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:	**Instrumentation for Materials Characterization**
Course Code:	**MSE5301**
Course Duration:	**One semester**
Credit Units:	**3**
Level:	**P5**
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)*	**AP5301 Instrumental Methods of Analysis and Laboratory (From the old curriculum)**
Exclusive Courses: *(Course Code and Title)*	**AP8301 Instrumental Methods of Analysis and Laboratory (From the old curriculum)**

Part II Course Details

1. Abstract

This course introduces a fundamental theoretical framework for instrumentation techniques used in characterizing structural, compositional, and surface properties in materials. It aims to provide knowledge on characterization in terms of materials properties and corresponding physics, instrumentation consideration, strength, and limitations. It helps the students to choose suitable characterization techniques and instruments in terms of the desired structural, compositional, morphological, and chemical information of materials. Hands-on experience in a laboratory will be provided for several selected analytical techniques.

Topics covered: generation principles and comparison of X-ray, electron, and neutron, diffraction of X-ray, electron, and neutron; crystal structure representation; Fourier analysis; reciprocal space; scanning probe microscopy including atomic force microscopy and scanning tunneling microscopy; X-ray photoemission spectroscopy and X-ray energy-dispersive spectroscopy; and scanning electron microscopy.

2. Course Intended Learning Outcomes (CILOs)

(CILOs state what the student is expected to be able to do at the end of the course according to a given standard of performance.)

No.	CILOs	Weighting (if applicable)	Discovery-enriched curriculum related learning outcomes (please tick where appropriate)		
			A1	*A2*	*A3*
1.	Explain theoretical frameworks of characterization techniques in various analytical instruments.	30%	√	√	
2.	Describe the methods of quantitative analysis on structural, compositional, morphological, and chemical information based on the various characterization techniques.	30%	√	√	
3.	Explain instrumental designs and generation principles of detection sources such as X-ray, electron, and neutron.	20%	√	√	
4.	Select suitable characterization techniques in terms of the strength and limitations of various instrumentations.	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 real-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)

(LTAs designed to facilitate students' achievement of the CILOs.)

LTA	Brief Description	CILO No.				Hours/week (if applicable)
		1	2	3	4	
Lectures	Students will engage in formal lectures to gain knowledge about instrumentation and techniques for materials characterization	√	√	√	√	26 hrs / 13 wks
Tutorial	Students will engage in in-depth discussion on the topics of characterization techniques and instrumentation, as well as the Q&A sessions of the homework assignments.	√	√	√	√	13 hrs / 13 wks
Laboratories	Students will conduct relevant experiments and write reports to obtain a practical understanding	√	√	√	√	2 hrs / 6 wks

4. Assessment Tasks/Activities (ATs)

(ATs are designed to assess how well the students achieve the CILOs.)

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

5. Assessment Rubrics

(Grading of student achievements is based on student performance in assessment tasks/activities with the following rubrics.)

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. Laboratory and homework 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. Final Examination	Ability to understand and explain the relevant materials	High	Significant	Moderate	Basic	Not even reaching marginal levels

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. Laboratory and homework 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. Final Examination	Ability to understand and explain the relevant materials	High	Moderate	Basic	Not even reaching marginal levels

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

1. Keyword Syllabus

- Overview of detection sources of X-ray, electron, and neutron.
- Crystal structure and material composition
- Optical Microscopy
- Scanning Electron Microscopy
- X-ray photoemission spectroscopy
- Diffraction techniques of X-ray, electron, and neutron
- Scanning probe microscopy: scanning tunneling microscopy and atomic force microscopy
- Surface techniques: auger electron microscopy
- Advanced development in characterization

2. Reading List

2.1 Compulsory Readings

(Compulsory readings can include books, book chapters, or journal/magazine articles. There are also collections of e-books, e-journals available from the CityU Library.)

2.2 Additional Readings

(Additional references for students to learn to expand their knowledge about the subject.)

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)