Centre for Renewable Energy
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Aim of the Course Work

The Pre- Ph.D. coursework is designed to develop investigative, evaluative, comprehensive, reasoning, statistical analyses and writing skills in students to create an in-depth understanding of his/her area of research.

Program Objectives

- Prepare and motivate the students to advance their research careers beyond a doctoral degree, pursue careers in academics and industries.
- Equip the students with such skills as to make them understand the mysteries of matters in different scales of dimensions
- Make the students understand that acquiring knowledge and skills appropriate to their professional activities is a never-ending process.
- Train-up the students in such a way that they can objectively carry out investigations, scientific and/or otherwise, without being biased or without having any preconceived notions.
- Enable the students to analyze problems starting from first principles, evaluate and validate experimental results, and draw logical conclusions thereof.
- As technology exploits various concepts of nanoscience, students properly trained in nanoscience research can be good value addition in the field of technology too.
- Imbibe effective scientific and/or technical communication abilities among the students.
- Inspire them in such a way that they can demonstrate and maintain the highest standard on ethical issues in their professional lives.
- Create an awareness among the students to be persons of integrity, to be responsible and enlightened citizens with a commitment to deliver goods to society within the scope of the bestowed rights and privileges.

Program outcomes

After completing the program the students should be able to

- developa specialization in a particular area of scientific research.
- acquire an overall idea of the ongoing scientific research in and outside the country.
- developlogical reasoning and such skills as to quantitatively solve a problem.

- mature as a researcher having reasonably good communication skills - ability to present scientific results and thoughts before an educated audience.
- gain training over a wide range of analytical and/or experimental and/or computational techniques that can be applied in physics, in other scientific and technological domains.
- acquire some amount of knowledge regarding the overall scientific progress (chronological) so that the results of a particular problem can be placed under proper perspective.

Course Structure

Year	Sem	Paper	Paper code	Title	Theory/ Research	Credits	Max. Marks
06	XI	I	B231101T	Materials for Energy Applications	Theory	6	100 [25(CIE)+75(UE)]
		II	B231102T	Material Characterization Techniques	Theory	6	100 [25(CIE)+75(UE)]
		III	B231103T	Research Methodology, Research Publication Ethics and Computer Applications	Theory	4	100 [25(CIE)+75(UE)]
		IV	B231104T	Research Project	Research	-	100 [25(CIE)+75(UE)]

Paper Setting and Evaluation Pattern (For Paper I, II and III)

Types of Question	Total Number of Questions	Questions to be attempted	Marks	Time
Objective Type	10	10	10×2=20	3 Hours
Short Type	8	5	5×8=40	
Long Type	4	2	2×20=40	
		Total marks	**100**	

Note: As Per UP government direction teachers in service are allowed to attend their Pre-Ph.D.- Course Work class either in online or in offline mode.

Syllabus/Course Contents

Programme: Post graduate diploma in Research (PGDR)		**Year: Sixth**	**Semester: XI**
Subject: Renewable Energy			
Course Code: B231101T		**Course Title: Materials for Energy Applications**	
Credits: 6	**Max Marks: 100**	**Min Marks to Pass: 55**	

COURSE OBJECTIVES:

- To understand the nature and properties of materials.
- To provide a scientific understanding of application of nanomaterials and nanotechnology in electronics, health and environmental conservation.

COURSE OUTCOME:

Students who successfully complete this course will be able to:
CO 1: Familiarize with working principles and various fundamentals of nanoscience&nanomaterials.
CO 2: Understand various properties of materials at nanoscale.
CO 3: Understand the dimensionality of nanomaterials and Thin films and its types.
CO 4: Understand of the strengths, limitationns and potential uses of nanomaterials.
CO 5: Grasp the importance of nanomaterials in biomedical applications
CO 6: Understand the potential of nanomaterials in energy conversion/storage

