PHY6504: PHYSICS AT NANOSCALE

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
Physics at Nanoscale

Subject Code
PHY - Physics
Course Number
6504

Academic Unit
Physics (PHY)

College/School
College of Science (SI)

Course Duration
One Semester

Credit Units
3

Level
P5, P6 - Postgraduate Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
Nil

Precursors
PHY3251 Quantum Mechanics or equivalent

Equivalent Courses
Nil

Exclusive Courses
PHY8504 Physics at Nanoscale

Part II Course Details

Abstract
This course is the introductory course on nanoscience for the MSc and PhD Students in Applied Physics Programme and is designed to familiarize the students to the interdisciplinary aspects of nano-science by integrating important components

of the broad research field. While focusing on physics, this integrated approach will cross the traditional disciplines of materials science, biology, chemistry, and electrical engineering. Fundamental properties of materials at the nanoscale, synthesis of nanoparticles/nanomaterials, characterization tools, and properties of nanoscale devices and systems will be covered.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Describe the unique interactions and effects occurring at the nanoscale.	25		x	
2	Describe how quantization in nanomaterials impacts electrical, optical, and magnetic properties.	25		x	
3	Describe how nanomaterials are synthesized and integrate nanomaterials in applications, particularly in the fields of: electronics, energy devices, and medicine/medical devices.	25	x		
4	Demonstrate the capacity for self-directed learning on topics related to nanoscience and nanotechnology.	25			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	Lecture	Explain key concepts and theory of topics of the course	1, 2, 3	2
2	Tutorial	Explain how some problems are solved and the techniques used	1, 2, 3, 4	1
3	Assignments	Homework and Projects	1, 2, 3, 4	

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Coursework	1, 2, 3	30	Bi-weekly assignments	Yes

2	Oral Presentation	1, 2, 3, 4	30	Oral presentation on the group project studying a specific nanoscience phenomenon	No
3	Final Report	1, 2, 3, 4	40	Final Report on the group project	Yes

Continuous Assessment (%)

100

Assessment Rubrics (AR)

Assessment Task

1. Coursework (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

1. Capacity for using physics knowledge and theory to solve problems.
2. Demonstrate correct understanding of key concepts.

Excellent

(A+, A, A-) Student completes all assignments, and demonstrates excellent understanding of the scientific principles governing the behaviour at the nanoscale.

Good

(B+, B, B-) Student completes at least 80% of assignments, and demonstrates understanding of the scientific principles governing the behaviour at the nanoscale.

Fair

(C+, C, C-) Student completes at least 60% of assignments, and shows some of the scientific principles governing the behaviour at the nanoscale.

Marginal

(D) Student completes at least 50% of assignments, but can only demonstrate brief understanding of the scientific principles governing the behaviour at the nanoscale.

Failure

(F) Student completes less than 50% of assignments. Or, fails to accurately describe the scientific principles governing the behaviour at the nanoscale.

Assessment Task

2. Oral Presentation (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

1. Demonstrate correct understanding of key concepts.
2. Expand on learned concepts via self-learning.

Excellent

(A+, A, A-) Student can thoroughly identify and describe how the principles are applied to science and technology. Student’ s work shows strong evidence of original thinking, as well as ability to utilize information sources other than taught material. Student is able to communicate ideas effectively via text and oral presentation.

Good

(B+, B, B-) Student can identify and describe how the principles are applied to science and technology. Student’s work shows evidence of original thinking, as well as ability to utilize information sources other than taught material. Student is generally able to communicate ideas via text and oral presentation.

Fair

(C+, C, C-) Student provides simple but accurate evaluations of how the principles are applied to science and technology. Student’s work shows some evidence of original thinking, as minimal as ability to utilize information sources other than taught material. Student is able to communicate ideas via text and oral presentation.

Marginal

(D) Student can provide only brief descriptions how the principles are applied to science and technology. Student’s work shows little evidence of original thinking, and no use of information sources other than taught material. Student is able to poorly, but accurately to communicate ideas via text and oral presentation.

Failure

(F) Student fails to demonstrate how the principles are applied to science and technology. Student’s work shows evidence of plagiarism. Student fails to complete the assignment.

