Syllabus for

PhD Course work

2021

Department of Physics

Rajiv Gandhi University

Rono Hills, Doimukh, Arunachal Pradesh

Preface

The development of science and technology in recent times has been accelerating in terms of surfacing many more diverse areas, the methodologies and to cope with the demand for better as well as future life style. To achieve the desired outcome, it is immensely felt that more fundamental as well as applied research are desirable in University education so that the scholars can find a wider scope of area in their Ph D research. A research scholar also must aware of the research ethics and methodology to carry out a good research to make him/her competent at any research platform for future work. Keeping in view the recent scenario in the field of R&D around the globe, UGC has emphasized Ph D course work under Choice Based Credit System (CBCS) through Learning Outcome Based Curriculum Framework (LOCF).

The Department of Physics, RGU thus made a revised course structure for Ph D program that to be effective from the session 2020-21. In the revised structure the students will find the adequate procedures for introducing themselves into the research activities and get due exposure to different area of research in the department. The course work structure contains two categories; core course and elective course. In core course there are two compulsory papers; Research methodology of credit 4 and Research and Publication Ethics of credit 2. The elective course comprises of two group; Open elective courses which are designed some of major areas of Physics, also relevant to other discipline, so the students from computer science, engineering and others can opt according to their need. The other group is discipline specific and the papers are assigned based on the ongoing research activities in the department. However a student may also go to SWAYAM platform (MOOC) in this group. The students may choose each from two groups with a total credit 6. Student have also the flexibility to register courses with a total credit 12 (minimum) and 16 credit (maximum) in the course structure. All the courses adopted by a scholar finally must be recommended by the respective Research Advisory Committee (RAC) of that scholar and dully approved by the Departmental Research Committee DRC).

The course work is designed such a way that each of research student can get the ample scope for systematic learning of research activities and smoothly carry forward his/her research according to his/her theme of research.

15/03/2021 15/3/2021

15/3/21

Content

- PhD course work in Physics
- Course structure and scheme of Examination
- Syllabus of core course
    - PHYC 601 Research Methodology
    - PHYC 602 Research and Publication Ethics
- Syllabus of Open Elective Courses
    - PHYOE 611 Astronomy and Astrophysics
    - PHYOE 612 Instrumentation: Data acquisition and Practice
    - PHYOE 613 Optoelectronics devices
    - PHYOE 614 Physics of Dielectrics
    - PHYOE 615 Physics of Magnetic material
- Syllabus of Discipline Specific Elective Courses
    - PHYDE 621 Astrophysics and Cosmology
    - PHYDE 622 Principle of surface science
    - PHYDE 623 Thin Films and Nanomaterials

Upamanyu D.

15/3/2021

15/03/21

15/03/21

PhD course work in Physics

Introduction:

The PhD program in the department admits students with master's degree in physics into research. The student admitted into this program under go one semester course work related to research methodology, research ethics and advanced topics relevant to their research work. Student have the fixability to choose course related to their interested research area. The course work enables them to grasp the research methodology and understand the basics of the advanced techniques to be used in their research work. The course work enables them to identify and apply appropriate research methodology in order to plan, conduct and evaluate basic research. The Course will enable scholars to develop the foundation for research skills at appropriate levels.

Course Structure

In PhD course work of Physics comprises of two categories of courses core and elective courses. A scholar has the choice to register a number of courses with minimum 12 and maximum of 16 credits form the various courses offered by the university as par the guidelines.

(a) **Core course:** A core course is a compulsory paper to be studied by all the scholars to complete the requirements Ph.D. degree. There are two such compulsory course one on Research Methodology of 4 credits and other on Research Ethics of 2 credits.

(b) **Elective course:** There are two sets of electives in the PhD Course work and Student has the choice to choose one elective from each set, minimum two courses of total 6 credit as par recommendation of RAC.

(i) **Open Elective course:** The scholar has to opted for at least one open elective course offered by the physics department or form the any other departments under the Faculty of Basic Sciences, Life Sciences, Computer Science and Engineering and Information & Technology.

