

PhD. Courses in Monsoon Semester

Course Type	Course Code	Course Name	Instructor	Credit
Core	PD801	Research Methodology	VVSSS	4L
Core	PD807	Research and Publication Ethics	VVSSS	2L
Elective	PD809	Mechanical Behavior at Various Length Scales	KVR	4L
Elective	PD810	Materials for Energy Harvesting	RKD	4L
Elective	PD811	Computational Thermodynamics for Materials	KGV	3L +1T

PhD. Courses in Winter Semester

Course Type	Course Code	Course Name	Instructor	Credit
Elective	PD812	Texture and Anisotropy in Polycrystalline Materials	JPG	3L+1P
Elective	PD808	Problems in Surface Engineering	VVSSS	3L +1T
Elective	PD813	Advanced Functional Ceramics	DD	3L+1P
Elective	PD814	Smart Materials for Sensors and Energy Applications	RKD	4L

PD801

Research Methodology

Unit I: Introduction – Understanding ‘Research’ and Philosophy of Research (with emphasis on Science and Engineering); Objectives of Research; What constitutes Good Research?; Introduction to- and the necessity of- Research Methodology (with emphasis on Science and Engineering);

Unit II: Nuances of Research – Basic differences between Research Methods and Research Methodology; Types of Research (Fundamental/Applied, Descriptive/Analytical, Quantitative/Qualitative, Empirical/Conceptual) with typical examples related to Materials Engineering and Nano Science and Technology; Research problem (Systematic representation, understanding and solving);

Unit III: Data Analysis – Importance of data analysis; Regression analysis (with typical examples related to Materials Engineering and Nano Science and Technology); Data fitting and validation; Importance of iteration; Demonstration of Origin and Peak Fitting softwares;

Unit IV: Research Reports – Levels of research reports; Systematic approach in reading a research report (case study: peer reviewed journal publication); Systematic approach in preparation of a research report;

Unit V: Ethics in Research – Understanding certain nomenclature; Ethics in measurements and Ethical decision making (with typical examples related to Materials Engineering and Nano Science and Technology); Plagiarism in problem definition and experimentation;

References

Lecture Notes and Demonstrations by Prof. Dr.-Ing. Vadali V S S Srikanth



प्रो. रजनीश जैन
सचिव
Prof. Rajnish Jain
Secretary



विश्वविद्यालय अनुदान आयोग
University Grants Commission

(मानव संसाधन विकास मंत्रालय, भारत सरकार)
(Ministry of Human Resource Development, Govt. of India)

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Respected Sir/Madam,

University Grants Commission in its 543rd meeting held on 9th August, 2019 approved two Credit Courses for awareness about publication ethics and publication misconducts entitled **“Research and Publication Ethics (RPE)”** to be made compulsory for all Ph.D. students for pre-registration course work (**attached as Annexure**).

In view of the above, you are requested to ensure that the above two Credit courses may be made compulsory for all Ph.D. students for pre-registration course work undertaken in your University from the forthcoming academic session.

With regards,

Yours sincerely,

(Rajnish Jain)

TO THE VICE-CHANCELLORS OF ALL UNIVERSITIES

ANNEXURE

Course Title:

- **Research and Publication Ethics (RPE)**-Course for awareness about the publication ethics and publication misconducts.

Course Level:

- 2 Credit course (30 hrs.)

Eligibility:

- M.Phil., Ph.D. students and interested faculty members (It will be made available to post graduate students at later date)

Fees:

- As per University Rules

Faculty:

- Interdisciplinary Studies

Qualifications of faculty members of the course:

- Ph.D. in relevant subject areas having more than 10 years' of teaching experience

About the course

Course Code: CPE- RPE

Overview

- This course has total 6 units focusing 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 metrics (citations, h-index, Impact Factor, etc.) and plagiarism tools will be introduced in this course.

Pedagogy:

- Class room teaching, guest lectures, group discussions, and practical sessions.

Evaluation

- Continuous assessment will be done through tutorials, assignments, quizzes, and group discussions. Weightage will be given for active participation. Final written examination will be conducted at the end of the course.

Course structure

- The course comprises of six modules listed in table below. Each module has 4-5 units.

