PHY6506: ADVANCED ELECTRODYNAMICS

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
Advanced Electrodynamics

Subject Code
PHY - Physics
Course Number
6506

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
PHY2191 Electricity and Magnetism
PHY3205 Electromagnetism

Equivalent Courses
Nil

Exclusive Courses
PHY8506 Advanced Electrodynamics

Part II Course Details

Abstract

This course aims to equip graduate students with advanced concepts and mathematical methods of electrodynamics that are necessary to conduct research in related fields such as photonics and metamaterials. The course will cover the fundamentals of electrodynamics including electromagnetic wave propagations in homogeneous materials, wave behaviors at a surface, plasmon, waveguides, cavities, scattering and radiation phenomena. In addition, the course will introduce applications related to electrodynamics, such as photonic crystals and metamaterials.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Recognize the importance of electrodynamics	10	x		
2	Understand the key concepts of electrodynamics	20	x		
3	Understand the physics mechanisms underlying electrodynamic phenomena	20		x	
4	Apply analytical methods to solve practical problems	40		x	
5	Develop electrodynamic systems with specific wave properties	10		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	Explain concepts and introduce mathematical methods	1, 2, 3, 4, 5	2
2	Tutorials	Explain the mechanisms of some electrodynamic systems and how to solve electrodynamic problems	1, 2, 3, 4, 5	1

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Assignments	1, 2, 3, 4, 5	50	-	Yes

Continuous Assessment (%)

50

Examination (%)

50

Examination Duration (Hours)

2

Assessment Rubrics (AR)

Assessment Task

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

Criterion

Understanding the key concepts and principles; Ability to explain the physical mechanisms of electrodynamic phenomena; Ability of applying mathematical methods to solve problems.

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Not reaching marginal level

Assessment Task

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

Criterion

Having an in-depth understanding of electrodynamic concepts and principles; Ability of applying analytical methods to solve practical problems independently.

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Not reaching marginal level

Assessment Task

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

Criterion

Understanding the key concepts and principles; Ability to explain the physical mechanisms of electrodynamic phenomena; Ability of applying mathematical methods to solve problems.

Excellent

(A+, A, A-) High

Good

(B+, B) Moderate

Marginal

(B-, C+, C) Basic

Failure

(F) Not reaching marginal level

Assessment Task

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

Criterion

Having an in-depth understanding of electrodynamic concepts and principles; Ability of applying analytical methods to solve practical problems independently.

Excellent

(A+, A, A-) High

Good

(B+, B) Moderate

Marginal

(B-, C+, C) Basic

Failure

(F) Not reaching marginal level

Part III Other Information

Keyword Syllabus

Maxwell's Equations
- Displacement current, vector and scalar potentials, gauge transformation, Green’ s functions

Conservation Laws
- Poynting's theorem, conservation of energy and momentum, Maxwell's stress tensor

Plane waves and wave propagation
- Impedance and admittance, polarizations, Stokes parameters, spin and orbital angular momentums, dispersion, Causality, Kramers-Kronig relations, plasmon

Waveguides, transmission line, and resonant cavities
- Fields at surface and within a conductor, modes in cylindrical and rectangular waveguides, transmission lines, resonant cavities, quality factor

Radiation
- Multipole expansions, electric dipole, magnetic dipole and electric quadrupole

Scattering and diffraction

- Rayleigh scattering, Mie scattering, optical theorem, scalar and vectorial diffraction theory

Electromagnetic waves in artificial structures and materials
- photonic crystals, photonic band theory, metamaterials, effective medium theory

Reading List

Compulsory Readings

	Title
1	J. D. Jackson, Classical Electrodynamics 3rd edition, Wiley & Sons, 1999.

Additional Readings

	Title
1	L. D. Landau and E. M. Lifshitz Electrodynamics of Continuous Media 2nd edition, Butterworth-Heinemann, 1984.
2	C. F. Bohren and D. R. Huffman, Absorption and Scattering of Light by Small Particles Wiley & Sons, 1983.
3	J. D. Joannopoulos S. G. Johnson, J. N. Winn, and R. D. Meade, Photonic Crystals: Molding the Flow of Light 2nd edition, Princeton University Press, 2008.
4	L. Solymar and E. Shamonina Waves in Metamaterials Oxford University Press, 2009.