(ii) **Discipline Specific Elective Courses:**

It shall be supportive to the discipline of study, providing an expanded scope, enabling an exposure to some other discipline/domain, and nurturing research scholar's proficiency/skill. The scholar has to opted for at least one form the set of course of minimum 4 credit. However, he/she has the option to register for a course form the SWAYAM platform (MOOC) instead of the courses offered by the department as par recommendation of RAC.

Course Structure of PhD Course-work (Physics)

Courses			Credits				Maximum Marks	
			L	T	P	Total	Internal Assessment	Terminal Examination
Core courses	PHYC 601	Research Methodology	3	1	0	4	20	80
	PHYC 602	Research and Publication Ethics	1	0	1	2	25	25
Open Elective Courses	PHYOE 611	Astronomy and Astrophysics	2	0	0	2	10	40
	PHYOE 612	Instrumentation: Data acquisition and Practice	2	0	0	2	10	40
	PHYOE 613	Optoelectronics devices	2	0	0	2	10	40
	PHYOE 614	Physics of Dielectrics	2	0	0	2	10	40
	PHYOE 615	Physics of Magnetic material	2	0	0	2	10	40
Discipline Specific Elective Courses	PHYDE 621	Astrophysics and Cosmology	3	1	0	4	20	80
	PHYDE 622	Principle of surface science	3	1	0	4	20	80
	PHYDE 623	Thin Films and Nanomaterials	3	1	0	4	20	80
	PHYDE** $690x$	Massive Open Online Course (MOOC) from SWAYAM platform				4	As decided by Course coordinator	

** The course code of MOOC courses will have the format PHYDE $690x$ where x stands for 1,2,3.......... and decided by the RAC.

PHYC-601: Research methodology and Computational Techniques (3:1:0)

Course Description:

The course will give a view of roadmaps of research from the beginning to the end and their intricacies and inform and equip the scholars with essential knowledgebase and infrastructures for conducting research before landing up in the field.

Learning Outcome:

After completion of the course a scholar will learn how to plan research objectives and to communicate research findings, about – research procedure, necessary statistical tools, data and information resources, research utilities, good laboratory practices, ethical aspects of research.

Basics of scientific research: Definition of Research, Characteristics, types, needs of research, qualities of Researcher, Components of a Research Problem, Difference between Methods of Research & Research Methodology. Motivation for Research, Research approaches and Related Tools, Conditions and criteria for good research. Various Steps in Scientific Research: Hypotheses, Research Purposes, Research Design, Literature survey, sources of information, review. Objectivity, Ethical issues and intellectual property rights, Patent laws, process of patenting a research finding, Copy right,

Developing a research plan and Literature survey: Aims and Objectives, information required for solving the problem, defining each major concept in operational terms: an overall description of approach, clearly stating any assumptions; details of techniques. Expected outcome, Methodology to be adapted, planning of experiments for achieving the aims and objectives, reproducibility of research work. Literature survey of the previous works Review of an article in the relevant field and preparation of a short report References, Abstraction of a research paper, possible ways of getting oneself abreast of current literature.

Research report and Presentation: Art of scientific writing: Steps to better writing, flow method, organization of material and style, Structure and Components of Research Report, Types of Report: research papers, thesis. Research Project Reports, drawing figures, graphs, tables, footnotes, references etc. in a research paper. Writing of research report and synopsis (steps involved), paper writing (steps involved), review writing, report preparation, publication process, selection of journals, citation index, impact factor, h-index. Presenting a paper in scientific seminar (oral/poster) development of communication skills in presentation of scientific seminars- eye to eye contact, facing to audience, question & answer sessions etc. Introduction to patent laws, patent of research wrok.

Computational Techniques in Research: Computer fundamental- word processing, spreadsheet and database software. Use of internet and internet networks in research activities - Literature survey, handling search engines, paper downloading, Email, relevant websites for journals and arXives, Accessing research databases (SciFinder, Scopus, Cambridge Structural Database (CSD), SPIRES database, Cyber laws. Introduction to various software packages and script languages for data analysis.

Books:

1. *Research Methodology: Methods and Techniques by C.R. Kothari and Gaurav Garg*
2. *Research Methodology and Techniques in Physics by Anil Kumar Singh*

PHYC 602: Research and Publication Ethics (1:0:1)

Course Description:

This course focus on basics of philosophy of science and ethics, research integrity, publication ethics. Hands on sessions are designed to identify research misconduct and predatory publications. Indexing and citation databases, open access publications, research and p metrics and plagiarism tools introduced in the course.

