Annexure VI

UNIVERSITY OF KERALA

SYLLABUS FOR M. Phil. DEGREE COURSE

IN

NANOSCIENCE AND NANOTECHNOLOGY

Revised syllabus

w.e.f 2015 admission

M. Phil Course in Nanoscience and Nanotechnology

Regulations, scheme and syllabus for the M. Phil degree course in Nanoscience and Nanotechnology

1. Regulations:

The M. Phil course may be conducted as per the existing M. Phil reformulated regulations No. Acad.L.3855/R/97 dated 18-11-1997.

2. Eligibility:

The qualification for admission to the M. Phil Degree course in Nanoscience and Nanotechnology shall be a second class Masters Degree in Nanoscience/Nanotechnology/Nanoscience and Nanotechnology/Nanoscience and Technology, Physics, Chemistry, Materials Science or Photonics of this University or a Masters Degree in one of the above subjects from any other University recognized by this University, with not less than 55% marks subject to the rules of relaxation for SC/ST candidates.

3. Admission Procedure:

Admissions to the M. Phil course will be made on the basis of the marks scored in the Entrance Examination and in the qualifying examination in the ratio 50:50.

4. Number of seats:

A total of ten (10) candidates will be admitted to the M. Phil course.

UNIVERSITY OF KERALA

M. Phil Course in Nanoscience and Nanotechnology

SCHEME AND SYLLABUS

Scheme of Examination

			Duration	Max. Marks
Paper	**I**	**RESEARCH METHODOLOGY**	3 hrs.	100
Paper	**II**	**NANOMATERIALS AND NANOSCIENCE**	3 hrs	100
Paper	**III**	**ADVANCED NANOMATERIALS AND NANOTECHNOLOGY**	3 hrs	100
		Dissertation		300
		Viva-voce		100
			TOTAL	**700**

Distribution of Marks

There will be two parts (Part A and Part B) for the question paper for each of the papers Paper I, Paper II and Paper III. Part A will contain **twelve** short answer type questions out of which **eight** questions will have to be answered. Part B will contain **six** long answer type questions out of which **four** questions will have to be answered. Mark distribution for each paper will be as follows:

Part A 8 questions to be answered - 8 x 5 = 40 marks

Part B 4 questions to be answered - 4 x 15 = 60 marks

Total 100 marks

Marks for Viva-voce based on Dissertation = 100

PAPER I RESEARCH METHODOLOGY

UNIT 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. (ref: 1,2,3)

UNIT II 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. (ref: 1,2,3)

UNIT III 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.

(ref: 1,2,3,4)

UNIT IV 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. (ref: 1,2,3)

UNIT V 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. (ref: 1,2,3)

UNIT VI 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. (ref: 5)

UNIT VII 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.

(ref: 1,6,7)

REFERENCES

1. Garg. B. L, Karadia. R, Agarwal. F and Agarwal. U. K- An introduction to Research Methodology, RBSA Publ, 2002.
2. Kothari. C. R- Research Methodology: Methods and Techniques, New Age Intl, 1990.
3. Sinha. S. C and Dhiman. A. K- Research Methodology, Vol I & II Ess Ess Publ, 2002.
4. Trochim W M K- Research Methods: the concise knowledge base, Atomic Dog Publ, 2005.
5. Wadehra. B. L- Law relating to patents, trade marks, copyright designs and geographical Indications, Universal Law Publ, 2000.
6. Rudolf J. Freund, William J Wilson, Donna L. Mohr- Statistical Methods (3rd edition), Elsevier, 2010.
7. Yogish. S. N- Statistical Methods, Mangal Deep Publ, 2007.

ADDITIONAL READINGS

1. Anthony. M, Graziano. A. M and M L Raulin. M L, Research Methods: A Process of Inquiry, Allyn and Bacon, 2009.
2. Carlos. C M, Intellectual property rights, the WTO and developing countries : the TRIPS agreement and policy options, Zed Books, New York, 2000.
3. Coley. S. M and Scheinberg. C. A, Proposal Writing, Sage Publ, 1990.
4. Day. R. A, How to Write and Publish a Scientific Paper, Cambridge University Press, 1992.
5. Fink A, Conducting Research Literature Reviews: From the Internet to Paper. Sage 2009
6. Leedy. P. D and Ormrod. J. E, Practical Research : Planning and Design, Prentice Hall, 2004.
7. Satarkar .S. V, Intellectual property rights and Copy right. Ess Ess Publ, 2000
8. Leedy P D, and J E Ormrod, Practical Research: Planning and Design, Prentice Hall, 2004.
9. Smith R V, Graduate Research: A Guide for Students in the Sciences, Univ Washington Press, 1998.