Assessment Task

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

Criterion

1. Demonstrate correct understanding of key concepts.
2. Expand on learned concepts via self-learning.

Excellent

(A+, A, A-) Student can thoroughly identify and describe how the principles are applied to science and technology. Student’s work shows strong evidence of original thinking, as well as ability to utilize information sources other than taught material. Student is able to communicate ideas effectively via text and oral presentation.

Good

(B+, B, B-) Student can identify and describe how the principles are applied to science and technology. Student’s work shows evidence of original thinking, as well as ability to utilize information sources other than taught material. Student is generally able to communicate ideas via text and oral presentation.

Fair

(C+, C, C-) Student provides simple but accurate evaluations of how the principles are applied to science and technology. Student’s work shows some evidence of original thinking, as minimal as ability to utilize information sources other than taught material. Student is able to communicate ideas via text and oral presentation.

Marginal

(D) Student can provide only brief descriptions how the principles are applied to science and technology. Student’s work shows little evidence of original thinking, and no use of information sources other than taught material. Student is able to poorly, but accurately to communicate ideas via text and oral presentation.

Failure

(F) Student fails to demonstrate how the principles are applied to science and technology. Student’s work shows evidence of plagiarism. Student fails to complete the assignment.

Assessment Task

1. Coursework (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

1. Capacity for using physics knowledge and theory to solve problems.
2. Demonstrate correct understanding of key concepts.

Excellent

(A+, A, A-) Student completes all assignments, and demonstrates excellent understanding of the scientific principles governing the behaviour at the nanoscale.

Good

(B+, B) Student completes at least 80% of assignments, and demonstrates understanding of the scientific principles governing the behaviour at the nanoscale.

Marginal

(B-, C+, C) Student completes at least 50% of assignments, but can only demonstrate brief understanding of the scientific principles governing the behaviour at the nanoscale.

Failure

(F) Student completes less than 50% of assignments. Or, fails to accurately describe the scientific principles governing the behaviour at the nanoscale.

Assessment Task

2. Oral Presentation (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

1. Demonstrate correct understanding of key concepts.
2. Expand on learned concepts via self-learning.

Excellent

(A+, A, A-) Student can thoroughly identify and describe how the principles are applied to science and technology. Student’s work shows strong evidence of original thinking, as well as ability to utilize information sources other than taught material. Student is able to communicate ideas effectively via text and oral presentation.

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(B+, B) Student can identify and describe how the principles are applied to science and technology. Student’s work shows evidence of original thinking, as well as ability to utilize information sources other than taught material. Student is generally able to communicate ideas via text and oral presentation.

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Failure

(F) Student fails to demonstrate how the principles are applied to science and technology. Student’s work shows evidence of plagiarism. Student fails to complete the assignment.

Assessment Task

3. Final Report (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

1. Demonstrate correct understanding of key concepts.
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Marginal

(B-, C+, C) Student can provide only brief descriptions how the principles are applied to science and technology. Student’s work shows little evidence of original thinking, and no use of information sources other than taught material. Student is able to poorly, but accurately to communicate ideas via text and oral presentation.

Failure

(F) Student fails to demonstrate how the principles are applied to science and technology. Student’s work shows evidence of plagiarism. Student fails to complete the assignment.

Part III Other Information

Keyword Syllabus

- Physical properties of nanomaterials: electrons in nanostructures, photons in nanostructures, electronic transport in mesoscopic devices.
-Introduction to the quantum Hall effects.
- Major classes of nanomaterials: quantum dots, nano-wires/nano-tubes, thin films and atomically-thin materials
- Synthesis of nanomaterials: thin film fabrication (thermal evaporation, e-beam evaporation, pulsed-laser deposition, molecular-beam epitaxy, sputtering), bottom-up fabrication (epitaxy, CVD, self-assembly), electron-beam lithography
- Characterization of nanomaterials: electron microscopy, atomic force microscopy, spectroscopy (Raman), crystallography

- Application areas: electronics, quantum computing, energy applications, nano-biology

Reading List

Compulsory Readings

	Title
1	Edward L. Wolf, Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience, Wiley-VCH, 2nd ed. (2006).
2	David K. Ferry, Transport in nanostructures, Cambridge University Press, 2nd ed. (2009).

Additional Readings

	Title
1	S. M. Lindsay, Introduction to Nanoscience.
2	C. Binns, Introduction to Nanoscience and Nanotechnology.
3	Supriyo Datta, Electronic Transport in Mesoscopic Systems.