Modules	Unit title	Teaching hours
Theory		
RPE 01	Philosophy and Ethics	4
RPE 02	Scientific Conduct	4
RPE 03	Publication Ethics	7
Practice		
RPE 04	Open Access Publishing	4
RPE 05	Publication Misconduct	4
RPE 06	Databases and Research Metrics	7
	Total	30

Syllabus in detail

THEORY

- RPE 01: PHILOSOPHY AND ETHICS (3 hrs.)**

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. 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 behavior 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(4 hrs.)**

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.

• **RPE 05: PUBLICATION MISCONDUCT (4hrs.)**

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.)

Use of plagiarism software like Turnitin, Urkund and other open source software tools

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

A. Databases (4 hrs.)

1. Indexing databases
2. Citation databases: Web of Science, Scopus, etc.

B. Research Metrics (3 hrs.)

1. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score
2. Metrics: h-index, g index, i10 index, altmetrics

References

- Bird, A. (2006). *Philosophy of Science*. Routledge.
- MacIntyre, Alasdair (1967) *A Short History of Ethics*. London.
- P. Chaddah, (2018) *Ethics in Competitive Research: Do not get scooped; do not get plagiarized*, ISBN:978-9387480865
- National Academy of Sciences, National Academy of Engineering and Institute of Medicine. (2009). *On Being a Scientist: A Guide to Responsible Conduct in Research: Third Edition*. National Academies Press.
- Resnik, D. B. (2011). What is ethics in research & why is it important. *National Institute of Environmental Health Sciences*, 1–10. Retrieved from <https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm>
- Beall, J. (2012). Predatory publishers are corrupting open access. *Nature*, 489(7415), 179–179. <https://doi.org/10.1038/489179a>
- Indian National Science Academy (INSA), *Ethics in Science Education, Research and Governance*(2019), ISBN:978-81-939482-1-7. http://www.insaindia.res.in/pdf/Ethics_Book.pdf

PD808

Problems in Surface Engineering

Unit I: Vacuum- How to make a choice between Vacuum based and non-Vacuum based surface engineering methods for a given/an identified problem. Numerical-, scientific reasoning- and logical- problems related to vacuum in terms of mean free path, dimensions of the reactor, flow type in the reactor, etc., that allow setting up the required level of vacuum and physical conductances in a real laboratory environment; trouble shooting.

Unit II: Thin Film Deposition Techniques- Numerical, scientific reasoning and logical problems related to i) the choice of technique (physical versus chemical) for a given/an identified problem, ii) achieving appropriate deposition rate/thickness and desired microstructure, and avoiding contamination and defects, iii) compound/alloy deposition, iv) choice of precursor in chemical vapor deposition (thermodynamics versus practice) and v) thin film growth models; trouble shooting.

Unit III: Coating Techniques- Numerical, scientific reasoning and logical problems related to the choice of technique for a given/an identified problem and achieving appropriate deposition rate/thickness and desired microstructure, and avoiding contamination and defects; application examples to be considered are chemical conversion coatings and plating processes, aluminizing and boronizing, hardfacing and cladding and spray processing;

Unit IV: Surface Cleaning- Scientific reasoning problems related to various surface cleaning methods that allow the proper choice among various surface cleaning methods for a given/an identified problem; application examples to be considered are pickling, mechanical cleaning, vacuum degreasing etc.

Unit V: Surface Evaluation- Scientific reasoning and logical problems related to various evaluation methods; application examples to be considered thickness, microstructure, composition, hardness, adhesion, etc.

References

- M. Ohring, "The Materials Science of Thin Films", Academic Press, 1992.
- D. L. Smith, "Thin Film Deposition, Principles and Practice", McGraw-Hill, 2000.
- H. Dimigen, "Surface Engineering", Wiley-VCH, 2000.
- J. B. Hudson, "Surface Engineering: An Introduction", Butterworth Heinemann, 2000.
- S. Grainger and J. Blunt, "Engineering Coatings", Woodhead Publishing, 1998.

