DEPARTMENT OF NANOSCIENCE AND NANOTECHNOLOGY

UNIVERSITY OF KERALA

M.PHIL PROGRAMME IN NANOSCIENCE AND NANOTECHNOLOGY

SYLLABUS

Under Credit and Semester System w.e.f 2016 admissions

DEPARTMENT OF NANOSCIENCE AND NANOTECHNOLOGY

UNIVERSITY OF KERALA

M.PHIL PROGRAMME IN NANOSCIENCE AND NANOTECHNOLOGY

Programme Objectives

- To introduce students to areas of creative thinking and critical reasoning which are relevant to his/her research and to introduce the students to the current research issues and processes.
- The programme will consist of lectures and related activities that will help in developing good understanding of methods of research process and management
- To provide students knowledge in the field of Nanoscience and Nanotechnology and Nanobiology
- The programme will consist of lectures and related activities that will help the students to understand the characterization techniques to analyze the nanomaterials.
- To provide students knowledge in the field of Nanoscience and current trends in the field of Nanotechnology.
- The programme will consist of lectures and related activities that will help the students to understand emerging technologies in the field of Nanoscience and Nanotechnology

Structure of the Programme

Semester No.	Course code	Name of the Course	No.of Credits
I	NST-711	Research Methodology	4
	NST-712	Nanomaterials and Nanoscience	4
	NST-713	Advance Nanomaterials and Nanotechnology	4
II	NST-721	Dissertation	20
		Total Credits	32

Semester : I
Course Code : NST- 711
Course title : RESEARCH METHODOLOGY
Credits : 4

Aim : To introduce students to areas of creative thinking and critical reasoning which are relevant to his/her research and to introduce the students to the current research issues and processes.

Objectives : The course will consist of lectures and related activities that will help in developing good understanding of methods of research process and management.

Module I : OBJECTIVES AND TYPES OF RESEARCH

Meaning of research – Motivation and objectives – Research methods vs. Methodology. Types of research – Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical.

Research formulation

Defining and formulating the research problem - Selecting the problem - Necessity of defining the problem - Formulation of a working hypothesis - Importance of literature review in defining a problem – Literature review – Primary and secondary sources – Reviews, treatise, monographs-patents – web as a source – Searching the web and information mining - Critical literature review – Identifying gap areas from literature review.

Module II : RESEARCH DESIGN, METHODS

Research design – Basic Principles- Need of research design – Features of good design – Important concepts relating to research design – Observation and facts, laws and theories. Prediction and explanation, induction, deduction - Development of models - Developing a research plan - Exploration, Description, Diagnosis - Experimentation - Determining experimental and sample design.

Data collection and analysis

Execution of the research - Observation and Collection of experimental data. Methods of data collection - Sampling Methods - Sampling techniques, steps in sampling, sampling size, advantages and limitations of sampling - Data Processing and Analysis strategies - Data Analysis with Statistical Packages - Hypothesis-testing - Generalization and Interpretation.

Module III : REPORTING AND THESIS WRITING

Structure and components of scientific reports - Types of report – Technical reports and thesis – Significance – Different steps in the preparation – Layout, structure and Language of typical reports – Data presentation – Illustrations, graphics, tables, histograms and pi diagrams - Bibliography, referencing and footnotes – Oral and poster presentation – Planning – Preparation – Practice – Making presentation – Use of visual aids.

Module IV : RESEARCH ETHICS

Environmental impacts - Ethical issues - Ethical Committees - Commercialisation – Copy right - royalty - Intellectual property rights and patent law – Trade Related aspects of Intellectual Property Rights - Reproduction of published material-Plagiarism - Citation and acknowledgement - Reproducibility and accountability.

Module V : ERRORS AND UNCERTAINTIES IN MEASUREMENTS

Introduction to Errors and uncertainties in the measurement - Performance parameters of instrument - Propagation of uncertainties in compound quantities - curve fitting, regression and correlation.

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ADDITIONAL REFERENCES

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Semester : I
Course Code : NST- 712
Course title : NANOMATERIALS AND NANOSCIENCE
Credits : 4

Aim : To provide students knowledge in the field of Nanoscience and nanotechnology.

Objectives : The course will consist of lectures and related activities that will help the students to understand the characterization techniques to analyze the nanomaterials.

Module I : INTRODUCTION TO NANOMATERIALS

Zero-dimensional, one-dimensional and two-dimensional nanostructures, size dependent properties – specific heat and melting point- mechanical properties – super plasticity - plastic deformation of ceramics - nanoceramics - catalytic properties.

Synthesis of nanomaterials - bottom-up and top-down approaches - nanoparticles - colloidal technique - homogeneous and heterogeneous nucleation - synthesis of metallic and semiconductor nanoparticles - stabilization of nanoparticles - sonochemical method - synthesis and properties of core-shell nanoparticles.

Nanowires and nanorods - spontaneous growth - vapour-liquid-solid growth – template-based synthesis - nanostructured films - Langmuir-Blodgett films - electrochemical deposition.

Nanobiology - Overview of cell structure and biomacromolecules - chemical building block of cells – Nanobiotechnology – Introduction - learning from nature - Engineered nanoparticles and biomedical applications.

