City University of Hong Kong
Course Syllabus

offered by Department of Materials Science and Engineering
with effect from Semester B 2023/24

Part I Course Overview

Course Title:	**Theory and Practice of Transmission Electron Microscopy and Related Spectroscopy**
Course Code:	**MSE8015**
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

The basically mathematics tools, Fourier transform and Convolution to illustrate the imaging theory of electron microscopy will be firstly introduced. The Abbe microscopy theory and lens aberration in Fourier optics will be discussed. The physics of electron Beam-Sample Interaction that gives the structural signal and radiation damage will be explained. Several imaging modes at atomic resolution in parallel (HRTEM) and focus beam modes will be discussed in detail. The electron beam effect on the dose (rate) dependent in-situ TEM experiment will be explored in detail. Finally, the theory and practice of the future trend of high space / time resolution TEM for atomic resolution dynamics will be discussed in depth. In the end, the theory of atomic resolution EDX and EELS will be lectured.

2. Course Intended Learning Outcomes (CILOs)

No.	CILOs	Weighting* (if applicable)	Discovery-enriched curriculum related learning outcomes (please tick where appropriate)		
			A1	*A2*	*A3*
1.	Describe the mathematics tools: Fourier transform and Convolution			√	
2.	Describe Abbe Imaging Theory and Aberration Theory and Fourier Optics			√	
3.	Describe Electron Beam-Sample Interaction: Elastic Scattering and In-elastic Scattering, Signal and / Radiation Damage			√	
4	Analyze of Structure via Diffraction Pattern			√	
5	Describe Imaging Modes and Imaging Interpretation: Bright Field/ Dark Field, Atomic Resolution in HRTEM and STEM modes			√	
6	In-Situ Transmission Electron Microscopy: Seeing and Believing is Wrong. What do we control to get it right? Dose vs Dose Rate			√	
7	The Future Trend: High Space/ Time Resolution Electron Microscopy: The theory and practice of atomic resolution dynamics for materials science			√	
8	Atomic Resolution Spectroscopy: EELS and EDX			√	
		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. Teaching and Learning Activities (TLAs)

TLA	Brief Description	CILO No.								Hours/week (if applicable)
		1	2	3	4	5	6	7	8	
Lectures	Detail Theory on Fourier Optics, Abbe Microscopy Imaging, Electron Beam Sample interaction, Atomic Resolution Imaging of Parallel and Focus Beams, Radiation Damage, In-Situ Electron Microscopy, High Space/ Time Resolution TEM…	√	√	√	√	√	√	√	√	2 hours/ wk
Tutorial	Homework	√	√	√	√	√	√	√	√	1 hours/ wk

4. Assessment Tasks/Activities (ATs)

Assessment Tasks/Activities	CILO No.								Weighting *	Remarks
	1	2	3	4	5	6	7	8		
Continuous Assessment: _50___%										
Assignments	√	√	√	√	√	√	√	√	15	
Midterm test	√	√	√	√	√	√	√	√	35	
Examination: (duration: 2 hours)	√	√	√	√	√	√	√	√	50	
									100%	

5. Assessment Rubrics

Applicable to students admitted in Semester A 2022/23 and thereafter

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B)	Marginal (B-, C+, C)	Failure (F)
1. Assignments	Understanding and becoming familiar with mathematical tools and theories in the field of electron optics and advanced electron microscopy	High	Moderate	Basic	Not even reaching the marginal levels
2. Midterm	Understanding of the imaging theory and electron beam-sample interaction	High	Moderate	Basic	Not even reaching the marginal levels
3. Examination	Understanding of the good, the bad and the ugly of each imaging mode and the fundamental physics for future trend of atomic resolution electron microscopy	High	Moderate	Basic	Not even reaching the marginal levels

Applicable to students admitted before Semester A 2022/23

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
1. Assignments	Understanding and becoming familiar with mathematical tools and theories in the field of electron optics and advanced electron microscopy	High	Significant	Moderate	Basic	Not even reaching the marginal levels
2. Midterm	Understanding of the imaging theory and electron beam-sample interaction	High	Significant	Moderate	Basic	Not even reaching the marginal levels
3. Examination	Understanding of the good, the bad and the ugly of each imaging mode and the fundamental physics for future trend of atomic resolution electron microscopy	High	Significant	Moderate	Basic	Not even reaching the marginal levels

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

1. Keyword Syllabus

- Fourier Optics
- Abbe Microscopy Theory
- Electron Optics and Aberration Theory
- Elastic Scattering and In-elastic Scattering
- Dose, Dose Rate and Radiation Damage
- High Resolution Electron Microscopy and Scanning Transmission Electron Microscopy
- Electron Beam Effect on In-Situ Electron Microscopy
- High Space/ Time Resolved Electron Microscopy

2. Reading List

2.1 Compulsory Readings

1.	Lecture Notes
2.	D.B.Williams 2009 Transmission Electron Microscopy A Textbook for Materials Science.pdf
3.	L.Raimer 2008 Transmission Electron Microscopy: physics of image formation
…	

2.2 Additional Readings

1.	
2.	
3.	
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