JSS MAHAVIDHYAPEETHA
JSS SCIENCE AND TECHNOLOGY UNIVERSITY
SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING

- Constituent College of JSS Science and Technology University
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DEPARTMENT OF PHYSICS

DOMAIN SPECIFIC COURSE - 1

QUANTUM MECHANICS

Subject Code:PHYD01

Credits: 04 **Total Hours: 52**

Course Content / Syllabus:

UNIT No.	Content	Hours
UNIT 1	**Origin of quantum theory:** Blackbody radiation, Photoelectric effect, Compton scattering, Matter waves, Uncertainty principle, Stern-Gerlach experiment. **Introduction:** The wave function, The Schrodinger equation, the statistical interpretation, Probability, Discrete and continuous variables, Normalization, Momentum, The uncertainty principle. **The time-independent Schroedinger equation:** Stationary states, The Infinite square well, The harmonic oscillator, Algebraic and analytic methods, The free particle, The Delta-function potential, and the finite square well.	12
UNIT 2	**Formalism:** Linear vector spaces and operators in Hilbert space, Measurements, Observables and the uncertainty relations, Change of basis, Momentum representations, Equations of motion in Schroedinger and Heisenberg pictures, One dimensional potential problems, Linear harmonic oscillator, Creation and annihilation operators, Eigen functions of a Hermitian operator, The generalized statistical interpretation. Quantum Mechanics in three dimensions, Schroedinger equations in Spherical Coordinates, The hydrogen atom, Angular momentum, Spin.	13
UNIT 3	**The time-independent perturbation theory:** Non-degenerate perturbation theory, First and second order perturbation, Degenerate perturbation theory, The fine structure of hydrogen, the Zeeman effect. The Variation Principle: Theory, the ground state of helium atom and hydrogen molecular ion. The WKB approximation: The classical region, Tunneling. Time dependent perturbation theory, Fermi's golden rule, Semi classical theory of interaction of atoms with radiation.	12
UNIT 4	**Relativistic kinematics:** Relativistic kinematics of scattering and reactions. Elastic, inelastic reactions, decay of a particle A→B+C, A+B→C, P+ →P+ +P+ . **Relativistic quantum mechanics:** Klein Gordon equation, Plane-wave solutions, Negative energy. Equation of continuity. The difficulties of the Klein-Gordon equation. The Dirac equation: The free-particle Dirac equation in the Hamiltonian form. The algebra of Dirac matrices, Plane wave solutions of the free-particle equation, the two-component form of the solution in the Dirac-Pauli representation, standard normalization of the solutions. Non-relativistic reduction and g factor.	15

Text Books:

- Griffiths D.J., Introduction to quantum mechanics, 2nd Edition, Pearson, India, 2005.
- Shankar R., Principles of quantum mechanics, 2nd Edn., Plenum Press, New York, 1984.
- Sakurai J.J. and Tuan S.F. (Editor), Modern quantum mechanics, Addison Wesley, India, 1999.
- Sakurai J.J., Advanced quantum mechanics, Addison-Wesley, Harlow, England, 1999. Sons, New York, 1987.

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DEPARTMENT OF PHYSICS

DOMAIN SPECIFIC COURSE - 2

CONDENSED MATTER PHYSICS

Subject Code:PHYD02

Credits: 04 **Total Hours: 52**

Course Content / Syllabus:

UNIT No.	Content	Hours
UNIT 1	**X-ray crystallography:** Crystalline state, Reference axes, Equation of a plane, Miller indices. Symmetry operations, Two- and three-dimensional point groups. Lattices; two dimensional lattices, choice of unit cell. Three-dimensional lattices; crystal systems and Bravais lattices, Screw and glide operations. Space groups; analysis of the space group symbol. Diffraction of X-rays by crystals: Laue equations. Reciprocal lattice, Bragg equation. Equivalence of Laue and Bragg equations. Atomic scattering factor (qualitative). **Experimental techniques:** Brief introduction to single crystal and powder methods. **Electron and neutron diffraction:** Basic principles. Differences between them and X-ray diffraction. Applications (qualitative).	13
UNIT 2	**Crystal growth techniques:** Czochralski, Kyropoulus, Stockbarger-Bridgman and zone refining techniques. **Liquid crystals:** Morphology, The smectic (A-H), nematic and cholesteric phases. Birefringence, Texture and X-ray studies in these phases. Orientational order and its determination in the case of nematic liquid crystals. **Crystal lattice dynamics:** Lattice vibrations, concept of phonons and polarons, vibrations of an infinite one-dimensional monoatomic lattice, Vibration First Brillouin zone, Group velocity, Finite lattice and boundary conditions. Vibrations of a linear diatomic lattice, optical and acoustical branches; relation.	13
UNIT 3	**Magnetic properties of solids:** Diamagnetism and its origin, Expression for diamagnetic susceptibility, Paramagnetism, Quantum theory of paramagnetism, Brillouin function, Ferromagnetism, Curie-Weiss law, Spontaneous magnetisation and its variation with temperature, Ferromagnetic domains, Antiferromagnetism, Two sub-lattice model, Susceptibility below and above Neel's temperature. **Superconductivity:** Experimental facts, Type I and type II semiconductors, Phenomena logical theory, London equations, Meissner effect, High frequency behavior, Thermodynamics of superconductors, Entropy and Specific heat in the superconducting state. Qualitative ideas of the theory of superconductivity.	13
UNIT 4	**Semiconductors:** Intrinsic Semiconductors, Crystal structure and bonding,	13

	Expressions for carrier concentrations, Fermi energy, electrical conductivity and energy gap in the case of intrinsic semiconductors. Extrinsic Semiconductors; impurity states and ionization energy of donors, Carrier concentrations and their temperature variation, Qualitative explanation of the variation of Fermi energy with temperature and impurity concentration in the case of impurity semiconductors. **Semiconductor devices:** Brief discussion of the characteristics and applications of phototransistors, JFET, SCR and UJT.	

Text Books:

- Buerger M.J., Elementary crystallography, Academic Press, UK, 1956.
- Ladd M.F.C. and Palmer R.A., Structure determination by X-ray crystallography, Plenum Press, USA, 1977.
- Sherwood D., Crystals, X-rays and proteins, Longman, UK, 1976.
- Rose R.M., Shepard L.A. and Wulff J., The structure and properties of materials Vol. 4, Electronic properties, Wiley Eastern, 1965.
- Vainshtein B.K., Modern crystallography, Vol. I, Springer-Verlag, Germany, 1981.
- Gray G.W. and Goodby J.W.G., Smectic liquid crystals: Textures and structures, Leonard Hill, USA, 1984.
- Dekker A.J., Solid state physics, Prentice Hall, 1985.
- Kittel C., Introduction to solid state physics, 7th Edn., John Wiley, New York, 1996.

DEPARTMENT OF PHYSICS
DOMAIN SPECIFIC COURSE - 3
PHYSICS OF MATERIALS
Subject Code:PHYD03

Credits: 04 **Total Hours: 52**

Course Content / Syllabus:

UNIT No.	Content	Hours
UNIT 1	Crystal symmetry and crystal systems: translational vectors and lattices, unit ISPl, Miller indices, symmetry operations, reciprocal lattices, hexagonal close packed structure, NaCl, CsCl, diamondand ZnS structures, X-ray diffraction and Bragg's law, Powder diffraction, different types of bondingin crystals, Vandervaal's, ionic, covalent and hydrogen bonds.	
UNIT 2	Lattice vibrations: phonons, phonon spectra of monatomic and diatomic linear lattices, scatteringof phonons by neutrons, experimental techniques to get phonon spectra, lattice heat capacity, Einstein's Model, Debye's Model.	
UNIT 3	Band theory of solids: density of states, Fermi level, origin of bands, Bloch theorem, Kronig- Pennymodel, classification of materials based on band gap, electrical conduction in metals andsemiconductors, effect of doping on Fermi level in semiconductors, Material characterisationusingSEM, TEM and AFM.	
UNIT 4	Dielectric properties of solids: polarisability, local electric field of an atom,ferroelectric crystals, Clausius Mosotti relation, Lorentz – Lorenz formula, Curie-Weiss Law,magnetic properties of solids, dia, para and ferro magnetism, Langevin's theory of diamagnetismandparamagnetism,ferromagnetic domains, hysterisis, BH curve, adiabatic demagnetization	

Text Books:

1. Solid State Physics – C Kittel, 7 th edition, John Wiley (2004)
2. Introduction to Solids – Azaroff, Tata McGraw Hill (1977)
3. Text Book of Solid State Physics - S O Pillai, New age International (2002)
4. Problems in Solid State Physics - S O Pillai,New age International (2003)
5. Solid State Physics- A J Dekker, MacMillian India Ltd (2005)
6. Solid State Physics- M A Wahab,2nd edition,Narosa Publishing House Pvt. Ltd (2005)
7. Solid State Physics, N W Ashcroft, N David Mermin, Harcourt, (1976)

DEPARTMENT OF PHYSICS

DOMAIN SPECIFIC COURSE - 4

CHARACTERIZATION TECHNIQUES OF MATERIALS

Subject Code:PHYD04

Credits: 04 **Total Hours: 52**

Course Content / Syllabus:

UNIT No.	Content	Hours
UNIT 1	**Compositional characterization:** Elemental analysis, identification of different elements present in a sample. **Mass spectrometry:** Principles, instrumentation, different methods of ionization. EI, CI, FD and FAB, Soft ionization – ESI, APCI, APPI, MALDI. Mass spectra – molecular ion, base peak, meta-stable peak. **Microscopic analysis**: Theory of Electron Microscopy. Principle, working and instrumentation involved in SEM and STEM. Instrumentation and working of TEM. Difference between SEM and TEM.	14
UNIT 2	**AFM**- Principle, instrumentation and working. Application of Microscopic techniques-Morphology, Crystallization behavior, phase separation etc. **FT-IR**: Instrumentation, sample handling, modes of recording spectra-transmission mode, ATR mode, diffuse reflectance mode. Interpretation of spectra.	12
UNIT 3	**Thermal method of analysis:** Introduction, **Thermogravimetric analysis (TGA):** types of thermogravimetric analysis, principles. Factors affecting the results - heating rate, furnace, instrument control/ data handling. Applications - purity and thermal stability, evaluation of correct drying temperature, analysis of complex mixture and determination of kinetic parameters of thermal degradation.	12
UNIT 4	**Differential thermal analysis (DTA):** Theory - variables affecting the DTA curves. Differences between TGA and DTA. General principles. Instrumentation. Applications - analysis of the physical mixtures and thermal behaviour study. Determination of melting point, boiling point and decomposition point. **Differential scanning calorimetry (DSC):** Basic principle. Differences between DTA and DSC. Instrumentation - power compensated DSC, Heat flux DSC. Applications - studies of thermal transitions and isothermal crystallization. Pharmaceutical industry for testing the purity of the samples. Thermomechanical analysis. Dynamic mechanical analysis. **Enthalpimetric analysis:** Thermometric titrimetry and direct injection enthalpimetry -principle, instrumentation, applications.	14

Text Books:

❖ Brown M. E., Introduction to thermal analysis: Techniques and applications, Chapman and Hall, USA, 1988.

- Banwell C. N., and McCash E. M., Fundamentals of molecular spectroscopy, McGraw-Hill, New York, 1994.
- Gunther H., NMR spectroscopy: Basic principles, concepts and applications in chemistry, John Wiley and Sons, USA, 2013.
- Woodward L. A., Introduction to the theory of molecular vibrations and vibrational spectroscopy, Oxford University Press, UK, 1972.
- Perkampus H. H., UV-VIS spectroscopy and its applications, Springer Science and Business Media, 2013.

DEPARTMENT OF PHYSICS

DOMAIN SPECIFIC COURSE - 5

PHOTONICS

Subject Code:PHYD05

Credits: 04 **Total Hours: 52**

Course Content / Syllabus:

UNIT No.	Content	Hours
UNIT 1	Optical properties of semiconductors- Radiative and non-radiative recombination, bandtobandrecombination , exciton absorption, donor-acceptor and impurity band absorption, longwavelength absorption, Relation between absorption and emission –stokes shift inoptical transitions, near band gap transitions, Deep level transitions, Auger recombination	13
UNIT 2	Junction Theory-PN junction- current density across junctions, injection efficiency, Quasi-fermi level and high level injection, graded junctions-heterojunction, double heterojunctionquantumwell and quantum dots, superlattices Basics of all solid state lamps- LED materials and device configurations, efficiency, high brightnessLEDs , light extraction from LEDs, DBR, LED structures- SH, DH, SQW,MQW- device performancecharacteristics White solid state lamps-generation of white light and applications	13
UNIT 3	Opto-electronic detectors-Thermal detectors, Photoconductive detectors -junction photodoides, P-I-N photodetector- quantum efficiency and frequency response, Silicon photodiodes-performance characteristics APD-design issues and band width, Phototransistors, Modulated barrier photodiodes, Schottkybarrier PD, Metal Semiconductor photodetectors, MSM PD, Detectors for long wavelengthoperation, Microcavity PD Solar cells- I-V characteristics and spectral response, Materials and design considerations of solarcells	13
UNIT 4	Display devices- PL, EL, CL displays, displays based on LED , Plasma panel and LCD Optoelectronics modulation –Analog and Digital modulation, Optical hetrodyning and electro-opticmeasurements, fibre coupling, EO,AO, and MO based switching devices and modulators, SEED	13

Text Books:

1. Semiconductor optoelectronic devices- Pallab Bhattachraya, PHI, ISBN-978-81203-2047-5(2009)
2. Semiconductor optoelectronics- Jasprit singh, Tata Mc Graw Hill (1995)
3. Semiconductor physics and optoelectronics- V Rajendren,J Hemaletha, M.Stalin Maccolin, Vikas Publishers Delhi(2004), ISBN,81-259-1448-X
4. Light Emitting Diodes- E Fred Scheubert, Cambridge University Press , (2003)
5. Optoelectronic devices and systems – S C Gupta , PHI, (2005)

6. Solid state Electronic devices- Ben G Streetmann and Sanjay Banerjee,PHI(2003)5th Edition, ISBN-81-203-1840-4
7. Introduction to Semi conductor Materials and Devices- M S Thyagi, John Wiley Sons, NY, (2003)
8. Physics of semiconductor devices- S M Sze John Wiley Eastern 2 nd Edition, (2002)ISBN-9971-51-266-1

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DEPARTMENT OF PHYSICS

DOMAIN SPECIFIC COURSE - 6

SMART MATERIALS

Subject Code:PHYD06

Credits: 04 **Total Hours: 52**

Course Content / Syllabus:

UNIT No.	Content	Hours
UNIT 1	Introduction to Smart Materials, Principles of Piezoelectricty, Perovskyte Piezoceramic Materials, Single Crystals vs Polycrystalline Systems, Piezoelectric Polymers, Principles of Magnetostriction, Rare earth Magnetostrictive materials, Giant Magnetostriction and Magneto-resistance Effect, Introduction to Electro-active Materials, Electronic Materials, Electro-active Polymers, Ionic Polymer Matrix Composite (IPMC), Shape Memory Effect, Shape Memory Alloys, Shape Memory Polymers, Electro-rheological Fluids, Magneto Rhelological Fluids	13
UNIT 2	Piezeoelctric Strain Sensors, In-plane and Out-of Plane Sensing, Shear Sensing, Accelerometers, Effect of Electrode Pattern, Active Fibre Sensing, Magnetostrictive Sensing, Villari Effect, Matteuci Effect and Nagoka-Honda Effect, Magnetic Delay Line Sensing, Application of Smart Sensors for Structural Health Monitoring (SHM), System Identification using Smart Sensors.	13
UNIT 3	Modelling Piezoelectric Actuators, Amplified Piezo Actuation – Internal and External Amplifications, Magnetostrictive Actuation, Joule Effect, Wiedemann Effect, Magnetovolume Effect, Magnetostrictive Mini Actuators, IPMC and Polymeric Actuators, Shape Memory Actuators, Active Vibration Control, Active Shape Control, Passive Vibration Control, Hybrid Vibration Control	13
UNIT 4	Review of Composite Materials, Micro and Macro-mechanics, Modelling Laminated Composites based on Classical Laminated Plate Theory, Effect of Shear Deformation, Dynamics of Smart Composite Beam, Governing Equation of Motion, Finite Element Modelling of Smart Composite Beams Self-Sensing Piezoelectric Transducers, Energy Harvesting Materials, Autophagous Materials, SelfHealing Polymers, Intelligent System Design, Emergent System Design	13

Text Books:

1. Brian Culshaw, Smart Structures and Materials, Artech House, 2000
2. Gauenzi, P., Smart Structures, Wiley, 2009
3. Cady, W. G., Piezoelectricity, Dover Publication