Unit	Content
I	**Background to Material Science** Crystal geometry: crystal lattices, space lattices, basis and crystal structure, unit cell, lattice parameter of a unit cell - Seven crystal systems - Bravais lattices - Crystal directions and crystal planes (Miller indices) - Coordination number, radius ratio, packing factor - Some special crystal structures Imperfections in solids: Points defects, thermodynamics of point defects. Dislocations: Grain
II	**Nanostructured Materials and Nano Composites** Nanostructured materials, Differences in the properties of bulk, nanoparticles, quantum dots, clusters, superlattices and nanostructured layers. Quantum confinement, surface enhanced properties. Optoelectronic Properties of 0D, 1D, 2D and superlattice structures. Types of nanocomposites, Synthesis of nanocomposites, Composite Interfaces, Bonding Mechanisms, other Interfacial properties, Polymer Matrix Composites, Metal Matrix Composites, Ceramic Matrix Composites.
III	**Thin Film Science and Technology** Kinetic Theory of Gases and basics of vacuum science and technology, Physical Vapor Deposition Evaporation of elements, compounds, alloys, Raoult's law, Homogenous and Heterogenous Nucleation, capillarity theory, atomistic and kinetic models of nucleation, basic modes of thin film growth.
IV	**Materials for PV Technology** Principles and fundamentals of Silicon Solar cell technology, Organic Solar Cell Technology, Perovskite Soalr Cell technology, Quantum Dot Solar Cells and other emerging solar cell technology.

V	**Materials in energy storage/conversion** Principles of energy storage devices (battery and capacitor) and electrochemical energy conversion reactions, hydrogen energy, Thermoelectric devices.

Suggested Resources:

1. Chemistry of nanomaterials: Synthesis, properties and applications by CNR Rao et.al.
2. Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim 2004.
3. Instrument E L Principe, P Gnauck and P Hoffrogge, Microscopy and Microanalysis (2005), 11: 830- 831, Cambridge University Press.
4. Processing & properties of structural naonmaterials - Leon L. Shaw,
5. Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry, Cambridge UK 2005
6. Graziano, A., M., and Raulin, M.,L.: Research Methods – A Process of Inquiry, Sixth Edition, Pearson, 2007.
7. Nanostructures and Nanomaterials: Synthesis, Properties, and Applications, 2nd ed., Guozhong Cao, Ying Wang; Imperial College Press, 2004.
8. Nanoparticles: From Theory to Application, Günter Schmid, Wiley, 2005.
9. Synthesis, Properties, and Applications of Oxide Nanomaterials, José A. Rodriguez, Marcos Fernández-García, Wiley, 2007
10. Nanotechnology in Biology and Medicine: Methods, Devices and Application by Tuan Vo-Dinh .CRC press, 2007.
11. Nanosystem characterization tools in the life sciences by Challa Kumar. WileyVCH, 2006.
12. Electrochemical methods: Fundamentals and Applications, Allen J.Bard and Larry R. Faulkner, 2nd Edition John Wiley & Sons. Inc (2004)
13. D. Linden Ed., Handbook of Batteries, 2nd edition, McGraw-Hill, New York (1995)
14. G.A. Nazri and G. Pistoia, Lithium Batteries: Science and Technology, KulwerAcdemic Publishers, Dordrecht, Netherlands (2004).
15. J. Larmine and A. Dicks, Fuel Cell System Explained, John Wiley, New York (2000).
16. NPTEL-Nano structured materials-synthesis, properties, self assembly and applications by Prof. A.K. Ganguli https://www.youtube.com/playlist?list=PLbMVogVj5nJTdeiLvuGSB_AE8hloTAHWJ
17. NPTEL-Nanotechnology: Science and Applications by Dr. PrathapHaridoss https://nptel.ac.in/courses/113106093

Course Code: B231102T	**Course Title: Material Characterization Techniques**	
Credits: 6	**Maximum Marks: 100**	**Minimum marks to pass: 55**

COURSE OBJECTIVES:

- Materials Characterization has gained enormous importance in diverse fieldsin which the chemical, microstructural and physical properties of different materials are probed, measured and determined using a variety of analytical methods, techniques,and tools. The course aims to provide the student with an overview of the current techniques used for physicochemical characterization.

COURSE OUTCOME:

Students who successfully complete this course will be able to:

CO 1: Explain the principles of crystallography and will be able to characterize materials through XRD technique.