Learning Outcome:

Theory

RPE 01: PHILOSOPHY AND ETHICS (3hrs)

1. Introduction to Philosophy: definition, nature and scope, concept, branches
2. Ethics: Definition, moral philosophy, nature of moral judgements and reactions.

RPE 02: SCIENTIFIC CONDUCT (5hrs.) 1.

1. Ethics with respect to science and research
2. Intellectual honesty and research integrity
3. Scientific misconducts: Falsification, Fabrication and Plagiarism (FFP)
4. Redundant publications: duplicate and overlapping publications, salami slicing
5. Selective reporting and misrepresentation of data

RPE 03: PUBLICATION ETHICS (7 hrs.)

1. Publication ethics: definition, introduction and importance
2. Best practices/standards setting initiatives and guidelines: COPE, WAME etc.
3. Conflicts of interest 4. Publication misconduct: Definition, concept, problems that lead to unethical behaviour and vice versa, types
5. Violation of publication ethics, authorship and contributorship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

Practice

RPE 04: OPEN ACCESS PUBLISHING (4hrs.)

1. Open access publications and initiatives
2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies
3. Software tool to identify predatory publications developed by SPPU
4. Journal finder/journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

RPE05: PUBLICATION MISCONDUCT (4 hrs.)

A. Group Discussions (2 hrs.)
  1. Subject specific ethical issues, FFP, authorship
  2. Conflicts of interest
  3. Complaints and appeals: examples and fraud from India and abroad

B. Software tools (2 hrs.)
  1. Use of plagiarism software like Turnitin, Urkund and other open source software tools

RPE 06: DATABASES AND RESEARCH METRICS (7 hrs.)

A. Databases (4hrs.)
  1. Indexing databases
  2. Citation databases: Web of Science, Scopus etc.

B. Research Metrics (3hrs.)
  1. Impact factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score
  2. Metrics: h-index, g index,i10 index, altmetrics

BOOKS:

1. The Ethics of Teaching and Scientific Research By Miro Todorovich; Paul Kurtz; Sidney Hook
2.Research Ethics: A Psychological Approach By Barbara H. Stanley; Joan E. Sieber; Gary B. Melton
3. Ethics and Values in Industrial-Organizational Psychology By Joel LefkowitzLawrence Erlbaum Associates, 2003.
4. Research Methods in Applied Settings: An Integrated Approach to Design and Analysis By Jeffrey A. Gliner; George A. Morgan Lawrence Erlbaum Associates, 2000

PHYOE 611: Astronomy and Astrophysics (2:0:0)

Course Description: This course consists of mainly stellar formation and observational tools of celestial objects. This is so designed so as to impart some concepts of astronomy and astrophysics which can be needed in advanced research levels and to make learners comfortable in observational data analysis and work as well.

Learning Outcome: At the end of this course, something about stellar structure and evolution can be known. The concept of observational tools for studying stars, galaxy structure & formation can be achieved.

1. **Stellar evolution:** Interstellar dust and gas, formation of protostars, Pre and post-main sequence evolution, evolution on the main sequence, late stages of evolution, fate of massive stars, supernovae, Stellar interiors-hydrostatic equilibrium, pressure equation of state, energy sources, energy transport and convection, Binary stars-classification, mass determination, accretion disks in close binaries, white dwarfs, neutron stars, and black holes in binaries; degenerate remnants of stars-white dwarfs, Chandrasekhar limit, neutron stars, pulsars.
2. **Observational tools:** Black body radiation, specific intensity and flux density, stellar parallax, magnitudes, colour index, atoms and ions and their spectral signatures, atomic spectral lines and Kirchhoff's laws, basic optics and optical telescopes, radio telescopes, Infrared, ultraviolet and X-ray telescopes, Partial coherence-aperture synthesis and image reconstruction-high angular resolution techniques and astrometry-databases in astronomy.

