PHY5506: DATA ANALYSIS AND MODELLING IN PHYSICS

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
Data Analysis and Modelling in Physics

Subject Code
PHY - Physics
Course Number
5506

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
Nil

Equivalent Courses
Nil

Exclusive Courses
PHY8516 Data Analysis and Modelling in Physics

Part II Course Details

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.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Recognize the importance of data analysis and modelling in multidisciplinary sciences.		x	x	x
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		x	x	x
3	Understand the principles of computer simulation methods, such as molecular dynamics, Monte Carlo		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.

Learning and Teaching Activities (LTAs)

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

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Assignments	1, 2, 3	10	-	No
2	Midterm exam	1, 2	20	-	Yes

Continuous Assessment (%)

30

Examination (%)

70

Examination Duration (Hours)

2

Assessment Rubrics (AR)

Assessment Task

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

Criterion

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

Excellent

(A+, A, A-) High (excellent accomplishment with creativity and correct understanding)

Good

(B+, B, B-) Significant (good accomplishment with mostly correct understanding)

Fair

(C+, C, C-) Moderate (fair accomplishment with some correct understanding)

Marginal

(D) Basic (essential accomplishment with basic understanding)

Failure

(F) Not reaching marginal level

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Assessment Task

Tests (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Capacity for using physics knowledge and theory to solve problems

Excellent

(A+, A, A-) Will exhibit a high level of competence in understanding, explaining, and integrating the knowledge in written format

Good

(B+, B) Will exhibit a good level of competence in understanding, explaining, and integrating the knowledge in written format

Marginal

(B-, C+, C) Will exhibit some deficiencies in understanding, explaining, and integrating the knowledge in written format

Failure

(F) Will exhibit lack of competence in understanding, explaining, and integrating the knowledge in written format

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Part III Other Information

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

Reading List

Compulsory Readings

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

Additional Readings

	Title
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)