Materials Characterization

1. GENERAL			
SCHOOL	Faculty of Sciences in collaboration with Faculty of Engineering, Aristotle University of Thessaloniki		
DEPARTMENT	Materials Science and Engineering		
LEVEL OF STUDIES	ISCED level 7 (5-year Integrated Master's programme) ISCED level 6 (4-year BSc programme)		
COURSE CODE	**MSEN 502**	**SEMESTER**	5th Semester
COURSE TITLE	Materials Characterization		
TEACHING ACTIVITIES Lectures, tutorials/problem sessions, laboratory/computer exercises (where applicable), case studies and guided self-study.		**TEACHING HOURS PER WEEK**	**ECTS CREDITS**
		4 (3L + 1T)	6
COURSE TYPE	Background / General knowledge / Scientific area		
PREREQUISITES	Physical Chemistry, Inorganic Materials Chemistry		
TEACHING AND EXAMINATION METHODS	Face-to-face lectures and guided problem-solving sessions; short in-class quizzes; final written examination.		
COURSE OFFERED TO ERASMUS STUDENTS	Yes.		
COURSE URL	https://elearning.auth.gr/course/view.php?id=xxxxx		

2. LEARNING OUTCOMES	
Learning Outcomes	**Knowledge** Upon successful completion of the course, students are expected to have acquired knowledge of the scientific principles governing the following topics: interaction of radiation with matter; basic principles and concepts of modern spectroscopic techniques in the field of Materials Science; elastic scattering theory; elastic scattering from individual atoms; X-ray and electron diffraction theory; secondary emission; radiation absorption by materials; radiation generation, detection, and measurement; X-ray Photoelectron Spectroscopy (XPS) and Auger Electron Spectroscopy (AES); electron microscopy (transmission and scanning); X-ray spectroscopy (EDS) for surface and interface analysis; UV–visible (UV-vis) spectroscopy, infrared spectroscopy (FT-IR), and Raman spectroscopy. Skills Upon successful completion of the course, students are expected to have developed skills related to: experimental techniques and instrumentation widely used in the structural and chemical analysis of materials, such as X-ray diffraction, X-ray Photoelectron Spectroscopy (XPS), Auger Electron

	Spectroscopy (AES), electron microscopy (transmission and scanning), and X-ray spectroscopy (EDS); UV–visible (UV-vis) spectroscopy, infrared spectroscopy (FT-IR), and Raman spectroscopy; the proper selection and use of specialized analytical experimental tools in Materials Science for the structural and chemical characterization of materials, including the identification of the appropriate operating regimes of each technique according to the requirements of a given experiment. Competences Upon successful completion of the course, students are expected to have developed the ability to: select and apply appropriate characterization techniques and experimental methodologies for the structural and chemical analysis of materials; and critically evaluate and appropriately use results reported in the scientific literature related to the characterization techniques presented, across different classes of materials.
General Skills	• Problem solving with quantitative reasoning • Teamwork in tutorial and lab-style activities • Information literacy (handbooks, databases, standards awareness) • Technical reporting and oral communication • Ethics and sustainability awareness in materials choices

3. COURSE CONTENT

The course Materials Characterization provides an overview of the fundamental principles and techniques used to analyze the structure, composition, and properties of materials. It introduces different types of radiation and their relationship between energy and wavelength, atomic theory, and electronic energy levels, followed by a discussion of the interaction of radiation with matter, including electromagnetic waves, ionizing and non-ionizing radiation, and elastic scattering phenomena. The course covers the theory and applications of X-ray diffraction (XRD), including X-ray generation, absorption, detection, and basic crystallographic concepts, with emphasis on phase identification and structural analysis. Surface and near-surface characterization techniques such as X-ray Photoelectron Spectroscopy (XPS) and Auger Electron Spectroscopy (AES) are presented, along with Energy Dispersive X-ray Spectroscopy (EDS) for elemental analysis. The principles and instrumentation of electron microscopy, including Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM), are discussed and compared, highlighting their integration with spectroscopic methods. Finally, the course introduces optical spectroscopic techniques, including UV–visible spectroscopy, Fourier Transform Infrared (FT-IR) spectroscopy, and Raman spectroscopy, focusing on their physical principles, instrumentation, spectral interpretation, and representative applications in materials science.

4. LEARNING & TEACHING METHODS - EVALUATION

Teaching method	Face-to-face. Lectures, guided problem sessions, short demonstrations, and small-group activities/case studies.

Use of ICT	Learning management system (e-learning platform) for notes, quizzes and announcements; spreadsheets for simple property charts; basic use of materials databases for information retrieval.
Teaching organization	The supervised and unsupervised workload per activity is indicated below (total workload complies with ECTS standards).

Activity	Workload/semester (hours)
Lectures	39
Tutorials / problem sessions	13
Short assignments / quizzes	10
Independent study	70
Exam preparation	16
Final written exam	2
Total	**150**

Student evaluation	Assessment language: English. Methods: written final exam (60%), homework/problem sets and short quizzes (25%), mini-case study/report (15%). Students are informed via the course guide and e-learning announcements.

5. SUGGESTED BIBLIOGRAPHY

EUDOXUS

To be specified in EUDOXUS.

Additional bibliography for study

- J. P. Eberhart, “Structural and Chemical Analysis of Materials”, John Willey & Sons Inc., 1991.
- D.C. Harris, M.D. Bertolucci, “Symmetry and Spectroscopy” (Dover, NY 1978)
- P.E.J. Flewitt, R.K. Wild, “Physical Methods for Materials Characterization”, IOP Publ., London (1994)
- H.-M. Tong and L.T. Nguyen, Eds., “New Characterization Techniques for Thin Polymer Films”, Wiley, New York (1990)
- D. A. Skoog, F. J. Holler and T. A. Nieman, “Principles of Instrumental Analysis”, 5th Edition, Saunders College Publishing, Philadelphia (1998)