Books:

1. Text Book on Astronomy and Astrophysics with Elements of cosmology, V B Bhatia, Narosa.
2. Physical Universe, Frank Shu
3. Text book of Spherical Astronomy, W.M.Smart.
4. Astronomy: From the Earth to the Universe (Sixth Edition), Jay M. Pasachoff.
5. Astrophysics: Stars and Galaxies, K.D.Abhyankar, Tata McGraw Hill Publication.
6. Astrophysics, K.S Krishnaswamy , CUP.
7. Astrophysics, BaidyanathBasu, Prentical Hall.
8. Astrophysics, KD Abhankar, Orient Longman.
9. Text Book on Astronomy and Astrophysics with elements of cosmology, V.B.Bhatia,Narosa

PHYOE-612: Instrumentation: Data acquisition and Practice (2:0:0)

Course objectives: To introduce the concept of acquisition and analysis the scientific data.

Learning Outcome:

Explain the analysis of the scientific data after acquisition

Theory:

Spectrometry: Introduction to atomic absorption spectrometer, emission spectrometer UV-visual spectrometer, infrared spectrometer, TCSPC system, excitation sources: arc and spark, Nuclear magnetic resonance spectrometer, Mass spectrometry, biomedical applications of spectrometry.

X-ray Analytical Methods: Introduction to X-ray spectral analysis, Fluorescence X-ray spectrometer Wavelength dispersive devices, Energy dispersive devices, Detectors, X-ray diffractometer, X ray absorption spectrometer, Applications of X ray analytical methods in biomedical, industrial applications.

Potentiometry: Potential and standard potential, ion selective electrode, Glass electrode, sensing electrode. Application of potentiometry.

Practice:

1. Analog and digital data acquisition through Transducers
2. Measurement of band gap through spectroscopy techniques
3. Analysis of X-rays diffraction pattern and EDAX
4. Use of interactive scientific graphing data analysis tool i.e Originlab.

PHYOE-613: Optoelectronics devices: (2:0:0)

Catalogue Description: This course provides a complete overview of the wide variety of different semiconductor optoelectronic devices employed in light wave systems and networks. Topics include a variety of different subjects including a detailed discussion of the design and operation and basic physics of optoelectronic devices.

Learning Outcome: The student can acquire fundamental understanding of the basic physics behind optoelectronic devices which can help them in further research in optoelectronic properties of materials

Optical processes in semiconductors- Absorption, charge separation and Recombination kinetics; PN junction, quasi Fermi levels and high-level injection, graded junction, Heterojunctions and Superlattices; Light dependent resistor, photodiode, photodetectors, phototransistor, solar cell, light emitting diode and their characteristics; charged coupled devices, Principle of Laser diode;

Organic Semiconductor: Conducting polymers- concept of solitons, polarons, biolarons, doping in conducting polymers, common conducting polymers, properties and applications of conducting polymers, PLED, sensors actuators. Polymer organic semiconductor, electrical and optical properties of organic semiconductors, organic light emitting diodes (OLED) , way to perceive colors, conventional, transparent, inverted and flexible OLEDs, Hole injection, hole transport, emissive, electron transport and electron injection layers organic LEDs, organic thin films transistors (OTFT), OTFT based display technology, organic laser-Lasing process, optically pumped lasing structures, applications; Organic multilayer, photodetectors; organic photovoltaic cells;

Books:

1. *Semiconductor Optoelectronic device*- Pallav Bhattacharya, Pearson (2017)

2. Organic Optoelectronics- Edited by Wenping Hu, Wiley- VCH (2013)

PHYOE-614: Physics of Dielectrics (2:0:0)

Catalogue Description:

The course is devoted to the study of dielectric polarization and relaxation phenomena in condensed matter. A basic theory of dielectrics is given. Different experimental technique of dielectric spectroscopy is presented. The application of dielectric spectroscopy to different systems is considered.

Learning Outcome:

Acquiring of knowledge concerning the electrical behavior of dielectric materials (polar and nonpolar). Understanding the field changes induced by dielectrics. Familiarize with the description of real dielectrics by the complex method. Knowledge about the experimental investigation methods of dielectrics.