PAPER II NANOMATERIALS AND NANOSCIENCE

UNIT I INTRODUCTION TO NANOMATERIALS

Zero-dimensional, one-dimensional and two-dimensional nanostructures, size dependent properties – quantum confinement – optical 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 - self-assembly - molecular self-assembly in solutions – self assembly of nanoparticles - Langmuir-Blodgett films - electrochemical deposition. (ref. 1-6)

UNIT 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 - FTIR and Raman spectroscopy - Thermal analysis – TGA, DTA and DSC. (ref. 7-10)

UNIT III NANOBIOLOGY

Overview of cell structure and biomacromolecules - chemical building block of cells – DNA - based nanomaterials - self-assembled DNA nanotubes and their applications, nucleic acid nanoparticles - chemical and physical properties of therapeutic DNA - synthesis and characterization of nucleic acid nanoparticles - DNA functionalization for cell recognition and internalization - preparation of DNA nanoparticles enveloped with protective coat and cell internalization elements.

Nanobiotechnology – Introduction - learning from nature - DNA nanotechnology -nanoparticles for biological assays - nanoparticles for drug delivery vehicles - surface modification of nanoparticulate drug carriers - need of surface modification - attaching various ligands to surface of nanocarriers - polymers for longevity – ligands for targeting combination with protecting polymers - ligands for intracellular delivery of nanocarriers.

Engineered nanoparticles and biomedical applications - engineered nanoparticles in therapeutics – bioimaging - drug delivery. (ref. 11-15)

UNIT IV 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 – linear optical properties – nonlinear optical properties – two phonon absorption – confinement induced mixing of valance bands – enhancement of optical nonlinearity – applications of semiconductor quantum dots – quantum dot lasers – all optical switching using quantum dots – quantum dots for optical data storage.
(ref. 16-19)

UNIT V NANOELECTRONICS

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.
(ref. 20-23)

UNIT VI CARBON NANOTUBES

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. (ref. 22, 24-26)

UNIT VII NANOPHOTONICS

Photons and electrons: similarities and differences – manifestation of quantum confinement – dielectric confinement effect – 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.
(ref. 27)

REFERENCES

1. G. Cao – Nanostructures & Nanomaterials-Synthesis, Properties and Applications, Imperial College Press, 2004.
2. Daniel L. Feldheim, Colby. A. Foss - Metal Nanoparticles: Synthesis, Characterization and Applications, Marcel Dekker, NY, 2002.
3. Janos. H. Fendler (Ed) - Nanoparticles and Nanostructured Films: Preperation, Characterization and Applications, Wiley – VCH, 1998.
4. Didier Astruc(Ed) - Nanoparticles and Catalysis, Wiley-VCH, 2008.
5. G.C. Hdjipanayis, R.W. seigel - Nanophase Materials- Synthesis, Properties and Applications, Kluwer Academic Publishers, 1994.
6. Yoon S Lee - Self-assembly and Nanotechnology-A force balance approach, Wiley, 2008.
7. Cullity. B. D and S. R. Stock - Elements of X-ray diffraction, Prentice-Hall, 2001.
8. Skoog. D. A, James Holler. F, Nieman. T. A - Principles of Instrumental Analysis, Harcourt College, 2007.
9. Willard H. H., Merrit. L. L., Dean. J. A and Settle. F. A - Instrumental Methods of Analysis, CBS Pub, 1986.
10. Williams. D. B and Carte. C. B - Transmission Electron Microscopy – A text Book of Materials Science, Plenum Press, N. Y, 1996.
11. Harvey Lodish, Arnold Berk et.al.–Molecular Cell Biology, W.H. Freeman & Co., New York, 2008.
12. Geoffrey M. Cooper, Robert E. Hausman – The Cell – A Molecular Approach – ASMPress, Washington, 2007.
13. Challa Kumar (Ed) – Biological and Pharmaceutical Nanomaterials, Wiley – VCH Verlag , Weinheim, 2006.
14. Ralph. S. Greco, Fritz B. Prinz and R. Lane Smith (Eds) - Nanoscale Technology in Biological Systems, CRC Press, 2005.
15. Challa Kumar(Ed) - Nanomaterials for Medical Diagnosis and Therapy, Wiley-VCH, 2006.
16. J.H.Davis – Physics of low dimensional structures, Cambride, 1998.
17. S.V.Gaponenko – Optical Properties of Semiconducting Nanocrystals, Cambridge Press, 1997.
18. C.Delerue,M.Lannoo - Nanostructures Theory and Modelling,Springer, 2004.
19. A. S. Edelstin and R. C. Cammarata - Nanomaterials: Synthesis, Properties and Applications, Taylor & Francis, 1996.
20. J. M. Martinez-Durat, R. J. martin-Palma and F. Agullo-Rueda - Nanotechnology for micro-electronics and optoelectronics, Elsevier, 2006.
21. T. Heinzel – Mesoscopic Electronics in Solid State Nanostructures, Wiley-VCH, 2003.
22. Rainer Waser (Ed) - Nanoelectronics and Information Technology- advanced Electronic materials and novel Devices, Wiley- VCH, 2005.
23. Teruya Shinjo(Ed) - Nanomagnetism and Spintronics, Elsevier, 2009.
24. R.Saito - Physical properties of Carbon Nanotubes, Imperial College Press, 1998.
25. Peter J F Harris - Carbon Nanotubes and Related Structures- New Materials for the twenty-first century, Cambridge, 1999.
26. Francois Leonard - The Physics of Carbon nanotube devices, Elsevier, 2009.
27. P. N. Prasad - Nanophotonics, Wiley-Interscience, 2004.

