City University of Hong Kong
Course Syllabus

offered by College/School/Department of Physics
with effect from Semester A 2025/26

Part I Course Overview

Course Title:	**Data Analysis and Modelling in Physics**
Course Code:	**PHY5506**
Course Duration:	**One semester**
Credit Units:	**3 credits**
Level:	**P5**
Medium of Instruction:	**English**
Medium of Assessment:	**English**
Prerequisites: *(Course Code and Title)*	
Precursors: *(Course Code and Title)*	
Equivalent Courses: *(Course Code and Title)*	
Exclusive Courses: *(Course Code and Title)*	

Part II Course Details

1. Abstract

Data analysis and computational modelling play essential roles in many areas of physics. This course aims to introduce some commonly used numerical techniques, such as root finding, integration and differentiation, solving ordinary differential equations, Fourier analysis, etc., and some commonly used computer simulation methods, such as molecular dynamics, Monte Carlo, etc.

2. Course Intended Learning Outcomes (CILOs)

(CILOs state what the student is expected to be able to do at the end of the course according to a given standard of performance.)

No.	CILOs	Weighting* (if applicable)	Discovery-enriched curriculum related learning outcomes (please tick where appropriate)		
			A1	*A2*	*A3*
1.	Recognize the importance of data analysis and modelling in multidisciplinary sciences.		√	√	√
2.	Implement common numerical techniques, such as data fitting, root finding, differentiation and integration, solution to ordinary differential equations, matrix operations, and apply them to solve physics problems		√	√	√
3.	Understand the principles of computer simulation methods, such as molecular dynamics, Monte Carlo		√	√	
** 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. Learning and Teaching Activities (LTAs)

(LTAs designed to facilitate students' achievement of the CILOs.)

LTA	Brief Description	CILO No.			Hours/week (if applicable)
		1	2	3	
Lectures	Presentation of course material	√	√	√	3

4. Assessment Tasks/Activities (ATs)

(ATs are designed to assess how well the students achieve the CILOs.)

Assessment Tasks/Activities	CILO No.			Weighting*	Remarks
	1	2	3		
Continuous Assessment: _30_%					
Assignments	√	√	√	10%	
Midterm exam	√	√		20%	
Examination: _70_% (duration: 2 hours, if applicable)					
** The weightings should add up to 100%.*				100%	

5. Assessment Rubrics

(Grading of student achievements is based on student performance in assessment tasks/activities with the following rubrics.)

Applicable to students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
1. Tests	Understand the typical data analysis methods for different tasks in physics; understand the popular modelling methods for different physical systems and problems; be able to describe popular algorithms in modelling; be able to write the codes to implement popular algorithms	High (excellent accomplishment with creativity and correct understanding)	Significant (good accomplishment with mostly correct understanding)	Moderate (fair accomplishment with some correct understanding)	Basic (essential accomplishment with basic understanding)	Not reaching marginal level
2. Assignments	Understand the typical data analysis methods for different tasks in physics; understand the popular modelling methods for different physical systems and problems; be able to describe popular algorithms in modelling; be able to write the codes to implement popular algorithms	High (excellent accomplishment with creativity and correct understanding)	Significant (good accomplishment with mostly correct understanding)	Moderate (fair accomplishment with some correct understanding)	Basic (essential accomplishment with basic understanding)	Not reaching marginal level
3. Examination	Understand the typical data analysis methods for different tasks in physics; understand the popular modelling methods for different physical systems and problems; be able to describe popular algorithms in modelling; be able to write the codes to implement popular algorithms	High (excellent accomplishment with creativity and correct understanding)	Significant (good accomplishment with mostly correct understanding)	Moderate (fair accomplishment with some correct understanding)	Basic (essential accomplishment with basic understanding)	Not reaching marginal level

Applicable to students admitted from Semester A 2022/23 to Summer Term 2024

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B)	Marginal (B-, C+, C)	Failure (F)
1. Tests	Capacity for using physics knowledge and theory to solve problems	Will exhibit a high level of competence in understanding, explaining, and integrating the knowledge in written format	Will exhibit a good level of competence in understanding, explaining, and integrating the knowledge in written format	Will exhibit some deficiencies in understanding, explaining, and integrating the knowledge in written format	Will exhibit lack of competence in understanding, explaining, and integrating the knowledge in written format
2. Assignments	Capacity for using physics knowledge and theory to solve problems	Will exhibit a high level of competence in understanding, explaining, and integrating the knowledge in written format	Will exhibit a good level of competence in understanding, explaining, and integrating the knowledge in written format	Will exhibit some deficiencies in understanding, explaining, and integrating the knowledge in written format	Will exhibit lack of competence in understanding, explaining, and integrating the knowledge in written format
3. Examination	Capacity for using physics knowledge and theory to solve problems	Will exhibit a high level of competence in understanding, explaining, and integrating the knowledge in written format	Will exhibit a good level of competence in understanding, explaining, and integrating the knowledge in written format	Will exhibit some deficiencies in understanding, explaining, and integrating the knowledge in written format	Will exhibit lack of competence in understanding, explaining, and integrating the knowledge in written format

Part III Other Information

1. Keyword Syllabus

- Data fitting
  Linear and non-linear fittings, determination of the goodness of the fit,

- Root finding methods
  Bisection method, Newton-Raphson method, applications (e.g. finite square well in quantum mechanics)

- Numerical integration
  Rectangular and trapezoid integration, Gaussian integration, applications (e.g. in electrostatics)

- Numerical differentiation
  Forward difference, central difference and higher order methods, higher order derivatives

- Numerical solutions to ordinary differentiation equations
  Euler methods, Runge-Kutta methods, applications (e.g. damped oscillators)

- Numerical methods for matrices
  Linear systems of equations, Gaussian elimination, Eigenvalue problems, applications (e.g. in quantum mechanics)

- Fourier analysis
  Fourier series, Fourier transform, discrete Fourier transform, Fast Fourier transform, spectral analysis, applications (e.g. non-linear oscillators)

- Molecular dynamics
  Principle of molecular dynamics, popular software, application areas

- Monte Carlo simulation

2. Reading List

2.1 Compulsory Readings

(Compulsory readings can include books, book chapters, or journal/magazine articles. There are also collections of e-books, e-journals available from the CityU Library.)

1.	Mark Newman, “Computational Physics”, CreateSpace, 2013

2.2 Additional Readings

(Additional references for students to learn to expand their knowledge about the subject.)

1.	Daan Frenkel, Berend Smit, “Understanding Molecular Simulation: From Algorithms to Applications”, San Diego: Academic Press, 1996. (QD461 .F86 1996)
2	K Binder, D W Heermann, “Monte Carlo Simulation in Statistical Physics: An Introduction”, Berlin : Springer Verlag, 1988. (C0092255)