**City University of Hong Kong**
**Course Syllabus**

**offered by Department of Physics**
**with effect from Semester B 2022/23**

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## Part I Course Overview

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|---|---|
| **Course Title:** | **Physics at Nanoscale** |
| **Course Code**: | **PHY8504** |
| **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)* | **PHY3251 Quantum Mechanics or equivalent** |
| **Equivalent Courses**: *(Course Code and Title)* | **Nil** |
| **Exclusive Courses**: *(Course Code and Title)* | **PHY6504 Physics at Nanoscale** |

**Part II Course Details**

## 1. 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.

## 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 unique interactions and effects occurring at the nanoscale. | 25 | | ✔ | |
| 2. | Describe how quantization in nanomaterials impacts electrical, optical, and magnetic properties. | 25 | | ✔ | |
| 3. | Describe how nanomaterials are synthesized and integrate nanomaterials in applications, particularly in the fields of: electronics, energy devices, and medicine/medical devices. | 25 | ✔ | | |
| 4. | Demonstrate the capacity for self-directed learning on topics related to nanoscience and nanotechnology. | 25 | | | ✔ |
| ** If weighting is assigned to CILOs, they should add up to 100%.* | | 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 | | | |
| Lecture | Explain key concepts and theory of topics of the course | ✔ | ✔ | ✔ | | | | 2 |
| Tutorial | Explain how some problems are solved and the techniques used. | ✔ | ✔ | ✔ | ✔ | | | 1 |
| Assignments | Homework and Projects | ✔ | ✔ | ✔ | ✔ | | | |

## 4. Assessment Tasks/Activities (ATs)

| Assessment Tasks/Activities | CILO No. | | | | | | Weighting* | Remarks |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | | | | |
| Continuous Assessment: 100% | | | | | | | | |
| Coursework | ✔ | ✔ | ✔ | | | | 30% | Bi-weekly assignments |
| Oral Presentation | ✔ | ✔ | ✔ | ✔ | | | 30% | Oral presentation on the group project studying a specific nanoscience phenomenon |
| Final Report | ✔ | ✔ | ✔ | ✔ | | | 40% | Final Report on the group project |
| ** The weightings should add up to 100%.* | | | | | | | 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. Coursework | 1. Capacity for using physics knowledge and theory to solve Problems.<br>2. Demonstrate correct understanding of key concepts. | Student completes all assignments, and demonstrates excellent understanding of the scientific principles governing the behaviour at the nanoscale. | Student completes at least 80% of assignments, and demonstrates understanding of the scientific principles governing the behaviour at the nanoscale. | Student completes at least 50% of assignments, but can only demonstrate brief understanding of the scientific principles governing the behaviour at the nanoscale. | Student completes less than 50% of assignments. Or, fails to accurately describe the scientific principles governing the behaviour at the nanoscale. |
| 2. Project | 1. Demonstrate correct understanding of key concepts.<br>2. Expand on learned concepts via self-learning. | 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. | 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. | 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. | 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. |

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. Coursework | 1. Capacity for using physics knowledge and theory to solve Problems.<br>2. Demonstrate correct understanding of key concepts. | Student completes all assignments, and demonstrates excellent understanding of the scientific principles governing the behaviour at the nanoscale. | Student completes at least 80% of assignments, and demonstrates understanding of the scientific principles governing the behaviour at the nanoscale. | Student completes at least 60% of assignments, and shows some of the scientific principles governing the behaviour at the nanoscale. | Student completes at least 50% of assignments, but can only demonstrate brief understanding of the scientific principles governing the behaviour at the nanoscale. | Student completes less than 50% of assignments. Or, fails to accurately describe the scientific principles governing the behaviour at the nanoscale. |
| 2. Examination | 1. Capacity for using physics knowledge and theory to solve Problems.<br>2. Demonstrate correct understanding of key concepts. | Demonstrates excellent understanding of the scientific principles governing the behaviour at the nanoscale. | Demonstrates understanding of the scientific principles governing the behaviour at the nanoscale. | Shows some of the scientific principles governing the behaviour at the nanoscale. | Can only demonstrate brief understanding of the scientific principles governing the behaviour at the nanoscale. | Fails to accurately describe the scientific principles governing the behaviour at the nanoscale. |
| 3. Project | 1. Demonstrate correct understanding of key concepts.<br>2. Expand on learned concepts via self-learning. | 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. | 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. | 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. | 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. | 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**

**1. 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

**2. Reading List**

**2.1 Compulsory Readings**

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|---|---|
| 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). |

**2.2 Additional Readings**

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