Module II : EXPERIMENTAL TECHNIQUES

Principle, working and interpretation of results of – XRD – XPS - AES – EDS - SEM - STM – AFM – TEM - HRTEM - BET surface area and porosimetry - UV-Vis - Photoluminescence - FTIR and Raman spectroscopy - Thermal analysis – TGA, DTA and DSC.

Module III : QUANTUM CONFINED SYSTEMS

Quantum confinement and its consequences – idealized quantum wells - idealized quantum wires - cubic quantum dots – artificial atoms – electron states from bulk to quantum dots - semiconductor nanoparticles – size quantization effects – electron states in direct gap semiconductors – indirect semiconductors - strong and weak confinement – hole states in silicon nanoparticles - Optical characterization of semiconductor quantum dots - applications of semiconductor quantum dots.

Manifestation of quantum confinement – superlattices - quantum–confined structures as lasing media – plasmonics – metallic nanoparticles and nanorods – metallic nano-shells - plasmonic waveguiding – photonic crystals – basic concepts – theoretical modeling of photonic crystals – features of photonic crystals.

Module IV : ELECTRICAL PROPERTIES

Quantum transport in nanostructures – single electron tunneling - Coulomb blockade – single electron transistor - Electronic devices based on nanostructures – MODFETs – heterojunction bipolar transistors – resonant tunnel effect – hot electron transistors – resonant tunneling transistor.

Spintronics - Diffuse spin dependent transport – spin dependent scattering – giant magneto resistance (GMR) and colossal magneto resistance (CMR) materials – ballistic spin transport.

Module V : MAGNETIC PROPERTIES

Nanoscale magnetism – single domain particles – coercivity of small particles - exchange coupling – oscillatory exchange coupling - hysteresis – superparamagnetism- spin glass - soft magnets - hard magnets – VSM – SQUID - FC and ZFC measurements.

REFERENCES

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Semester : I
Course Code : NST- 713
Course title : ADVANCE NANOMATERIALS AND NANOTECHNOLOGY
Credits : 4

Aim : To provide students knowledge in the field of Nanoscience and nanotechnology and current trends in the field of nanotechnology.

Objectives : The course will consist of lectures and related activities that will help the students to understand emerging technologies in the field of nanotechnology.

Module I : NANOSTRUCTURED FILMS Synthesis - physical vapour deposition (PVD) – molecular beam epitaxy (MBE) - DC/RF magnetron sputtering - chemical vapour deposition (CVD) – progress and challenges of photovoltaic applications of silicon nanocrystalline materials - sol-gel technique – sol-gel films – properties and applications of sol-gel derived nanostructured thin films.

Electrodeposition of semiconductor quantum dot films – electrodeposition of thick films of semiconductors from DMSO – ultrathin films and isolated nanocrystal deposition – electronic characterization of electrodeposited semiconductor nanparticle films.

Module II : NANOLITHOGRAPHY

Nanostructures fabricated by physical techniques – lithography – photo, electron beam, X-ray, ion beam, and AFM and STM based lithography – nanolithography – soft lithography – microcontact printing – dip-pen nanolithography – assembly of nanostructures - self-assembly - molecular self-assembly in solutions – self assembly of nanoparticles.

Module III : PHOTOCHEMISTRY AND ELECTROCHEMISTRY OF NANO-ASSEMBLIES

Photoinduced charge transfer processes in semiconductor nanoparticles systems – photoinduced transformations of metal nanoparticles – electrochemistry of semiconductor nanostructures – nanostructured metal oxide films – nanostructured oxide films modified with dyes and redox chromophores - electrochemistry of metal nanostructures – semiconductor-metal nanocomposites – nanoelectrode ensembles – charge transport in nanostructured thin film electrodes - intensity modulated photocurrent and photovoltage spectroscopy – basic ideas of dye sensitized solar cells - key efficiency parameters of a DSSC – key components of DSSC – improvement in efficiency through nanostructuring of materials – dye solar cells based on nanorods/nanotubes and nanowires.

Module IV: SPECIAL NANOMATERIALS

Fullerenes - graphene - carbon nanotubes (CNTs) - SWCNT- MWCNT – synthesis - methods of opening, filling and purifying carbon nanotubes – geometrical structure of CNTs – electronic structure of CNTs – metallic and semiconducting CNTs – CNTFETs – CNT circuits - prospects of an all-CNT nanoelectronics.

Module V: NANOCOMPOSITES

Ceramic/metal nanocomposites - thin-film nanocomposites: multilayers and granular films – carbon nanotube-based nanocomposites – inorganic nanocomposites for optical applications – inorganic nanocomposites for electrical applications – nanoporous structures and membranes – nanocomposites for magnetic applications - nanocomposite structures having miscellaneous properties.

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Semester : II
Course Code : NST- 721
Course title : DISSERTATION
Credits : 20

Aim: The aim of this course is to enable students to develop an understanding and obtain practical experience of the research process and research skills required to undertake a supervised research project.

Students will be required to identify relevant information on a topic and critically review the research of others. A range of approaches should be used in the field of Nanoscience and Nanotechnology.

Objective: This course aims to develop an understanding of the processes and skills required to undertake a supervised research project at M.Phil level, and to write it up as dissertation.

The objectives are

- develop research skills commensurate with the accomplishment of a degree
- develop skills in independent inquiry
- produce a coherent and logically argued piece of writing that demonstrates competence in research and the ability to operate independently
- address issues of research design, methodology, ethics and theoretical arguments, and apply these to research