PAPER III ADVANCE NANOMATERIALS AND NANOTECHNOLOGY

UNIT 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. (ref. 1, 2, 3)

UNIT 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. (ref. 1)

UNIT 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. (ref. 4, 5)

UNIT IV DYE SENSITIZED SOLAR CELLS

Introduction to Photovoltaic (PV) systems - the PV cell - the PV module - the PV array - photoelectrochemical conversion of solar enegy – photoredox reactions of colloidal semiconductors and particulates – dye sensitization of semiconductors – sequence of electron transfer steps of a dye-sensitized solar cell (DSSC) – 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 – sensitization using quantum dots - pervoskite solar cells. (ref. 5, 6, 7)

UNIT V PHOTOLUMINESCENCE OF NANOCRYSTALS

Principles of photoluminescence – photoluminescence in solid systems – radiative transitions in pure semiconductors – radiative transitions across the band gap – nonradiatives processes – quantum dots and nanophosphors – weak and strong confinement regimes – photoluminescence of quantum dots prepared by wet chemical precipitation – photoluminescence from doped quantum dots – nanoscale particles for molecular imaging – photoluminescence in undoped and doped nanocrystals of ZnO and TiO_2. (ref. 8, 9)

UNIT VI MAGNETIC PROPERTIES OF NANOPARTICLES

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. (ref. 10, 11)

UNIT VII NANOCOMPOSITES

Ceramic/metal nanocomposites - nanocomposites by mechanical alloying – nanocomposites from sol – gel synthesis – nanocomposites by thermal spray synthesis – thin-film nanocomposites: multilayers and granular films – carbon nanotube-based nanocomposites – inorganic nanocomposites for optical applications – inorganic nanocomposites for electrical applications – percolation effects and transport phenomena in composite systems – nanoporous structures and membranes – nanocomposites for magnetic applications - nanocomposite structures having miscellaneous properties. (ref. 12)

REFERENCES

1. G. Cao – Nanostructures & Nanomaterials-Synthesis, Properties and Applications, Imperial College Press, 2004.
2. Anis Zribi and Jeffrey Fortin - Functional thin films and nanostructures for sensors: synthesis, physics and applications, Springer, 2009.
3. Sam Zhang - Nanostructured thin films and coatings: functional properties, CRC Press, 2010.
4. C. N. R. Rao, A. Muller, A. K. Cheetham (Ed) - The Chemistry of Nanomaterials – Synthesis, Properties and Applications, Vol. 2, Wiley-VCH, 2004.
5. Gary Hodes - Electrochemistry of nanomaterials, Wiley-VCH, 2001.
6. Roger A Messenger, Jerry Ventre - Photovoltaic Systems and Engineering (3rd edition), CRC Press, 2010.
7. Kalyanasundaram K(Ed) - Dyesensitized Solar Cells,EPFL Press, Switzerland, 2010.
8. Leah Bergman, Jeanne L. McHale (Eds) - Handbook of Luminescent Semiconductor Materials, CRC Press, 2012.
9. C. Ronda (Ed) - Luminescence – from theory to applications, Wiley_VCH, 2008.
10. R.C.O.Handley – Modern Magnetic Materials: Principles and Applications, Wiley, 1999.
11. K. J .Klabunde - Nanoscale Materials in Chemistry, Wiley, 2001.
12. P. M. Ajayan, L. S. Schadler, P. V. Braun - Nanocomposite Science and Technology, Wiley VCH, 2003.

Annexure VI

UNIVERSITY OF KERALA

SYLLABUS FOR M. Phil. DEGREE COURSE

IN

NANOSCIENCE AND NANOTECHNOLOGY

Revised syllabus

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Nanoscience and nanotechnology are disciplines at the cutting-edge of scientific knowledge. They combine aspects of basic and applied sciences applied to specific fields, such as biotechnology, medicine, chemistry, pharmaceutical sciences, physics, materials engineering, sciences and electronic engineering.Â The master's degree in Nanoscience and Nanotechnology at the University of Barcelona is taught in English and intended for students with an academic background in science. The aim of the master's degree is to provide students with professional competences in the field of nanoscience and nanotechnology, for industry and science. Students must be capable of addressing problems that require interdisciplinary skills.