PD 809 Mechanical Behavior at Various Length Scales

Instructor: Prof. Koteswararao V. Rajulapati

- Definition and introduction to length scales, feature size vs component size, hierarchical structures, classification and importance.
- Mechanical properties of conventional materials: yield strength, ductility, Hall-Petch effect, strain hardening, strain rate sensitivity etc. Factors that control the deformation: lattice defects, long-range/short-range obstacles, frictional stress etc.
- Strengthening methods in conventional materials (grain refinement, strain hardening, dispersion strengthening, precipitation strengthening, composite strengthening etc.).
- Ultrafine and nanomaterials: origin and their classification, processing methods (Top-Down and Bottom-Up), processing of bulk nanomaterials by various severe plastic deformation methods (ECAP, HPT, ball milling, ARB, RCS etc.), Processing by electrodeposition.
- Deformation mechanisms at finer length scales: dislocation pile-up breakdown, grain boundary dislocation sources and sinks, grain-boundary sliding, rotation and coalescence, shear bands.
- Length scale dependent fatigue behavior and creep behavior in structural materials. Mechanical behavior of natural materials and “nature-inspired” materials.
- Available tools to probe the mechanical behavior and the associated mechanics (for bulk materials and thin films): macro- and microindentation hardness testing, nanoindentation, miniaturized disc bend testing, shear punch testing, automated ball indentation testing, miniaturized tensile testing, impression creep testing.

Suggested Reading:

1. *Mechanical behavior of materials*, M. A. Meyers and K. K. Chawla, Cambridge University Press (2009).
2. *Structural Nanocrystalline Materials: Fundamentals and Applications*, by C. C. Koch, I. A. Ovidko, S. Seal and S. Veprek, Cambridge University Press (2007).
3. *Nanomaterials by Severe Plastic Deformation*, edited by M. J. Zehetbauer and R. Z. Valiev, Wiley-VCH (2004).
4. Several recent scientific and review articles (will be intimated and circulated during lectures).

Subject Code: **PD 810**

Title of the Course: **Materials for Energy Harvesting**

L-T-P: 3-0-0 Credits: 4

Prerequisite Course/Knowledge (If any): Basics in physics, chemistry, nanomaterials and nanotechnology

After completion of this subject successfully, the students will be able to:

CO-1: explain the fundamental concepts and phenomena of materials utilized for energy harvesting

CO-2: apply the defect engineering for the development of efficient materials

CO-3: apply the nanostructuring for the development of efficient materials

CO-4: develop energy generators for powering portable devices

Detailed Syllabus

Unit 1 : Materials concept and phenomena related to energy harvesting materials such as thermoelectric, piezoelectric, photovoltaic etc.

Unit 2: Defect engineering: Different approaches such as interface phenomena, dislocation, etc to improve materials properties with case studies.

Unit 3: Nanostructuring: Nanostructuring concept, nanofiller, nanocomposites, nanostructured materials and the corresponding underlying mechanism with case studies from the recent journals.

Unit 4: Development of different energy generators based on piezoelectric, thermoelectric etc materials

Unit 5: Applications: portable devices, sensors, MEMS, smartphone etc,

Suggested Books :

1. Introduction to solid state physics, Charles Kittel
2. Mechanical metallurgy, George Dieter
3. C. P. Poole and F.J. Owens, Introduction to Nanotechnology, Wiley Interscience.
4. Recent papers (high impact factor journals)

Computational thermodynamics for materials

Subject Code: PD811

L-T-P: 3-1-0 Credits: 4

Prerequisite Course/Knowledge (If any): Basic materials thermodynamics

After completion of this subject successfully, the students will be able to:

CO-1: analyze the thermodynamic stability of material systems (analyze)

CO-2: apply thermodynamics to material systems through Calphad approach (apply)

CO-3: comprehend the Gibbs energy assessment procedure (understand)

CO-4: calculate thermodynamic property and phase diagrams of unary, binary and higher order systems (calculate)

CO-5: extend Calphad spirit to kinetic studies, defects and nano materials (apply)

Detailed Syllabus:

Unit 1: Gibbs energy- composition plots, chemical potential, activity, equilibrium, Gibbs energy minimization, phase diagrams, solution models, metastability, entropy generation

Unit 2: Calphad approach: history, applications, key activities

Unit 3: Thermodynamic assessment: Input data generation: thermodynamic & phase equilibria data - experimental and theoretical methods, models, Gibbs energy optimization.

Unit 4: Thermodynamic calculations: issues in compilation of thermodynamic database files, calculation of property diagrams and phase diagrams, Gibbs energy minimization

Unit 5: Diffusion in solid state, mobility assessment, kinetic simulations, defect energy incorporation

Suggested Books:

1. Phase equilibria, phase diagrams and phase transformations: their thermodynamic basis. M. Hillert, Cambridge University Press, 2007.
2. Thermodynamics in materials science, R. DeHoff, CRC Press, 2006.
3. Thermodynamics of Solids, R. A. Swalin. Wiley and Sons, 1972.
4. Phase transformations in metals and alloys, D. A. Porter and K. E. Easterling, CRC press, 2009.
5. CALPHAD (calculation of phase diagrams): a comprehensive guide, N. Saunders and A. P. Miodownik, Elsevier, 1998.
6. Computational Thermodynamics: The Calphad Method, H. Lukas, S. G. Fries and B. Sundman, Cambridge university press, 2007.
7. Methods for phase diagram determination, J.-C. Zhao, ed. Elsevier, 2011.

