Expected learning outcomes: *At the end of this course the students are expected to learn basic concepts of positional astronomy, astronomical techniques, telescope optics and instrument detectors. Students are also expected to gather knowledge on the formation of planetary system and its evolution with time, the physical properties of Sun and the components of the solar system with special reference to our Milky Way galaxy. On successful completion of this course, the students will also have the knowledge to understand the physical laws that enable us to know the origin and evolution of galaxies, presence of dark matter and large-scale structures of the Universe.*

Reference Books:

i. Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.

ii. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.

iii. Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.

iv. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.

v. The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University Science Books.

vi. Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer.

vii. Baidyanath Basu, 'An introduction to Astro physics', Second printing, Prentice -Hall of India Privatelimited, New Delhi, 2001.

viii. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.

PHYDSC453 (B)T

NANO SCIENCE & MATERIAL SCIENCE

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *This course introduces the essence of nano materials, their synthesis, and characterization. On successful completion of this course students should also be able to understand the various optical properties of nanomaterials along with few important applications of nano materials used in this technological era.*

Unit 1: Nanoscale systems

Introduction to Nanoscience: Emergence of Nanoscience with special reference to Feynman and Drexler, Length scales in physics, Role of particle size , Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods), surface effect, Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences.

(12 Lectures)

Unit 2: Synthesis of nanostructure materials

Top down and Bottom-up approach, Photolithography. Ball milling. Gas phase condensation. Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, E-beam evaporation, Pulsed Laser deposition. Chemical vapor deposition (CVD). Sol-Gel. Electro deposition. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods. MBE growth of quantum dots.

Basic Idea about Buckyballs, Carbon nano tubes, Graphene, Zeolites Porous Materials, Metal Nanocrystals, Semiconductor nanomaterials. **(13 Lectures)**

Unit 3: Characterization

X-Ray Diffraction. UV Visible spectroscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunneling Microscopy. Electron transport: Carrier transport in nanostructures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects.

(11 Lectures)

Unit 4: Optical properties:

Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures and charging of nanostructure. Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasi-particles and excitons, charging effects. Radiative Processes: General formalization-absorption, emission and luminescence. Optical properties of Nano materials. **(12 Lectures)**

Unit 5: Applications:

Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices, Surface Acoustic Wave (SAW), Sensor applications, Single electron transfer devices (no derivation). CNT based transistors.

Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots - magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS).

(12 Lectures)

Expected learning outcomes: *At the end of this course the students are expected to learn basic concepts of nano scale systems, Role of particle size, Nanostructures, Quantum confinement, Synthesis and characterization of nano materials along with applications of nanoparticles, quantum dots, nanowires and thin films and Nanomaterial Devices. On successful completion of this course, the students are expected to know the methods of creating many new materials and devices with a range of applications, such as nanoelectronics, biomaterials energy production and consumer products.*

Reference Books:

i. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).

ii. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company).

iii. K.K. Chattopadhyay and A.N. Banerjee, Introduction to Nanoscience & Technology (PHI Learning Private Limited).

iv. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).

v. M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook (Elsevier, 2007).

vi. Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.

vii. Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004).

viii. Guozhong Cao, Wang, Ying, Nanostructures And Nanomaterials: Synthesis, Properties, And Applications (2nd Edition) (World Scientific Series in Nanoscience and Nanotechnology), January 2011

ix. Sulabha K. Kulkarni, Nanotechnology: Principles and Practices, November 2014, Springer.

PHYDSC454T

ATOMIC AND MOLECULAR PHYSICS

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *This course introduces students to the basic physics of atoms, molecules, their spectra and the interaction of light with matter including the study of influence of electric and magnetic fields on atoms with the help of understanding Stark effect and Zeeman effect.*

Unit 1:

Review of atomic models and concepts, Hydrogen spectrum from the Bohr and Bohr-Sommerfeld theories, Variation of the Rydberg constant, Unquantized states and continuous spectra, Larmor's precession, Space quantization, Electron spin, Stern-Gerlach experiment. Magnetic moment of atom (one and two electrons system), Quantization of magnetic moment.

(12 Lectures)

Unit 2:

Excitation & Ionization potentials, Frank and Hertz experiment. Characteristics X-ray spectra, Moseley's law, Difference between continuous & characteristics X-ray spectra. Moseley's law. Effect of nuclear motion on atomic spectra. Reduced mass, modified Rydberg constant and wave number, Evidences in favour of Bohr's theory. Correspondence principle. Zeeman Effect and its Experimental arrangement. Anomalous Zeeman effect. Classical & quantum treatment of normal Zeeman Effect. **(12 Lectures)**

Unit 3:

Paschen-Back effect, Stark effect. Spin orbit coupling - LS and JJ coupling schemes. Spectral notations for atomic states. Lande Interval rule. Normal and inverted multiplets. Spectra of alkali