Introduction into the physics of dielectrics: Polarization and dielectric constant. Types of polarization. Dipole moments and electrostatic problems. Polarizability. Polarization and energy. Internal field Langeven function. Non-polar dielectrics. Lorentz's field. Clausius-Massotti formula. Reaction field. Polarization in gases, Debye's Theories, Polar molecules in nonpolar solvent. Onsager's theory. The dielectric properties of polar non-associative liquids. Kirkwood-Frelich's theory, the dipole-dipole interaction, the correlation factor of Kirkwood. The static dielectric permittivity of strong polar associative liquids. The modern theories of the static dielectric permittivity (Böttcher, Nienhuis and Deutch, Ramshaw, Wertheim etc). The theory of linear response. The time dependent fields. The dielectric response function. The dielectric relaxation theory. Frequency and Time Domain. The complex dielectric permittivity. Dielectric losses and dispersion. The distribution functions of the relaxation times.. The dipole correlation function. Models of dielectric relaxation.

Dielectric Spectroscopy. Classification of the experimental methods. Frequency methods: Bridges, Resonance methods, Coaxial lines, Waveguides, Transient methods, Strip lines, Slot lines, etc. Broad Band Dielectric Spectroscopy. A frequency response analyzer (10-5 Hz - 106 Hz), automatic radio - frequency bridge (10 Hz - 107 Hz) coaxial line reflectometer (106 Hz - 109 Hz) and coaxial vector network analyzer (107 Hz - 1011 Hz). Time Domain Dielectric Spectroscopy. The single reflection and transition methods. Multiple reflection, transition, lumped capacitance methods. Nonuniform sampling. Furier transform and the time domain treatment. The applications of dielectric spectroscopy. Pure liquids and Solutions. Glass forming liquids. Dielectric relaxation of water. Dielectric relaxation of ice.

Books:

1. Theory of Dielectrics by Frolich,
2. Dielectrics and Waves and Dielectric Materials and Aplications and by Von Hippel.
3. Polar dielectric materials and application by J.C. Burfoot and Taylor

PHYOE-615: Physics of Magnetic material (2:0:0)

Catalogue Description: This course will provide students with the fundamental knowledge in the field of magnetism and magnetic materials

Learning Outcome:

At the end of the course, the student will be able to explain fundamental concepts of magnetism; apply those concepts to understand the nature of magnetic behavior of various materials; propose methods for characterization of magnetic materials; discuss various applications of magnetic materials in cutting edge technologies and devices

Physics of Magnetism : Quantum theory of magnetism, Landau diamagnetism, magnetism in rare-earth and iron group atoms, Van-Vleck Paramagnetism and Pauli paramagnetism, temperature dependence of magnetic materials, Heisenberg exchange interaction in ferromagnetic material, magnetic domains –magnetostatic energy, magnetostrictive energy, Neel and Bloch wall, Bloch T3/2 law, Neel model of antiferromagnetism and ferrimagnetism. magnetic anisotropy and magnetostatic interactions- direct, exchange, indirect exchange and itinerant exchange, spin waves - magnons, measurement of magnon spectrum, magnetic resonance and crystal field theory, Jahn-Teller effect, pinning effects, Kondo effect, spin glass, solitons

Magnetic materials and applications: Soft Magnetic Materials: Preparation, structure, electrical, magnetic, magneto-optical properties and applications of ferrites, garnets, permalloy and super-permalloy Hard magnetic materials: Properties and applications of hard ferrites, Nd-Fe-B alloy, Al-N-iCo alloys, rare earth-Co alloys. Magnetic recording: Materials used and their applications. CMR Materials: their properties and applications. Nano-magnetic material: Superparamagnetsm, spintronics, spin valve, Giant magnetoresistance, MR ratios, applications in spin valve and read heads, comparison of GMR and AMR, oscillation of coupling energy, non-coupling type GMR, CPP and CIP GMR, GMR in nano-grains, mechanism of GMR. Tunnel magnetoresistance: ferromagnetic tunnel junctions, experiments for TMR, phenomenological theory of TMR, MR ratio and spin polarization, factors influencing TMR, MR ratio for Fe/MgO/ Fe system, oscillations in TMR, tunnel junctions with manganites, Heusler alloys, nanoscale graunules, Coulomb blockade in tunnel junctions, ballistic magneto resistance

BOOKS:

1. Introduction to Magnetism and Magnetic Materials, Darel Jiles.
2. Introduction to Magnetism Materials, Luting.
3. Solid State Physic C. Kittel.
4. *Modern Magnetic Materials, Principles and Applications.* R. C. O'Handley,
5. *Introduction to Magnetism and Magnetic Materials by* D. C Jiles,.
6. . *Introduction to Magnetic Materials.* By B. Cullity,

PHYDE-621: Astrophysics and Cosmology (3:1:0)

Course Description: The courses are designed, emphasizing the aspects which are directly relevant to Astrophysics and Cosmology which is with a healthy mix of theoretical, observational and experimental studies. The study of the physical processes that govern the behaviour of astronomical objects is done, and the study of the origin, evolution, composition, and fate of the Universe as a whole is further explored. This course covers a wide range of concepts needed for research from the reviews of Theory of Relativity to Cosmology through Galaxies, electrodynamics and radiative processes.

Learning Outcome: At the end of this course, Students can attempt scientific problems and present results in the research area of Astrophysics and Cosmology through Galaxies, radiative processes in astrophysical systems

Theory of relativity: Principles of special and general relativities, their consequences, Geodesic curves, covariant derivatives-its manipulation and consequences; Curvature tensor, gravitational and matter action, Gravitational field equations; Einstein's equations as a thermodynamic identity; Gravitational entropy and the boundary term in the action, Concept of black hole and entropy.

Cosmology: Cosmological principle, Robert Walker metric, Einstein equation and standard models-closed, flat, open universe, Age of the universe, critical density and problems of missing mass or light, Kinematics and dynamics of the Friedman model-measures of distance and distribution functions for particles and photons; Brief thermal history of the universe; helium formation, decoupling of matter and radiation, microwave background radiation.

Galaxies and the Universe: The Galaxy- Hubble's law, kinematics- Hubble's classification scheme for external galaxies- spirals and elliptical –irregulars and AGNs-Quasi-stellar objects-Unified Model-Gamma Ray burst; Normal Galaxies, Modern classification scheme for external galaxies, Distances, Big Bang and steady state theory of the origin of universe, The present epoch and evolution of universe.

Electrodynamics and radiative processes: Maxwell's equations & Electromagnetic waves-Polarization and geometrical optics, Radiation of electromagnetic waves-Scattering of radiation (Thomson and Compton)-Bremsstrahlung and synchrotron radiation; Hydrostatic equilibrium in fluid, with applications to self-gravitating bodies-Instabilities-Accretion and winds-Shocks–Turbulence, MHD-Dynamos-Radiative processes in astrophysical systems, Moments of radiative transfer equations and simple approximate solutions.

Books:

1. *Introduction to cosmology, J V Narlikar, CUP.*
2. *General relativity and cosmology, J V Narlikar, Mcmmillan.*
3. *Text Book on Astronomy and Astrophysics with Elements of cosmology, V B Bhatia, Narosa.*
4. *Cosmology by Steven Weinberg (Oxford University, 2008)*
5. *Physical Universe, Frank Shu*
6. *Text book of Spherical Astronomy, W.M. Smart.*
7. *Astronomy: From the Earth to the Universe (Sixth Edition), Jay M. Pasachoff.*
8. *Astrophysics: Stars and Galaxies, K.D. Abhyankar, Tata McGraw Hill Publication.*
9. *Astrophysics, K.S Krishnaswamy, CUP.*
10. *Astrophysics, BaidyanathBasu, Prentical Hall.*
11. *Astrophysics, KD Abhankar, Orient Longman.*
12. *Text Book on Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia,Narosa.*

PHYD-622: Principle of surface science (3:1:0)

Course Description: The purpose of the course is to acquaint students in physics, chemistry, materials science with the static and dynamic behavior of clean and adsorbate-covered solid surfaces as well as solid-solid and solid-liquid interfaces.

Learning Outcome

The scholar will be acquired the knowledge of phenomenon at the interfaces to explain their experimental data. The research data can be explained scientifically at fundamental level.

1. Surfaces and Interfaces:

Structure of Surfaces, Thermodynamics of surfaces, Dynamics at surfaces, Physico-chemical properties of surfaces, Physical processes at interfaces, micelles, Reverse micelles, Microemulsions. Structure and properties of surface-active molecules.

