dirac equation – Dirac matrices – Free particle solutions - The electron in an electromagnetic field – spin angular momentum – spin orbit energy – The hydrogen atom – Classification of energy levels – Negative energy states.

Books for study:

1.L.I.Schiff, Quantum Mechanics , IIIEdition,McGraw Hill,1968

2. Ajoy Ghatak, S.Lokanathan, Quantum Mechanics Theory and Applications, 5th Edition, Macmillan India Ltd, NewDelhi.

3. Quantum Mechanics ,Chatwal Anand, Fourth Edition,1993,Himalaya Publishing house,Bombay,

4.P.M.Mathews and K.Vengatesan, A text book of Quantum Mechanics, 38 reprint 2007, Tata Mc Graw Hill Publishing Company Ltd, NewDelhi.

Unit	Book no.	Sections / Page No
I	4	335 – 345, 351 – 354
	2	594 – 598
	1	289 – 291, 292 -295
II	1	362 – 366, 368, 372 – 374, 378 – 383
	4	381 - 383
III	2	552 – 560, 574 - 578
	1	324 – 326, 123 - 129
IV	1	398 , 401 – 406, 416 – 417, 420 - 422
	2	227 - 228
V	1	466 - 488

Books for Reference:

1. Richard L.Liboff , Introductory Quantum mechanics, Fourth edition, Pearson Education 2003
2. SathyaPrakash, Advanced Quantum Mechanics, Reprint 2013,Kedar Nath and Ram Nath Publications, Meerut.
3. P.M.Mathews and K.Vengatesan, A text book of Quantum Mechanics, 38 reprint 2007, Tata Mc Graw Hill Publishing Company Ltd, NewDelhi.
4. S.N.Biswas, Quantum Mechanics, 2011 Reprint, Books and Allied P Ltd, Kolkata.
5. Ajoy Ghatak, S.Lokanathan, Quantum Mechanics Theory and Applications, 5th Edition, Macmillan India Ltd, NewDelhi.
6. Vimal Kumar Jain, Introduction to Quantum Mechanics, 2010 Edition, Narosa publishing P Ltd, NewDelhi.

SEMESTER - IV			
CORE XII ATOMIC AND MOLECULAR SPECTROSCOPY			
Code :17PPHC42	**Hrs/Week: 6**	**Hrs/Semester: 90**	**Credits: 4**

Course Outcomes

CO No.	Upon completion of this course, students will be able to	PSOs addressed	CL
CO 1	Explain the structure of atoms and the origin of the observed spectra	PSO1	U
CO 2	Interpret rotational spectra, get information about molecular dimension and atomic masses	PSO4	U
CO 3	Explain pure rotational Raman spectra and understand the techniques in instrumentation	PSO3	U
CO 4	Apply knowledge of Mossbauer spectroscopy in solid state physics and nanotechnology	PSO4	A
CO 5	Assess how nuclear spins are affected by magnetic field and able to explain what happens when radio frequency radiation is observed	PSO1	E
CO 6	Discuss the techniques of ESR spectroscopy	PSO1	U

Unit I: Atomic Spectra

Introduction-Different Spectral lines of hydrogen-Origin of Atomic Spectra: Rutherford's explanation-Bohr's theory of Hydrogen Spectrum-Critical potential (excitation & ionization potentials)-vector atom model.

Electronic Spectroscopy: Structure of atoms-electronic angular momentum-The angular momentum of many –electron atoms-The Zeeman effect

Unit II: Microwave Spectroscopy

Microwave Spectroscopy: The rotation of molecules – Rotational spectra – Diatomic molecules – Polyatomic molecules –Techniques and instrumentation –Chemical analysis. Applications(Microwave oven)

Unit III:Infra-Red Spectroscopy and Raman Spectroscopy

Infra Red Spectroscopy: The vibrating diatomic molecule – The Diatomic vibrating rotator- The interactions of rotations and vibrations- The vibrations of polyatomic molecules- Techniques and instrumentations.

Raman spectroscopy: Pure rotational Raman Spectra- vibrational Raman spectra- Techniques and instrumentation.

Unit IV: Electronic Spectroscopy of Molecules and Mossbauer Spectroscopy

Vibrational coarse structure: progressions – intensity of vibrational electronic spectra: The Frank – Condon principle – Dissociation energy and Dissociation products – rotational fine structure of electronic- vibration transition.