CO 2: Comprehend the sophisticated microscopic analysis of materials and gain knowledge about SEM, TEM AFM etc.

CO 3: Understand and utilize the basic principles of various spectroscopic techniques and also analyze samples based on those techniques

CO 4: Explain the basic compositional techniques of materials such as XPS, EDS etc and understand

where and how to use them for material analysis
CO 5: Explain the principles and have hand-on experience of operations of a range of advanced electroanalytical techniques that are currently used in the characterization of various materials and compounds.

Unit	Content
I	**X-ray techniques for materials characterization** X-ray diffraction: Principle, measuring system and applications for characterization of powdered materials. X-ray diffraction profile and analysis: FWHM and line broadening, Crystallite size effect and Scherrer formula, Effect of strain (tensile vs compressive, uniform vs. non-uniform) Introduction to Extended X-ray absorption fine structure (EXAFS), Surface extended X-ray absorption fine structure (SEXAFS). Hand on experience on X-ray difrffraction technique and the corresponding data analysis
II	**Microscopic Techniques** Instrumentations and applications of Optical microscope, Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM) for characterization of different samples. Energy dispersive X-ray microanalysis (EDS) - Basic aspects of Atomic force microscopy (AFM)
III	**Spectroscopic Techniques** Principle, instrumentation and applications of UV-Visible Diffuse Reflectance (UV-Vis DRS) spectroscopy, FT-IR, Raman and photoluminescence spectroscopy. Hand on experience on operation of UV-Vis and, FT-IR and data analysis..
IV	**Compositional Analysis** Energy dispersive x-ray (EDX), X-ray photoelectron spectroscopy (XPS), Ultraviolet photoelectron spectroscopy (UPS) low energy electron diffraction (LEED), Reflection high energy electron diffraction (RHEED), Auger electron spectroscopy (AES), Secondary ion mass spectroscopy (SIMS), x-reflectivity (XRR), electron energy loss spectroscopy (EELS).
V	**Material compositional analysis** Voltammetric principles, hydrodynamic voltammetry, stripping voltammetry, cyclic voltammetry, criteria of reversibility of electrochemical reactions, quasi-reversible and irreversible processes, qualitative and quantitative analysis current-potential relation applicable for Linear Sweep Voltammetry (LSV) and Cyclic Voltammetry (CV), interpretation of cyclic voltammograms and parameters obtainable from voltammograms. Hand-on experience inthe operation of CV and data analysis.

Suggested Resources

1. P.J. Goodhew, F.J. Humphreys, and R. Beanland, Electron Microscopy and Analysis: 3rd Edition, Taylor and Francis, NY, 2001.
2. Theory and Applications of UV Spectroscopy, H.H.Jaffe and M.Orchin, IBH-Oxford.
3. Inorganic spectroscopic methods, A.K. Brisdon, Oxford Chem. Primers, 1997, New York. 4. Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi and F.L.Ho, Wiley Inter science.
5. Introduction to Spectroscopy, Pavia, Brooks/Cole Cenage, 4th edition, 2009, Belmont.
6. Introduction to Photoelectron Spectroscopy, P.K.Ghosh, John Wiley.
7. Fundamental of Molecular Spectroscopy, C. N. Banwell and E. McCash, Tata McGraw Hill, 4th edition, 1994, New Delhi.
8. 'Encyclopedia of Materials Characterization, Surfaces, Interfaces, Thin Films,' Editors C. Richard Brundle, Charles A. Evans, Jr., Shaun Wilson, Butterworth-Heinemann, Boston, US
9. 'Elements of X-ray diffraction' B.D. Cullity and S.R. Stock, 2001, Prentice Hall, Inc. USA
10. NPTEL – Material Characterization
https://onlinecourses.nptel.ac.in/noc22_mm14/preview
11. https://sites.google.com/view/kd2021/classroom
12. https://www.vssut.ac.in/lecture_notes/lecture1429901637.pdf
13. Material Characterization by Prof. B.S. Murthy (IIT M)
https://www.youtube.com/watch?v=FkPeSMHCoX0&list=PLU_BQrxXuAddD_aEk270mcD9XvFT

