

# PHY6506: ADVANCED ELECTRODYNAMICS

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## 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

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**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

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### 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

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### 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

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## 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.