COURSES OF STUDIES

FOR

M.Phil Examination

(With effect from 2021-22)

MATERIAL SCIENCE

(Semester system)

DEPARTMENT OF MATERIAL SCIENCE

Maharaja Sriram Chandra Bhanja Deo University

Sriram Chandra Vihar

Takatpur, Baripada-757003

M. Phil (Material Science) Examination

1. The course is of one year duration comprising of two semesters.
2. Each student has to carry out project work on Semester-II and submit a dissertation at the end of the semester followed by presentation and Viva-Voice.
3. The examination system for each theory paper consists of 20 marks of IAE, 20 assignments, 10 marks seminar and 50 marks end term semester examination. The IAE will be of one hour duration. The semester examination shall be of 3-hours duration and the question paper shall be of unit pattern with two alternatives from each unit having equal weight.
4. A candidate must secure at least 40% marks in a paper to pass the semester examination.
5. If the candidate passes all the two semester examinations he/she will be declared to have passed the M.Phil examination in Material Science. The student has to secure at least 75% of attendance to be eligible to appear at the University examination.

Programme Outcomes:

- Making aware the students about the various research domains of Material Science.
- Building research aptitude among students regarding the various methodologies that are essential for carrying out cutting edge research.
- Familiarizing students with various data acquisition, interpolation and presentation techniques.
- To make students appreciate the intricacies of field studies that are essential for data validation and problem defining as well as solving in Material Science.
- Enabling students to develop logic in building hypothesis about natural processes and manifestations.
- Enabling students to develop scientific acumen and sound discipline in carrying out field cum laboratory studies.
- To develop scientific knowledge with respect to preparation of scientific reports, project proposals, dissertations, field reports, research articles etc.
- To develop and build discipline and respect for fellow researchers in gathering knowledge and strategy from them.

PROGRAMME SPECIFIC OUTCOME

The M.Phil in Material Science is designed to specifically achieve a few targets such as:

- Sound critical thinking of students based on scientific logic
- Enablement of students with theoretical, field and laboratory skills.
- Motivate themselves and develop an interest in planning and implementation of research.
- Expertise of students with equipment handling for sample acquisition, storage, analysis and error correction.
- Expertise of students with natural process characterization and interpretation.
- Development of the teaching-learning process within the students.
- Development of scientific interest for scientific innovation.
- Substantial aptitude of students towards research ethics

Curricular structure

Semester-I

Course Code	Course Title	Credit	Marks
MS601	Theory Paper-I: (Research Methodology)	05	50
MS603	Theory Paper-II: (X-ray Photo electron Spectroscopy-I)	05	50
MS605	Practical	10	100
Grand Total		20	200

Semester-II

Course Code	Course Title	Credit	Marks
MS602	Theory Paper-III: Elective -I	05	50
MS604	Theory Paper-IV: Elective-II	05	50
MS606	Research review	10	100
Grand Total		20	200

Semester-I

PAPER CODE: MS-601

Detailed Syllabus

PAPER-I: Research Methodology

PAPER OBJECTIVE:

This course is designed based on the objective following objectives;

- ✓ Enlighten students towards creative and critical thinking
- ✓ Develop problem solving skills
- ✓ Quick response to situation

Unit I: What is research? Why to peruse research? Defining the Research problem: objectives, approaches, planning or design, process / methods of research; literature survey. Basics of Research, Fundamental questions like definition of research, logical and systematized applications of the fundamentals of science and scientific techniques, necessity of research in science. Importance of research, generalizations of new theories, outlet for new ideas and insights.

Unit II: Identification of Material Science related research problem, formulating work plan, Dos and Don'ts for selecting a research problem. Importance of problem in National and International scenario, how to conduct research survey (books, journals, electronic search engines like Google, SCOPUS, Wikipedia Research-gate, IGCP Project Data Base, etc.). Research Methodology and techniques used in the field and laboratory for Material Science, Dissemination of research results through conferences, workshops, data generation, report writing and publication of research paper.

