PHY4285: INTRODUCTION TO SCATTERING SCIENCES

New Syllabus Proposal

Effective Term
Semester B 2024/25

Part I Course Overview

Course Title
Introduction to Scattering Sciences

Subject Code
PHY - Physics
Course Number
4285

Academic Unit
Physics (PHY)

College/School
College of Science (SI)

Course Duration
One Semester

Credit Units
3

Level
B1, B2, B3, B4 - Bachelor's Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
Nil

Precursors
Nil

Equivalent Courses
Nil

Exclusive Courses
Nil

Part II Course Details

Abstract

This is an introductory course covering a range of experimental and applied physics topics that involve synchrotron X-ray and neutron scattering. Its central aims are: (1) to describe the fundamentals of scattering by matter, (2) to introduce different scattering techniques and instruments available at large facilities, and (3) to motivate the students for discovery and innovation in applying advanced scattering techniques in their own research and development work.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Explain the importance of modern scattering techniques and their applications in scientific research.		x		
2	Clarify the similarities and differences between X-ray and neutron scattering.		x		
3	Recognize the fundamental theory of scattering and its application to study the structures of different classes of materials.			x	
4	Apply X-ray and neutron diffraction to determine the structure and understand the structural change during a phase transformation.			x	x
5	Familiar with the principles of deformation study with neutron and synchrotron X-ray.			x	x
6	Master the basic knowledge of small angle X-ray scattering (SAXS), small angle neutron scattering (SANS) for determining the large-scale structure of materials.			x	x
7	Describe the basics of inelastic neutron-scattering (INS) and quasi-elastic-neutron-scattering (QENS) to study the dynamics of liquids and soft materials.			x	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.

Teaching and Learning Activities (TLAs)

	TLAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lectures	Explain the basic principles of modern theories related to diffraction, small-angle, inelastic and quasi-elastic scattering techniques.	1, 2, 3, 4, 5, 6, 7	3
2	Tutorials	Problem solving related to scattering.	1, 2, 3, 4, 5, 6, 7	1

Additional Information for TLAs

The "Lectures" will be in the form of 3-hrs lectures each week, while the "Tutorials" and/or the "Laboratory demonstrations" will always follow the lectures.

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Assignments	2, 3, 4, 5, 6, 7	40	
2	Midterm Test	1, 2, 3, 4, 5, 6, 7	30	

Continuous Assessment (%)

70

Examination (%)

30

Examination Duration (Hours)

2

Assessment Rubrics (AR)

Assessment Task

1. Assignments

Criterion

Ability to explain key concepts of modern scattering methods and applying the theory to select problems.

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not even marginal level

Assessment Task
2. Midterm Test

Criterion
Ability to explain concepts of different scattering methods.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even marginal level

Assessment Task
3. Final examination

Criterion
Understanding of fundamental concepts of different scattering methods, including diffraction, SAXS, SANS, INS, and QENS .

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even marginal level

Part III Other Information

Keyword Syllabus

1. Keyword Syllabus

· Introduction

Applications of scattering techniques on different materials: the structures of crystalline, liquid and amorphous substances with showing materials of specific interest in modern life

- Fundamentals of scattering techniques: neutron diffraction, X-rays diffraction, scattering mechanisms, similarities and differences in X-ray and neutron scattering
- Neutron and synchrotron diffraction to determine the crystal structures, experimental methods and the associated data analysis techniques, characterizing the physical mechanisms underlying the structural changes during a phae transition
- Engineering diffraction, application to the study of deformation behaviors, experimental methods and the associated data analysis to extract microscopic insights on deformation in advanced materials
- Small angle X-ray scattering (SAXS) and small angle neutron scattering (SANS), scattering by non-crystalline materials
- Neutron Reflectometry (NR) and polarized neutrons, study of thin films and 2D materials
- Inelastic-neutron-scattering (INS) and magnetic and crystal field excitations
- Quasi-elastic-neutron-scattering (QENS), atomic and molecular motion
- Neutron spin echo (NSE) and its applications

Reading List

Compulsory Readings

	Title
1	B. E. Warren, X-ray diffraction, Dover Books on Physics, 1964
2	"Neutron Scattering Primer", by Roger Pynn
3	G. L. Squires, Introduction to the Theory of Thermal Neutron Scattering, Cambridge University Press, 1978

Additional Readings

	Title
1	L. H. Schwartz & J. B. Cohen, Diffraction from materials, Academic Press, 1977
2	G. E. Bacon, Neutron diffraction, Clarendon Press, 1975
3	Ilias Michalarias & Dr. Jichen Li, Neutron Scattering Experiments of Water in Biomolecules, University of Manchester, 2005
4	F. H. Chung & D. K. Smith Eds. Industrial Applications of X-ray Diffraction, Marcel Dekker, Inc. USA, 2000
5	M. Bee, Quasielastic Neutron Scattering, Principles and Applications in Solid State Chemistry, Biology and Materials Science, Taylor & Francis; 1 edition (January 1, 1988)
6	Stewart F. Parker, Inelastic Neutron Scattering Spectroscopy, Wiley, 2006.
7	T. Egami and S. J. L. Billinge, "Underneath the Bragg Peaks, Structure Analysis of Complex Materials," Elsevier, 2003.
8	"Interactions of Photons and Neutrons with Matter" by Sow-Hsin Chen and Michael Kotlarchyk, 2nd edition
9	"Small Angle X-ray and Neutron Scattering from Solutions of Biological Macromolecules" by Dmitri I. Svergun, Michel H.J. Koch, Peter A. Timmins, Roland P. May
10	"Elements of Slow-Neutron Scattering: Basics, Techniques, and Applications" by J.M. Carpenter & C.-K. Loong, Cambridge University Press (2015)
11	"Theory of neutron scattering from condensed matter" by Stephen W. Lovesey
12	"Principles of Neutron Scattering from Condensed Matter" by Andrew Boothroyd