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Course Code: B231103T	**Title:** Research Methodology, Research Publication Ethics and Computer Applications	
Credits: 04	**Maximum Marks: 100**	**Min Marks to Pass: 55**

COURSE OBJECTIVES:

- To develop an understanding of the basic framework the of research process, publication and patent scopes.
- To develop an understanding of various research designs and techniques.
- To identify various sources of information for literature review and data collection.
- To develop an understanding of the ethical dimensions of conducting applied research.
- Appreciate the components of scholarly writing and evaluate its quality.
- Provide students with the fundamental knowledge of 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 metrics (citations, *h* index, Impact Factor etc).
- Guide and mentor students in presenting plagiarism tools for a valid and ethical research report.

COURSE OUTCOMES:

Students who successfully complete this course will be able to:

CO1: With the help of this course, students will be able to decide the research field, topic, design, and pros and cons of research, sampling, and data collection techniques.

CO2: The student will be able to understand the research process and acquire the skill of writing research articles.

CO3: The course will enable you to execute the best practices, morals, and ethical values in scientific conduct and avoid publication misconduct.

CO4: With the help of this course, students will be able to learn about the standards of journals for good-quality publications of their research work.

CO5: After this course, the students will be able to learn how to use computers and different application software for manuscript writing.

CO6: This course will enable the students to learn about reference management and the maintenance of academic integrity using scientific tools. They will be familiar with the protection of the machines from computer hazards

Unit	Content
I	**Research Methodology** Definition, and Objectives, Motivation and Significance of Research, Types of Research, Truth and Facts of Research, Similarity and Contrast in Literary Research and Scientific Research, Research and Criticism, Research Problem and Research Design, Sampling Design and Methods of Data Collection.
II	**Research standards:**

	Layout of the Research Report, Research Process: subject Selection, Outline of the Research, Review of Literature, Material Collection; Testing and Classification, Analysis, Discussion and Conclusions, Precautions in Writing Synopsis/Research Paper/Thesis/Research Report.
III	**Philosophy, Ethics, Scientific Conducts and misconducts:** Moral Philosophy, Nature of Moral Judgments and Reactions, Publication Ethics, Best Practices/Standards Setting Initiatives and Guidelines: Committee on Publication Ethics (COPE), World Association of Medical Editors (WAME) etc., Intellectual Honesty and Research Integrity: Falsification, Fabrication and Plagiarism (FFP), Open Access Publishing, and Publication Misconduct.
IV	**Databases and Research Metrics Databases:** Indexing Databases, Citation Databases: Web of Science, Scopus etc., Research Metrics: Impact Factor of Journal as Per Journal Citation Report, SNIP, SJR, IPP, Cite Score; Metrics: hIndex, g-Index, i-10 Index, and Altimetric
V	**Fundamentals of Computers and application Softwares** Types Of Computers, Computer Peripherals and internal component, Types of Operating Systems, Web Browser, Web Search Engine, Spreadsheet Processing, Presentation (MS PowerPoints Preparation or Beamer or Libre Office (Optional), Project/Thesis/Report writing, Using MS-Word or LaTeX or LibreOffice documentation style Labelling, References Style, Footnotes etc.
VI	**Scientific Softwares:** Use of Reference Management Software Like Mendeley, Zotero, Reference Manager, Endnote, Authorea Etc. Anti-Plagiarism Software Like Turnitin, iAuthenticate, Urkund, Ebooks and Virtual Library, UGC-Infonet, Computer Hazards and Security

Suggested Resources:

1. C.R. Kothari, Research methodology Methods and Techniques, 4th Edition, New Age International (P) Ltd. Publisher, 2014.
2. W. Creswell, Research Design, Qualitative, Quantitative and mixed method approaches, 3rd Edition, Sage Publications, Inc.
3. D.B. Resnik, (2011) What is ethics in research & Why is it important. National institute of Environmental Health Science, 1-10 Retrieved from https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm 7
4. Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance (2019), ISBN:978-81-939482-1-7. https://www.insaindia.res.in/pdf/Ethics_Book.pdf
5. ReemaThareja (2019) Fundamentals Of Computers (2nd Edition), Oxford University Press
6. Microsoft Office 365 : A complete Guide to Master Word, Excel, and PowerPoint 365 for Beginners, Matt Vic
7. Leslie Lamport, LaTeX, A Document Preparation System, 2nd Edition, Addison-Wesley Professional Publisher, July, 1994.
8. Latex tutorials https://www.tug.org/twg/mactex/tutorials/ltxprimer-1.0.pdf
9. Libre Office tutorial: www.documentation.libreoffice.org/en/english-documentation