Unit III:

Research Methodology is an art of scientific investigations, Material Science related questions and new insights of a Material related event or phenomenon (For Example, Corrosion, Renewable energy like solar, wind etc, Smart electronic material, Failure analysis of metallic structure like turbine, railway tracks etc). Planning, Selection, Formulation and Execution of research project, Thrust area of the project, Objectives of the project and the Course of action (work plan), Conceptual and Empirical literature review. Status of research on international and national level

Unit IV: Data generation and analysis. Fundamentals of scientific Writing and relevant software, Research Ethics, Intellectual Property Rights (IPR) and Plagiarism

PAPER OUTCOME:

At the completion of the course the students will be enlighten towards following facts;

- ✓ Can think creatively and critically towards scientific and societal problems.
- ✓ Can formulate scientific problems and approach towards its solution.
- ✓ Can conduct scientific experiments and analyze the collected data in solving those outlines problems.
- ✓ **Skill development to undertake further research.**
- ✓ **Learn about research ethics.**

Reference Books:

1. Research Methodology For Scientific Research by K. Prathapan.
2. HANDBOOK OF RESEARCH METHODOLOGY, Edition: 1, Publisher: Educreation, ISBN: 978-1-5457-0340-3

Semester-I

PAPER CODE: MS-603

Detailed Syllabus

PAPER-II: X-ray Photoelectron Spectroscopy-I

PAPER OBJECTIVE:

This course is designed based on the objective to develop in depth theoretical and experimental concepts on X-ray Photoelectron spectroscopy to enable learners to perform XPS operation and data analysis independently.

Unit I: Out line and Historical back ground of XPS, Basic of vacuum technology, Vacuum pumps, Rotary pump, diffusion pump, Scroll pump, Ion pump, Titanium sublimation pump, Importance of Vacuum in XPS, attainment of UHV and its maintenance.

Unit II: Introduction to surface characterization, Basic principle of XPS, Why XPS is different from other advance characterization tool, Why to read XPS, X-ray generation in

XPS, X-ray source, Twin-electrode, Monochromator, electron gun, Ion gun charging effect, Electron energy analyzer and types in XPS.

Unit III: Notation of Atomic Electron Levels, Qualitative XPS, Principle of XPS Analysis ,Photoelectron Spectra: Elemental Identification, Chemical Shift of Photoelectron Peak Energy , Auger Parameter, Valence Band Spectra , Satellite Peaks , XPS Line Shapes, Emission Angle Effects.

Unit IV: Introduction to CASA XPS software.

PAPER OUTCOME:

At the completion of the course the students will able to;

- ✓ Understand X-ray Photoelectron spectroscopy.
- ✓ Importance of X-ray Photoelectron spectroscopy as an advance surface characterization tool.
- ✓ Instrumental operation of the spectroscope.
- ✓ Generate the data and analyze it.
- ✓ Able to use CASA-XPS software to analyze the XPS data.
- ✓ **Employability in respective R&D sectors, industries, and laboratories.**
- ✓ **Data production ethics.**

Reference Books:

1. Auger- And X-Ray Photoelectron Spectroscopy in Materials Science: A User-Oriented Guide by Siegfried Hofmann, ISBN: 978-3-642-27381-0.

Semester-II

PAPER CODE: MS-605

Detailed Syllabus

PAPER-III: Practical

PAPER OBJECTIVE: This paper is designed with the following objectives;

- To make students learn the state of art how to synthesize material with tuned morphology
- To motivate students to understand the morphology study by SEM

- To motivate student to learn how to characterize material by XPS

Detailed syllabus

1. Synthesis of morphology controlled nano transition metal oxide powders.
2. Characterization of the synthesized morphology controlled nano transition metal oxide powders by Scanning electron microscopy.
3. Characterization of the synthesized morphology controlled nano transition metal oxide powders by X-ray Photo electron spectroscopy.
4. Data analysis.

PAPER OUTCOME: At the end of this course students will be able to

- ✓ Synthesize material with different morphology according to desired property.
- ✓ Characterize material by SEM and analyze the data
- ✓ Characterize material by XPS and the data analysis thereof.
- ✓ **Skill development and employability in R&D sector, laboratories and academia.**

Semester-II

PAPER CODE: MS-602-A

Detailed Syllabus

PAPER-IV: Elective-I: Physical Metallurgy

PAPER OBJECTIVE:

To develop an understanding of the basis of physical metallurgy and correlate structure of materials with their properties for engineering applications.

Unit I: Diffusion, energetic of solidification Nucleation and growth-dealing homogeneous and heterogeneous nucleations and growth of solids, dendritic growth in pure metals, constitutional super cooling and dendritic growth in alloys.

Unit II: Diffusion, energetic of solidification Nucleation and growth-dealing homogeneous and heterogeneous nucleations and growth of solids, dendritic growth in pure metals, constitutional super cooling and dendritic growth in alloys.

Unit III: Phase diagrams – solid solution –types, Hume –Rothery rule. Phase diagrams – Binary- types – Lever rule. Solidification of different types of solid solutions – Iron-Carbon

diagram – Effect of alloying element on Iron-carbon diagram. Ternary phase diagrams-Understanding of isotherms and isopleths.