Mossobaur Spectroscopy: Principles of Mossbauer-Applications of Mossbauer Spectroscopy

Unit V: Resonance Spectroscopy

NMR – Chemical shift – The coupling constant – Nuclear quadrupole effects – Techniques and instrumentation.

ESR – The hyperfine structure – Double resonance – Fine structure - Techniques of ESR spectroscopy.

Books for study:

1. M.K.Dutta, Atomic and Molecular Spectroscopy, Ist Edition 2010, IVY Publishing House, Delhi.

2. C.N.Banwell, Fundamentals of Molecular spectroscopy, 4th Edition, Tata McGraw hill Publishing Company, NewDelhi.

Unit	Book No.	Sections
I	1	1-4
	2	5.1,5.2,5.4,5.6
II	2	2.1-2.7
III	2	3.1,3.2,3.4,3.5,3.8,4.2,4.3,4.6
IV	2	6.1.2-6.1.5,9.1,9.2
V	2	7.2, 7.2.1 - 7.2.2,7.3.4,7.4,7.5.1,7.5.3-7.5.6

Books for Reference:

1. G.M.Barrow, Introduction to Molecular Spectroscopy, 17thprint, MGH Publishing Company.
2. Gary M.Lampman, Donald L.Pavaia, George S.Keiz, James R.Vyvyan, Spectroscopy, 4th Edition, Cengage Learning India P Ltd, Delhi.
3. G.Aruldhas, Molecular structure & Spectroscopy, Second edition,Prentice hall Private Ltd.
4. Suresh Chandra, Molecular Spectroscopy, Narosa Publishing House Ltd, Newdelhi.

SEMESTER - IV			
ELECTIVE - III	**CONDENSED MATTER PHYSICS**		
Code :17PPHE41	**Hrs/Week: 6**	**Hrs/Semester: 90**	**Credits: 5**

Course Outcomes

CO No.	Upon completion of this course, students will be able to	PSOs addressed	CL
CO 1	Recall about the crystal structure and degree of ordering to atom binding and packing	PSO1	R
CO 2	Explain the physics of different types of bonds in crystalline structure	PSO6	U
CO 3	Classify condensed matter upon its degree of order with emphasis on scattering experiments	PSO3	U
CO 4	Explain the effective electron mass and apply it to describe electron dynamics in semiconductors	PSO5	U
CO 5	Develop the knowledge of magnetism to explain natural physical process and related technological advances	PSO6	A
CO 6	Calculate the intrinsic carrier concentration of semiconductor crystals	PSO1	A

Unit I: Crystal Structure

Periodic arrays of atoms-Fundamental types of lattice –Index systems for crystal planes- Simple crystals structures - Non ideal crystal structure-Reciprocal lattice vectors-Diffraction conditions-Brillouin zones-Fourier analysis of the basis.

Unit II: Crystal binding and Elastic constants

Crystals of inert gases-Ionic crystals-Covalent crystals-metals-hydrogen bonds-atomic radii-analysis of elastic strains-elastic compliance and stiffness constants-elastic waves in cubic crystals

Unit III: Crystal vibrations

Vibrations of crystals with monatomic basis - Two atoms per primitive basis -Quantization of elastic waves - Phonon momentum – Inelastic scattering by phonons

Unit IV: Semiconductor Crystals

Band gap-equations of motions-intrinsic carrier concentration-impurity conductivity-thermo electric effects-semimetals-superlattices

Unit V: Magnetism

Langevin dia magnetism equation-Quantum theory of dia magnetism of mono nuclear systems-para magnetism-Quantum theory of para magnetism-Ferro magnetic order-magnons-ferrimagnetic order-anti ferro magnetic order-ferromagnetic domain

Books for study:

1.Charles Kittel, Introduction to Solid state Physics, Wiley, 7th Edition, 1995.

Unit	Book No.	Page Number
I	1	1-19,29-42
II	1	47-85
III	1	89-102
IV	1	185-218
V	1	297-311,323-352

Books for Reference:

1. L. V. Azaroff, Introduction to Solids (McGraw Hill), 9th Reprint, Newyork.
2. P.K.palanisamy, Solid State Physics, 2013 Reprint, Scitech publications Private Ltd, Chennai.
3. H.C.Gupta , Solid State Physics, II Edition, Vikas Publishing home Ltd, Noida.
4. R.L.Singhal, Solid State Physics, Kedar Nath and Ram Nath publishers, Meerut.