Add-on Course Syllabus: Materials Characterization and Analysis

Course Description: Materials Characterization and analysis is an add-on course offered by the Department of Physics, designed to provide students with a comprehensive understanding of the principles, techniques, and applications of materials characterization methods. Through a combination of theoretical lectures, laboratory sessions, and practical demonstrations, students will gain practical skills in analyzing the structure, properties, and behavior of materials at the micro- and nanoscale.

Course Objectives:

1. To introduce students to the fundamental concepts and techniques of materials characterization.
2. To familiarize students with various analytical instruments and methods used for characterizing materials.
3. To enable students to interpret and analyze experimental data obtained from materials characterization techniques.
4. To cultivate critical thinking skills in the evaluation and selection of appropriate characterization techniques for different materials.

Course Outline:

Module 1: Introduction to Materials Characterization

- Overview of materials characterization
- Importance and applications of materials characterization techniques
- Basic principles of materials analysis

Module 2: Crystallography and Microstructural Analysis

- Crystal structure and symmetry
- X-ray diffraction (XRD) analysis
- Electron microscopy techniques (SEM, TEM) for microstructural analysis

Module 3: Spectroscopic Techniques

- Introduction to spectroscopy
- Optical spectroscopy (UV-Vis, FTIR)
- Raman spectroscopy
- Nuclear magnetic resonance (NMR) spectroscopy

Module 4: Thermal Analysis Techniques

- Differential scanning calorimetry (DSC)
- Thermogravimetric analysis (TGA)
- Differential thermal analysis (DTA)

Module 5: Surface Analysis Techniques

- Scanning probe microscopy (AFM, STM)
- X-ray photoelectron spectroscopy (XPS)
- Secondary ion mass spectrometry (SIMS)

Module 6: Mechanical and Electrical Characterization

- Mechanical testing methods (tensile, compressive, hardness)
- Electrical conductivity measurements
- Dielectric spectroscopy

Module 7: Data Analysis and Interpretation

- Statistical analysis of experimental data
- Interpretation of characterization results
- Correlation between structure, properties, and performance of materials

Module 8: Advanced Techniques and Emerging Trends

- Advanced characterization techniques (TEM tomography, in-situ microscopy)
- Nanoscale characterization methods
- Emerging trends in materials characterization (machine learning, big data analytics)

Laboratory Sessions: The course includes hands-on laboratory sessions where students will gain practical experience in using various materials characterization techniques. Laboratory exercises will complement theoretical concepts covered in lectures and provide students with the opportunity to analyze real-world materials samples.

Assessment: Students will be assessed through a combination of assignments, laboratory reports, quizzes, and a final examination. Active participation in laboratory sessions and class discussions will also contribute to the overall assessment.

Prerequisites:

- Basic knowledge of physics and chemistry
- Familiarity with mathematical concepts (calculus, algebra)
- Understanding of basic materials science principles

Textbooks:

1. "Materials Characterization Techniques" by Sam Zhang and Lin Li
2. "Introduction to Materials Science and Engineering" by William D. Callister Jr. and David G. Rethwisch

References:

1. "Scanning Electron Microscopy and X-Ray Microanalysis" by Joseph Goldstein et al.
2. "Transmission Electron Microscopy: A Textbook for Materials Science" by David B. Williams and C. Barry Carter
3. "Handbook of Materials Characterization: Nondestructive Methods and Microscopy" by R.S. Srinivasan and A. Mahadevan