Unit IV: Heat treatment of ferrous alloys; Annealing, Normalising, TTT and CCT diagrams, Hardening – hardenability measurements, tempering. Thermo mechanical treatments. Heat treatment furnaces – atmospheres – quenching media – case hardening techniques.

PAPER OUTCOME:

After successfully completing the course, student will be able to:

- ✓ Describe the basic crystal structures (BCC, FCC, and HCP), recognize other crystal structures, and their relationship with the properties.
- ✓ Define and differentiate engineering materials on the basis of structure and properties for engineering applications.
- ✓ Select proper processing technologies for synthesizing and fabricating different materials.
- ✓ Analyse the microstructure of metallic materials using phase diagrams and modify the microstructure and properties using different heat treatments.
- ✓ **Employability in metallurgical industries.**

References

1. Avner, S. H., "Introduction to Physical Metallurgy", second edition, McGraw Hill, 1985.
2. William F. Hosford, Physical Metallurgy, Taylor & Francis Group, 2008.
3. Raghavan, V., "Physical Metallurgy", Prentice Hall of India, 1985 .
4. Donald R Askland and Pradeep P Phule "Essentials of Materials Science and Engineering, Baba Barkha NathPrinters, Delhi.
5. Willam D. Callister, Jr. Materials Science and Engineering, Wiley India Pvt. Ltd.
6. Vijendra Singh, Physical Metallurgy, Standard Publishers.

Semester-II

PAPER CODE: MS-602-B

Detailed Syllabus

PAPER-IV: Elective-I: Advance Material

PAPER OBJECTIVE:

The course intends to present new, relevant and advanced topics within modern materials science and engineering.

UNIT I: Nanostructural Material

Magnetism in particles of reduced size and dimensions- variations of magnetic moment with size – magnetism in clusters of non magnetic solids- magnetic behavior of small particles – diluted magnetic semiconductors (DMS)- Fe –DMS and IV- VI Mn DMS and their applications- intermettalic compounds- binary and ternaries and their magnetic properties

UNIT II : Composite materials: Metal matrix composites- polymer matrix composites- ceramic matrix composites- reinforcements- whisker reinforced ceramics- carbon- carbon composites- design of composite materials –hybrid composites- angled plied composites- unidirectional fiber composites- discontinuous fiber composites- applications of composites in electrical components and nuclear industry.

UNIT III: Light Weight High Strength material

Properties and structural of Titanium- alloying elements- manufacture of titanium wrought products- mechanical properties and microstructural correlation- alloys, aerospace and medical applications- yttrium based iron- chromium aluminum alloy, mechanical alloying process of MA 956 alloy- MAODS super alloys- high temperature and medical application

UNIT IV:

Electrets-properties and applications- metallic glasses- properties and applications- SMART materials- piezoelectric, magnetostrictive, electrostrictive materials- shape memory alloys- rheological fluids- CCD device materials and applications- single crystalline solar cells- amorphous silica solar cells- thin film polycrystalline solar cells- surface acoustic wave and sonar transducer materials and applications

PAPER OUTCOME:

At the end of this course, the students would be able to:

- ✓ Understand Nanostructure material.
- ✓ Understand composite material.
- ✓ Understand strength of material.
- ✓ Understand display device and its basics.
- ✓ **Skill development and Employability in semiconductor industry.**

References:

1. Hand book of Nanophase Materials- edited by Avery N. Goldstein, Maecel Dekker
2. Science and Technology of Nanostructured Magnetic Materials – George C. Hadjipanayis and Gary A. Prinz, NATO ASI series

3. Composite Materials- S. C Sharma
4. Heat Treatment Structure and properties of non- ferrous – Charlie Brooks. R

Semester-II

PAPER CODE: MS-604-A

Detailed Syllabus

PAPER-V: Elective-II: X-ray Photoelectron Spectroscopy-II

PAPER OBJECTIVE:

This course is designed based on the objective to develop in depth theoretical and experimental concepts on X-ray Photoelectron spectroscopy to enable learners to perform XPS operation and data analysis independently.

Unit I: Quantities data analysis, Measurement and determination of intensity, Survey scan, Determination of charging effect, peak calibration, Peak identification, chemical shift, origin of chemical shift.

Unit II: XPS peaks for s, p, d and f orbital, peak symmetry, peak broadening, peak splitting, origin of peak splitting, peak energy separation and its significance.