Course Code: PD812

Title of the Course: **Texture and Anisotropy in polycrystalline materials**

L-T-P.....L + P..... Credits.....3+1.....

Prerequisite Course / Knowledge (If any): BTech or MTech in Metallurgy, Materials, Mechanical engineering, Nano Science and Technology.

Course Outcomes (COs)

After completion of this course successfully, the students will be able to.....

CO-1: Identify the crystallographic orientation relationship (understand)

CO-2: Compare the orientation measurement and distribution techniques. (Analyze)

CO-3: Evaluation of texture with different materials processing techniques (Analyze)

CO-4 Describe the texture analysis with anisotropy in material properties (Evaluate)

Detailed Syllabus:

Unit 1: Structure and properties of materials Introduction, different types of materials, crystallographic directions and planes, structure of crystalline solids.

Unit 2: Microstructural Characterization Techniques with Orientation, Average texture by X-ray diffraction pole figures, Electron diffraction in the SEM (EBSD, OIM) and analysis of EBSD data acquisition (Practical)

Unit 3: Origin and development of textures during materials processing stages: solidification, deformation, annealing, phase transformation, coating processes and thin film deposition.

Unit 4: Texture control in Aluminium industry, automotive grade and electrical steels, magnetic and electronic materials.

Unit 5: The effect of texture on elastic and plastic anisotropy in polycrystals; the uniform stress model (Sachs), the Taylor-Bishop Hill model, the Eshelby analysis

Unit 6: Introduction to grain boundary engineering and its applications.

Reference Books:

1. Authors (year), *Title of the Book*, Edition, Publishers, Place of Publication, Page Nos.
2. Olaf Engler, Valarie Randle, Introduction to texture analysis, 2nd Edition, CRC Press, Taylor & Francis, 2009.

3. Satyam Suwas, R.K. Ray, Crystallographic Texture of Materials, Springer, 2014.
4. A.J. Schwartz, M. Kumar, B.L. Adams, D. Field, Electron Back Scattered Diffraction in Materials Science, 2nd Edition, Springer, 2010.
5. U.F. Kocks, H.R. Wenk, C.N. Tome, Texture and anisotropy, Cambridge University Press, 2000.

Course Code: **PD813**

Title of the Course: **Advanced Functional Ceramics**

L-T-P: 3-0-1 Credits: 4

Prerequisite Course/Knowledge (If any): Basic knowledge of physics and chemistry at bachelor level and materials science at bachelor/master level

Advanced and novel ceramic materials with ultimate physical and chemical properties are required to realize next-generation devices. Various intrinsic and extrinsic approaches are utilized to develop new functional ceramics with exotic properties. This course provides an understanding of functional ceramics and the materials design rules for developing some of the advanced ceramics with controlled physical and chemical properties.

After successful completion of this course, the students will be able to:

CO-1: evaluate the physical properties (such as melting point, thermal expansion, strength, surface energy etc) from the bonding and crystal structure of the ceramics

CO-2: analyze the electrical conductivity, oxygen pressure dependence of electronic conductivity of oxygen sensor and color centers in ceramics based on the defect chemistry

CO-3: evaluate the piezoelectric, dielectric, magnetic and electro-optic properties for various engineering applications and to suggest means to optimize these properties

CO-4: correlate the structures with electrical, magnetic, piezoelectric, dielectric and optical properties of various functional ceramics

CO-5: interpret the results of P-E loop, M-H loop, frequency dependence of dielectric constant of any given material

Detailed syllabus:

Unit 1: Bonding and crystal structure of ceramics: Ionic and covalent bonding, FCC, BCC, HCP structure, Different ionic structures according to anion packing: AX , AX_2 , A_2X , $A_mE_nX_p$ structures; Rock salt, Rutile, Zinc blende, Antifluorite, Wurtzite, Corundum, CsCl, Perovskite, Spinel (normal/inverse)

