EE6609: NONLINEAR OPTICAL DEVICES

Effective Term
Semester B 2024/25

Part I Course Overview

Course Title
Nonlinear Optical Devices

Subject Code
EE - Electrical Engineering
Course Number
6609

Academic Unit
Electrical Engineering (EE)

College/School
College of Engineering (EG)

Course Duration
One Semester

Credit Units
3

Level
P5, P6 - Postgraduate Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
EE4035 Optical Communications, or EE6428 Optical Communications; or equivalent

Precursors
Nil

Equivalent Courses
Nil

Exclusive Courses
Nil

Part II Course Details

Abstract

This course aims to provide students with an understanding of the fundamental physics, photonics devices, and unique applications using nonlinear optics in engineering, which encourages students to discover the latest technological developments towards all-optical systems.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Describe the origin of optical nonlinearities and analyze their effects in photonic devices.				
2	Apply the concept of phase matching and estimate the efficiencies in optical signal conversions.				
3	Discuss the parameters for frequency conversion.				
4	Calculate the parameters for nonlinear optical switches.				
5	Comprehend and present on special topics in nonlinear optics.		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	Lecture	Students will engage in lectures on the subject matter for the whole class.	1, 2, 3, 4, 5	2 hrs/wk
2	Tutorial and in-class exercise (including a presentation)	Students will engage in working out solutions to examples on selected topics. The presentation is designed to encourage students to research into the latest topics in nonlinear optical devices	1, 2, 3, 4, 5	1 hr/wk

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Assignments including laboratories (min. 3)	1, 2, 3, 4, 5	15	
2	Test(s)	1, 2, 3, 4, 5	15	

Continuous Assessment (%)

30

Examination (%)

70

Examination Duration (Hours)

2

Additional Information for ATs

Remark: To pass the course, students are required to achieve at least 30% in course work and 30% in the examination.

Assessment Rubrics (AR)

Assessment Task

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

Criterion

Achievements in CILOs

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Not even reaching marginal level

Assessment Task

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

Criterion

Achievements in CILOs

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not even reaching marginal level

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

Criterion
Achievements in CILOs

Excellent
(A+, A, A-) High

Good
(B+, B) Medium

Marginal
(B-, C+, C) Low

Failure
(F) Not even reaching marginal level

Assessment Task
Coursework (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
Achievements in CILOs

Excellent
(A+, A, A-) High

Good
(B+, B) Medium

Marginal
(B-, C+, C) Low

Failure
(F) Not even reaching marginal level

Additional Information for AR

Constructive Alignment with Programme Outcomes

PILO 1, 2, 3, 4 The application of current knowledge in photonics technology, specialized knowledge in nonlinear optics, and formulation of solutions is central to the aim of this course.

Part III Other Information

Keyword Syllabus

Introduction:
- Maxwell's equations
- Optical fields
- Linear susceptibility
- Dispersions

Foundations of Nonlinear Optics
- Nonlinear optical susceptibility
- Coupled-wave analysis
- Phase matching
- Nonlinear optical interaction

Parametric Frequency Converters
- Parametric frequency conversion
- Sum- and difference- frequency generation (SFG/DFG)
- Second-harmonic generation (SHG)
- Optical parametric amplification (OPA)
- Applications: Imaging, pulse measurements, signal amplification

Nonparametric Frequency Generators
- Raman amplifiers and generators
- Brillouin amplifiers and generators
- Applications: Spectroscopy, sensing, lasing

All-Optical Modulators
- Kerr lenses
- Saturable absorbers
- All-optical interferometers
- Applications: All-optical switch, all-optical storage

Special topics may be included:
- Super-continuum generation
- Nonlinear optical imaging
- Raman lasers

Reading List

Compulsory Readings

	Title
1	J. M. Liu, Photonic Devices Cambridge University Press (2005)
2	R. W. Boyd, Nonlinear Optics 2/e, Academic Press (2002)

Additional Readings

	Title
1	G. P. Agrawal, Nonlinear Fiber Optics 3/e, Academic Press (2001)
2	N. Bloembergen, Nonlinear Optics 4/e, World Scientific (1996)
3	P. N. Butcher and D. Cotter, The Elements of Nonlinear Optics Cambridge University Press (1990)
4	H. A. Haus, Waves and Fields in Optoelectronics Prentice-Hall (1984)
5	E. G. Sauter, Nonlinear Optics Wiley (1996)
6	Y. R. Shen, The Principles of Nonlinear Optics Wiley (1984)
7	R. L. Sutherland, Handbook of Nonlinear Optics Marcel Dekker (2003)