Unit III: Deconvolution of XPS peaks, Why to deconvolute, how to deconvolute, back ground subtraction, types of peak fitting, dos and don't in peak fitting.

Unit IV: Data analysis and interpretation, data plotting and writing.

PAPER OUTCOME:

At the completion of the course the students will able to;

- ✓ Understand X-ray Photoelectron spectroscopy.
- ✓ Importance of X-ray Photoelectron spectroscopy as an advance surface characterization tool.
- ✓ Instrumental operation of the spectroscope.
- ✓ Generate the data and analyze it.
- ✓ Able to use CASA-XPS software to analyze the XPS data.
- ✓ **Employability in respective R&D sectors, industries, and laboratories.**

Reference books:

1. Auger- And X-Ray Photoelectron Spectroscopy in Materials Science: A User-Oriented Guide by Siegfried Hofmann, ISBN: 978-3-642-27381-0.

Semester-II

PAPER CODE: MS-604-B

Detailed Syllabus

PAPER-V: Elective-II: Smart material and structures

PAPER OBJECTIVE:

- To study various types of smart materials used in engineering application.
- To study processing of smart materials.
- To study basics of sensors and its engineering application.
- To study basics of actuators and its engineering application

UNIT I: Light Weight Materials and Metallic foam

Classes of materials and their usage-intelligent /smart materials-Evalution of materials science-structural materials-functional materials-polyfunctional materials-generation of smart materials Introduction, properties, processing of Aerogels, Aerographite, Metallic Foams, Polymeric Foams, Metallic Microlattices

UNIT II: Smart materials and structural systems

The principal ingredients of smart materials-thermal materials-sensing technology-micro sensors-intelligent systems-hybrid smart materials-an algorithm for synthesizing smart materials-passive sensory smart structures-reactive actuators based smart structures-active sensing and reactive smart structures-smart skins-Aeroelastic tailoring of airfoils-synthesis of future smart systems

UNIT III: Electrorehological (fluids) smart materials

Suspensions and electro-rheological fluids-Bingham body-Newtonian viscosity and non-Newtonian viscosity-principal characteristics of electro-rheological fluids-the electro-rheological phenomena-charge migration mechanism for the dispersed phase-electro-rheological fluid domain-electro-rheological fluid actuators-electro rheological fluid design parameters-Application of Electrorehological fluids

UNIT IV: Piezoelectric smart materials: Background-electrostriction-pyrroelectricity—industrial piezoelectric materials-PZT-PVDF-PVDF film-properties commercial piezoelectric

materials-properties piezoelectric films (explanation)-smart materials featuring piezoelectric elements-smart composite laminates with embedded piezoelectric actuators-SAV filters

Shape memory alloys based smart materials : Background on shape –memory alloys (SMA)-Nickel /Titanium alloys (Nitinol)-Materials characteristics of NitinolMartenstic transformations-Austenitic transformation-thermoplastic martensitic transformation-Cu based SMA-Applications of SMA-continuum applications of SMA fastner-SMA fibers-reaction vessels, nuclear reactor, chemical plants, etc-micro robot actuated by SMA-SMA memorization process (satellite antina application)-SMA blood clot filter-impediments to applications of SMA-SMA plastics-primary molding-secondary molding-potential applications of SMA plastics

PAPER OUTCOME:

At the end of this course, the students would be able to:

- ✓ Understand various smart materials and its importance in engineering application.
- ✓ Know various processing techniques of smart materials.
- ✓ Get knowledge of use of smart material as sensors and actuators.

References:

1. MV Gandhi and BS Thomson, Smart Materials and structures , Chapman and Hall, London, First Ed., 1992.
2. T W Deurig, K N Melton, D Stockel, and C M Wayman, Enggineering aspects of Shape Memory Alloys, Butterworth-Heinemann,1990.
3. C R Rogers, Smart materials, Structure and Mathematical Issue, Technomic Publishing Co., USA, 1989.

Semester-II

PAPER CODE: MS-606

Detailed Syllabus

PAPER-VI: Research review

PAPER OBJECTIVE:

To know in depth exploration of a topic of special interest and to explain, apply relevant theories and laws in the chosen area.

PAPER OUTCOME:

At the end of this course, the students would be able to:

- ✓ Interpret theories and doctrines, and give recommendations where appropriate

- ✓ Acquire knowledge on the chosen topic and apply the knowledge, experience, and skills learned.
- ✓ Produce a thesis of publishable quality.
- ✓ Effectively present and defend research orally.
- ✓ **Serve in any of the academic, Industrial and Research Organizations.**
- ✓ **Learn research ethics.**