Unit 2: Defects in ceramics and electrical conductivity: Point defects, Kroger-Vink notation, defect chemical reaction, Defect Equilibria in Pure and Stoichiometric Compounds, Schottky Defects, Frenkel Defect Pairs and Intrinsic Ionization of Electrons, Defect Equilibria in Non-stoichiometric Oxides, Brouwer Diagrams, application of defect chemistry in estimating crystal density, color centers, Oxygen sensors

Unit 3: Electro ceramics: Frequency dependence of dielectric constant, polarization and breakdown mechanisms, Ceramic Capacitors: Ferroelectric ceramic materials; Relaxor ferroelectrics; Basic Ceramic Dielectric formulation for capacitors; Grain Boundary Barrier Layer Capacitors, Multi-layer Capacitors; Performance Categories of Ceramic Capacitors

Unit 4: Magnetic ceramics: Soft and hard ferrites. Ni-Zn ferrites, Mn-Zn ferrites, garnets, cubic and hexagonal ferrites, processing and manufacture of ferrites, effect of composition, processing and microstructure on the magnetic properties, applications of magnetic ceramics.

Unit 5: Piezoelectric and Electro-optic ceramics: Piezoelectric constants; Hysteresis, Poling and equivalent circuit for piezoelectric ceramics; Electro optic effect; linear, quadratic and memory electro-optic devices; Piezoelectric material systems, their processing and applications.

Unit 6: Exotic ceramics: Functionally graded, smart/ Intelligent, bio-mimetic, nano- ceramics and applications in energy, environment and health

References:

1. Physical ceramics - Yet-Ming Chiang, Dunbar P. Birnie, W. David Kingery
2. Fundamental of Ceramics - Michel W. Barsoum
3. Ceramic Materials for Electronic Application – R. C. Buchanon
4. Electroceramics: Materials, Properties, Applications - A.J. Moulson & J. M. Herbert,
5. Introduction to Ceramics - W. D. Kingery, H. K. Brown and D. R. Uhlmann
6. Modern Ferrite Technology – Alex Goldman
7. Modern Ceramic Engineering - David. W. Richerson
8. Electroceramics – Hench and West
9. Modern Magnetic materials : Principles and Applications – Robert C.o Handly
10. Review articles and journal papers

Smart Materials for Sensors and Energy Applications

Course Code: PD814

Credit: 4

Smart Materials (SMS) is a multi-disciplinary engineering that explores the creation and utilization of smart material for various applications and is defined as any material that is capable of being controlled such that its response and properties change under a stimulus.

After taking this class, students should be able to understand the basic concepts of smart materials and utilization of smart materials for the development of sensors and energy harvesting. Students will also be able to explain the underlying phenomena or principles that are responsible for the development of sensors and energy devices. They are capable of the development of novel smart materials based on nanomaterials and nanotechnology concepts for sensors and energy applications.

On successful completion of this course, students will be able to:

- Understand the basic concept of smart materials and smart structures
- Develop familiarity with nanomaterials/nanocomposites and their use as sensors and energy applications with various domain
- Able to develop novel nanomaterials and nanotechnology for sensors and energy applications
- Knowledge of various smart materials and utilization in engineering applications
- Read and understand emerging technical literature about the subject

Content

1. An overview of smart materials and its importance to develop sensors and energy materials. Basic concepts about sensors and energy material.
2. Review of materials/nanomaterials selections and requirements related to sensors and energy applications
3. Concept of sensing materials such as nanomaterials, nanocomposites with Case studies
4. Concept of energy materials, development and applications with case studies

Learning Outcomes:

- ✓ Ability to understand the key concepts of sensors and energy materials and related phenomena
- ✓ Ability to develop nanomaterials based smart materials with unique properties for sensors and energy applications
- ✓ Ability to achieve engineering skills to develop sensors for different domains such as chemicals sensors, medical sensors, gas sensors, touch sensors, force sensors etc.
- ✓ Ability to interpret emerging technical literature related to smart materials for sensors and energy applications

TEXTBOOK:

1. Engineering Analysis of Smart Material Systems”, Donald J. Leo, Wiley, 2007.
2. Smart Material Systems and MEMS: Design and Development Methodologies, Vijay K. Varadan and K. J. Vinoy, John Wiley & Sons, 2006.

3. Smart Materials, CRC Press, 2008.
4. Current literature from high impact factor journals

Exam/evaluation: Three internal exams related to project/literature-based including project report submission, presentation and one final exam as per UoH policy.