

# MSE5301: INSTRUMENTATION FOR MATERIALS CHARACTERIZATION

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## Effective Term

Semester A 2025/26

## Part I Course Overview

### Course Title

Instrumentation for Materials Characterization

### Subject Code

MSE - Materials Science and Engineering

### Course Number

5301

### Academic Unit

Materials Science and Engineering (MSE)

### College/School

College of Engineering (EG)

### Course Duration

One Semester

### Credit Units

3

### Level

P5, P6 - Postgraduate Degree

### Medium of Instruction

English

### Medium of Assessment

English

### Prerequisites

Nil

### Precursors

Nil

### Equivalent Courses

AP5301 Instrumental Methods of Analysis and Laboratory (From the old curriculum)

### Exclusive Courses

AP8301 Instrumental Methods of Analysis and Laboratory (From the old curriculum)

## Part II Course Details

### 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.

### Course Intended Learning Outcomes (CILOs)

CILOs		Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Explain theoretical frameworks of characterization techniques in various analytical instruments.	30	x	x	
2	Describe the methods of quantitative analysis on structural, compositional, morphological and chemical information based on the various characterization techniques.	30	x	x	
3	Explain instrumental designs and generation principles of detection sources such as X-ray, electron and neutron.	20	x	x	
4	Select suitable characterization techniques in terms of the strength and limitations of various instrumentations.	20	x		

#### 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.

### Learning and Teaching Activities (LTAs)

LTAs	Brief Description	CILO No.	Hours/week (if applicable)	
1	Lectures	Students will engage in formal lectures to gain knowledge about instrumentation and techniques for materials characterization	1, 2, 3, 4	26 hrs / 13 wks

2	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.	1, 2, 3, 4	13 hrs / 13 wks
3	Laboratories	Students will conduct relevant experiments and write reports to obtain a practical understanding	1, 2, 3, 4	2 hrs / 6 wks

**Assessment Tasks / Activities (ATs)**

	ATs	CILO No.	Weighting (%)	Remarks ("- for nil entry)	Allow Use of GenAI?
1	Laboratories	1, 2, 3, 4	10	-	No
2	Homework assignments	1, 2, 3, 4	10	-	No
3	Midterm test and quizzes	1, 2, 3, 4	30	-	No

**Continuous Assessment (%)**

50

**Examination (%)**

50

**Examination Duration (Hours)**

2

**Assessment Rubrics (AR)****Assessment Task**

Laboratory and homework assignments (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

**Criterion**

Ability to understand and explain the relevant materials

**Excellent**

(A+, A, A-) High

**Good**

(B+, B, B-) Significant

**Fair**

(C+, C, C-) Moderate

**Marginal**

(D) Basic

**Failure**

(F) Not even reaching marginal levels

**Assessment Task**

Midterm Test and Quizzes (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

**Criterion**

Ability to understand and explain the relevant materials

**Excellent**

(A+, A, A-) High

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(B+, B, B-) Significant

**Fair**

(C+, C, C-) Moderate

**Marginal**

(D) Basic

**Failure**

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**Assessment Task**

Final Examination (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

**Criterion**

Ability to understand and explain the relevant materials

**Excellent**

(A+, A, A-) High

**Good**

(B+, B, B-) Significant

**Fair**

(C+, C, C-) Moderate

**Marginal**

(D) Basic

**Failure**

(F) Not even reaching marginal levels

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**Assessment Task**

Laboratory and homework assignments (for students admitted from Semester A 2022/23 to Summer Term 2024)

**Criterion**

Ability to understand and explain the relevant materials

**Excellent**

(A+, A, A-) High

**Good**

(B+, B) Moderate

**Marginal**

(B-, C+, C) Basic

**Failure**

(F) Not even reaching marginal levels

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Midterm Test and Quizzes (for students admitted from Semester A 2022/23 to Summer Term 2024)

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## Part III Other Information

**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

### Reading List

#### Compulsory Readings

Title	
1	Nil

#### Additional Readings

Title	
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)