Suggested equivalent online courses: https://epgp.inflibnet.ac.in/

Programme: Post graduate diploma in Research (PGDR)	**Year: six (**6)	**Semester:** XI
	Subject:Renewable Energy	
Course Code: B231104T	**Course Title: Research Project**	

Course Outcomes (COs)	
Students who successfully complete this course will be able to: CO1: Formulate precise research questions, proficiency in conducting comprehensive literature reviews, understanding various research methodologies and techniques, and mastering the skills required for collecting, analyzing, and interpreting data effectively. CO2: to write proficiently using proper citation and referencing techniques. This includes presenting research findings clearly and persuasively, both in written documents and oral presentations. Additionally, researchers would possess the skill to create visually engaging and informative presentations, ensuring effective communication of complex ideas and data. CO3: to prepare Presentation and Defense, researchers are expected to demonstrate their proficiency in defending their research methods, findings, and conclusions during presentations or thesis defenses. This involves the ability to articulate their research process and outcomes clearly and convincingly.	
Credits: Non –Credit	**Core Compulsory**
Max. Marks: 25 (CIE) + 75(UE)	**Min. Passing marks: 55**

Suggested Readings:

1. Ortiz, Daniel, and Jennifer Greene. "Research design: qualitative, quantitative, and mixed methods approaches." Qualitative Research Journal 6.2 (2007): 205-208.
2. Booth, Wayne C., Gregory G. Colomb, and Joseph M. Williams. The craft of research. University of Chicago press, 2003.
3. Eco, Umberto. How to write a thesis. MIT Press, 2015.
4. Machi, Lawrence A., and Brenda T. McEvoy. "The literature review: Six steps to success." (2009).
5. Creswell, John W., and Cheryl N. Poth. Qualitative inquiry and research design: Choosing among five approaches. Sage publications, 2016.

10-point grading system for evaluation of the Pre-Ph.D. course work

As per the UP GOs 1567/सत्तर-3-2021-16 (26)/2011 TCdated13 July 2021, 401/सत्तर-3-2022, dated09 Feb. 2022, and 1032/सत्तर-03-2022-08(35)/2020, dated 20 April2022 regarding NEP-2020, the grading system for the Pre-Ph.D. course work shall be followed as given in table -1.

Table-1

Letter Grade	Details	Limit of Marks	Grade Point
O	Outstanding	91-100	10
A+	Excellent	81-90	9
A	Very Good	71-80	8
B+	Good	61-70	7
B	Above Average	55-60	6
F	Fail	<55	0
AB	Absent	Absent	0
Q	Qualified		
NQ	Not Qualified		

In pre-Ph.D. course work, there is a mandatory research project that is qualifying in nature. This research project shall be a **non-credit course**. The letter grade for the research project will be Q or NQ. The grade of research project will not be included in the computations of the CGPA.

Computation of CGPA:

Calculations for SGPAand CGPAshall be followed as given table 2:

Table 2

For j^{th}Sem. SGPA $(S_j) = \frac{\sum Ci.Gi}{\sum Ci}$	Here: C_i = number of credits of the i^{th} course in the j^{th} semester G_i = grade point scored by the student in the i^{th} course in j^{th} semester
CGPA = $\frac{\sum Cj.Sj}{\sum Cj}$	Here: S_j = SGPA of the j^{th} semester C_j = total number of credits in the j^{th} semester

Allocation of CGPA Into Division:

The allocation of CGPA into division in pre-Ph.D. course work follows as given in Table 3:

Table 3

Division	CGPA
First	Greater than or equal to 6.5 and less than or equal to 10
Second	Greater than or equal to 5.5 and less than 6.5