PHY2100: MATHEMATICAL METHODS IN PHYSICS

Effective Term

Semester A 2024/25

Part I Course Overview

Course Title

Mathematical Methods in Physics

Subject Code

PHY - Physics

Course Number

2100

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

1. MA1200 Calculus and Basic Linear Algebra I or MA1300 Enhanced Calculus and Basic Linear Algebra I
2. MA1201 Calculus and Basic Linear Algebra II or MA1301 Enhanced Calculus and Basic Linear Algebra II

Part II Course Details

Abstract

This course covers fundamental mathematical methods used in undergraduate physics courses that are not covered or insufficiently covered in other mathematics courses. The course aims to equip students with essential mathematical skills for important fundamental physics courses such as Electricity and Magnetism, as well as subsequent more advanced courses including Electrodynamics and Quantum Mechanics.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Understand basic mathematical techniques in physics and master their operations.	40		x	x
2	Analyse common problems in physics and apply suitable mathematical methods to solve the problems.	40		x	x
3	Appreciate the mathematical structures in different areas of physics.	20	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	Explain the concepts of the mathematical methods and demonstrate their applications in physics.	1, 2, 3	3 hours/ week
2	Tutorials	Provide supplemental examples and explanations to help students better understand the lectures.	1, 2, 3	1 hour/week
3	Assignments	Individual works to be done by the students to train students with hands-on mathematical skills.	1, 2, 3	After-class

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Assignments (4-6 sets)	1, 2, 3	30	
2	Mid-term exam	1, 2, 3	20	

Continuous Assessment (%)

50

Examination (%)

50

Examination Duration (Hours)

2

Additional Information for ATs

For a student to pass the course, at least 30% of the maximum mark for the examination must be obtained.

Assessment Rubrics (AR)

Assessment Task

1. Assignments

Criterion

The student’s capacity in understanding the concepts and his/her ability to apply the mathematical techniques to solve physical problems.

Excellent (A+, A, A-)

The student can, at a high level, identify and explain how the principles are applied to solving the problems.

Good (B+, B, B-)

The student can significantly identify and explain how the principles are applied to solving the problems.

Fair (C+, C, C-)

The student can moderately identify and explain how the principles are applied to solving the problems.

Marginal (D)

The student can, at a basic level, identify and explain how the principles are applied to solving the problems.

Failure (F)

The student cannot, even at a basic level, identify and explain how the principles are applied to solving the problems.

Assessment Task

2. Mid-term exam

Criterion

The student’s ability to analyse the physical problems, identify and apply suitable mathematical methods to solve the problems.

Excellent (A+, A, A-)

The student can, at a high level, identify and explain how the principles are applied to solving the problems.

Good (B+, B, B-)

The student can significantly identify and explain how the principles are applied to solving the problems.

Fair (C+, C, C-)

The student can moderately identify and explain how the principles are applied to solving the problems.

Marginal (D)

The student can, at a basic level, identify and explain how the principles are applied to solving the problems.

Failure (F)

The student cannot, even at a basic level, identify and explain how the principles are applied to solving the problems.

Assessment Task

3. Examination

Criterion

The student's ability to analyse the physical problems, identify and apply suitable mathematical methods to solve the problems.

Excellent (A+, A, A-)

The student can, at a high level, identify and explain how the principles are applied to solving the problems.

Good (B+, B, B-)

The student can significantly identify and explain how the principles are applied to solving the problems.

Fair (C+, C, C-)

The student can moderately identify and explain how the principles are applied to solving the problems.

Marginal (D)

The student can, at a basic level, identify and explain how the principles are applied to solving the problems.

Failure (F)

The student cannot, even at a basic level, identify and explain how the principles are applied to solving the problems.

Part III Other Information

Keyword Syllabus

· Complex analysis (analytic functions, contour integral, Cauchy's formula, residue theorem, complex series, etc.)
· Singularities (Analytic continuation, divergence, etc.)
· Matrix algebra (matrices, representation, inverse, similar matrices, matrix inverse, matrix equations, etc.)
· Determinants (Linear equations, cofactors, determinant evaluation, determinants of matrices, Cramer's theorem)
· Vector space, linear combination, basis, dimension, inner product, etc.
· Linear space (Linear space, subspace, linear independence, basis, coordinates, direct sum, direct product, inner product, Euclidean space, etc.)
· Linear transformation (Linear transformation, equivalence, product, matrix representation, basis transformation, invariant subspace, eigenvalues, eigenvectors, characteristic subspace, etc.)

Reading List

Compulsory Readings

	Title
1	Serge Lang, Introduction to Linear Algebra at http://www.math.nagoya-u.ac.jp/~richard/teaching/f2014/Lin_alg_Lang.pdf
2	Lars V. Ahlfors, Complex Analysis at https://mccuan.math.gatech.edu/courses/6321/lars-ahlfors-complex-analysis-third-edition-mcgraw-hill-science_engineering_math-1979.pdf

Additional Readings

	Title
1	James Nearing, Mathematical Tools for Physics Available online at http://www.physics.miami.edu/~nearing/mathmethods/
2	Sean Mauch, Advanced Mathematical Methods for Scientists and Engineers Available online at https://physics.bgu.ac.il/~gedalin/Teaching/Mater/
3	Richard Courant & David Hilbert, Methods of Mathematical Physics, Vols. 1 & 2

4	K. F. Riley, M. P. Hobson, and S. J. Bence, Mathematical Methods for Physics and Engineering, 3rd ed. (Cambridge University Press, 2006)
5	M. L. Boas, Mathematical Methods in the Physical Sciences, 3rd ed. (Wiley, 2006)
6	Samuel D Lindenbaum, Mathematical Methods in Physics (World Scientific, 1996)
7	Tai L. Chow, Mathematical Methods for Physicists: A concise introduction (Cambridge University Press, 2000)