香港城市大學
City University of Hong Kong

City University of Hong Kong
Course Syllabus

offered by Department of Materials Science and Engineering
with effect from Semester A 2024/25

Part I Course Overview

Course Title:	**Materials Characterization Techniques**
Course Code:	**MSE8016**
Course Duration:	**One semester**
Credit Units:	**3**
Level:	**R8**
Medium of Instruction:	**English**
Medium of Assessment:	**English**
Prerequisites: *(Course Code and Title)*	**Nil**
Precursors: *(Course Code and Title)*	**Nil**
Equivalent Courses: *(Course Code and Title)*	**Nil**
Exclusive Courses: *(Course Code and Title)*	**Nil**

Part II Course Details

1. Abstract

This course introduces the fundamental theoretical framework underlying the techniques and instrumentation used in characterizing structural, compositional, and surface properties of materials. The focus is on the acquisition of knowledge of characterization of materials properties and their corresponding physics, instrumentation consideration, strength, and limitations.

Topics covered: Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectroscopy (EDS), Transmission Electron Microscopy (TEM), Scanning Probe Microscopy (SPM), Scanning Tunnelling Microscopy (STM), Atomic Force Microscopy (AFM), Electron Energy Loss Spectroscopy, X-Ray Photoelectron Spectroscopy (XPS), Auger Electron Spectroscopy (AES), Neutron Diffraction, X-ray Diffraction, Electron Diffraction, etc.

2. Course Intended Learning Outcomes (CILOs)

No.	CILOs	Weighting (if applicable)	Discovery-enriched curriculum related learning outcomes		
			A1	*A2*	*A3*
1.	Describe the characteristics of analytical instruments for advanced materials, such as their sensitivities, spectral resolution, spatial resolution, depth of analysis, etc.	25%		√	
2.	Describe the various types of materials characterization techniques, and be able to relate them to the principles of fundamental physics and chemistry.	30%	√	√	
3.	Select advanced analytical techniques and apply them to characterization of different materials and nanomaterials under various analysis conditions.	25%	√	√	√
4.	Analyze, interpret and mutually correlate data to arrive at meaningful conclusions.	20%	√		√
		100%			

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to self-life problems.

A3: *Accomplishments*
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

3. Learning and Teaching Activities (LTAs)

LTA	Brief Description	CILO No.				Hours/week (if applicable)
		1	2	3	4	
Lectures	Explain key concepts, such as the foundation of knowledge in modern methodologies of materials characterization and their applications	√	√	√	√	2hrs/wk
Tutorials	Quizzes related to fundamental knowledge; data analysis and interpretation, such as determination of chemical and phase composition, crystal structure	√	√	√	√	1hr/wk
Term Paper	Write a report to select suitable characterization techniques to obtain structural, chemical, and morphological information on materials	√	√	√	√	

4. Assessment Tasks/Activities (ATs)

Assessment Tasks/Activities	CILO No.				Weighting	Remarks
	1	2	3	4		
Continuous Assessment: 50%						
Assignments	√	√	√	√	15%	
Term paper	√	√	√	√	10%	
Midterm test	√	√	√	√	25%	
Examination (duration: 2 hours)	√	√	√	√	50%	
					100%	

5. Assessment Rubrics

Applicable to students admitted from Semester A 2022/23 to Summer Term 2024

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B)	Marginal (B-, C+, C)	Failure (F)
1. Assignments	Ability to understand and explain the relevant materials	High	Moderate	Basic	Not even reaching marginal levels
2. Midterm test	Ability to understand and explain the relevant materials	High	Moderate	Basic	Not even reaching marginal levels
3. Term Paper	Ability to select suitable characterization techniques to obtain structural, chemical, and morphological information of materials	High	Moderate	Basic	Not even reaching marginal levels
4.Final Examination	Ability to understand and explain the relevant materials	High	Moderate	Basic	Not even reaching marginal levels

Applicable to students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
1. Assignments	Ability to understand and explain the relevant materials	High	Significant	Moderate	Basic	Not even reaching marginal levels
2. Midterm test	Ability to understand and explain the relevant materials	High	Significant	Moderate	Basic	Not even reaching marginal levels
3. Term Paper	Ability to select suitable characterization techniques to obtain structural, chemical, and morphological information of materials	High	Significant	Moderate	Basic	Not even reaching marginal levels
4. Final Examination	Ability to understand and explain the relevant materials	High	Significant	Moderate	Basic	Not even reaching marginal levels

Part III Other Information (more details can be provided separately in the teaching plan)

1. Keyword Syllabus

- General classification of analytical techniques based on the detection source.
- Scanning electron microscopy (SEM). Environmental SEM. Energy dispersive X-ray spectroscopy (EDS).
- Crystallography and diffraction. Real and reciprocal space.
- Transmission electron spectroscopy (TEM). Bright and dark field imaging. High-resolution TEM (HRTEM). Selected area diffraction (SAD).
- Analytical techniques associated with TEM, Electron energy loss spectroscopy (EELS). Energy dispersive x-ray spectroscopy integrated (EDS) in TEM.
- Auger electron spectroscopy (AES). Scanning Auger spectroscopy (SAM). X-ray photoelectron spectroscopy (XPS).
- X-ray Diffraction.
- Neutron Diffraction.
- Scanning probe microscopy (SPM). Atomic force microscopy (AFM). Scanning tunneling microscopy (STM).

2. Reading List

2.1 Compulsory Readings

Nil

2.2 Additional Readings

1.	X-Ray Diffraction for Materials Research: From Fundamentals to Applications, by Myeongkyu Lee (2017)
2.	Transmission Electron Microscopy A Textbook for Materials Science, by David B. Williams, C. Barry Carter (2009)
3.	Transmission Electron Microscopy and Diffractometry of Materials, by Brent Fultz, James How (2008)
4.	Magnetic neutron diffraction (1st edition), Plenum Press, New York, by Yurii A. Izyumov, Ruslan P. Ozerov (1970)
5.	A Beginners' Guide to Scanning Electron Microscopy, by Anwar UI-Hamid (2018)
6.	Scanning Electron Microscopy: Physics of Image Formation and Microanalysis, by Ludwig Reimer (1998)
7.	Auger Electron Microscopy: Practical Application to Materials Analysis and Characterization of Surface, Interfaces, and Thin Films, by John Wolstenholme (2015)
8.	Advanced Transmission Electron Microscopy: Imaging and Diffraction in Nanoscience, by Jian Min Zuo, John C.H. (2017)
9.	Scanning Probe Microscopy: Atomic Force Microscopy and Scanning Tunneling Microscopy, by Bert Voigtländer (2016)