2. Surface properties:

Surface tension, contact angle, Wetting of solid surfaces, Experimental techniques for characterization of surfaces, Attractive forces at interfaces, van der Waal's forces, Flocculation, Adhesion, Electrostatic forces between interfaces, Electrical double layers, zeta potential

3. Self-assembly of nano-structures:

Biological systems and forces responsible for self-assembly, Molecular recognition and attachment of subunits of nano-systems, self-assembly in chemical systems, Langmuir Blodgett film.

4. Thin liquid films

Physics, the theory and role of interfacial rheological properties, Introduction to monolayers, Foams, antifoams and emulsions. de-emulsification, multiple emulsions, liposomes, vesicles, liquid crystalline phase in water oil system

Books:

1. *Physical Chemistry of Surfaces by A W Adamson.*
2. *Colloid and Surface Chemistry by Duncan J Shaw*

Upamanyu

15/3/2021

15/03/21

15/3/21

PHYD-623: Thin Films and Nanomaterials (3:1:0)

Catalogue Description: This paper is designed to expose the students in the field of Thin film science and Nano-optoelectronics. Deposition technology of thin film and their properties, nanomaterials, their characterization techniques and feature trend of optoelectronic application has been discussed.

Learning Outcome: The students can learn the silent features of thin films and their importance in optoelectronic device technology. Knowledge on nanomaterials will enable them to use of nanostructured films in development of new generation optoelectronic devices. Recent trend for fabrication of devices at nanoscale is of considerable interest in research community

Physics of Thin Films: Thin and thick films; Deposition technology- Thermal evaporation, Flash evaporation, Sputtering, Chemical deposition; Multiple beam interferometry- Tolansky method for thickness measurement; Nucleation, Thin film growth and structure, substrate effect, epitaxy; Defects in thin films- grain boundary, stacking fault, dislocation, twinning; Surface states and interfacial effect; Defects and energy states; Conduction in metallic and semiconductor film, size effect, activation energy, grain boundary effect, conduction mechanism- Richardson-Schottky, Pool-Frenkel, SCLC; Photoconductivity and photovoltaic effect in Thin films.

Nanomaterials: Quantum confinement and Electronic structure, Metallic and Non- metallic nanostructures, surface plasmon resonance, Exciton Bohr radius; Carbon based nanomaterial (Fullerene, Carbon nanotubes, graphene etc); Magnetic Nanomaterials-DMS, Optical properties-band gap engineering, Photoluminescence, electroluminescence, thermoluminescence; Quantum Transport in nanostructures-Ballistic transport, Coulomb blockade, SET; Memristor Characteristics, Molecular electronics; Kondo effect in nanostructures.

Synthesis of nanomaterials: Various synthesis process, lithography, Ball milling, Atom manipulation by SPM, Microcontact printing, Ion beam deposition, chemical bath deposition, SILAR, self-assembled mono layers, Molecular beam epitaxy, chemical vapor deposition (CVD) based techniques, pulsed laser deposition, ion beam assisted techniques including embedded nanoparticles, RF sputtering

Characterization of Nanomaterials: Different Characterization techniques, Principle of characterization techniques- X-Ray diffraction (XRD, XRF, XPS), Electron Microscopy (SEM, TEM, HRTEM), Scanning probe microscopy (AFM, MFM, STM), UV-Vis, spectroscopy and its applications. FT-IR spectroscopy, Luminescence spectroscopy techniques- steady state and time resolved luminesce spectroscopy Raman spectroscopy, Thermal analysis using DTA, TGA, DSC; Current -Voltage measurement techniques– two probe and four probe methods.

Books:

1. *An introduction to physics and technology of thin films* - Alfred Wagendristel, Yuming Wang, World Scintific
2. *Advanced characterization of thin film solar cells*- Edited by Mowafak Al-Jassim and Nancy Haegel ,
3. The Institution of Engineering and Technology, London, United Kingdom (2020)
4. *Semiconductor Nanostructures*-Thomas Ihn, Oxford University Press (2010)

15/3/21 15/3/2021 15/03/21