COURSE UNIT DESCRIPTION

Course unit title	Code
Semiconductor Optics	

Lecturer(s)	Department where the course unit is delivered
Coordinator: dr. Ramūnas Aleksiejūnas **Other(s): -**	Faculty of Physics

Study cycle	Type of the course unit (module)
Second (master studies)	Compulsory

Mode of delivery	Period when the course unit (module) is delivered	Language(s) of instruction
Lectures, seminars	II (spring) semester	Lithuanian / English

Requirements for students	
Prerequisites: “Electricity and Magnetism”, “Optics”, “Quantum Mechanics”, “Condensed matter physics” or other courses of similar content.	**Additional requirements (if any):** -

Course (module) volume in credits	Total student’s workload	Contact hours	Self-study hours
5	140	64	76

Purpose of the course unit (module): programme competences to be developed		
The purpose of this course is to teach the students the theoretically and practically important topics related to light interaction with semiconductors. The students are expected to be able to analyse the phenomena, to solve complex problems, to apply required specific techniques and methods related to semiconductor optics. An emphasis will be placed on student’s abilities to conduct independent studies and to communicate in auditory-specific way the obtained results and their importance for both engineering applications and fundamental understanding of light interaction with semiconductors.		
Learning outcomes of the course unit (module)	**Teaching and learning methods**	**Assessment methods**
Ability to analyse phenomena, to solve complex problems, to apply required specific techniques and methods related to semiconductor optics	Seminars	Evaluation of presentation; written tests
Acquisition of theoretical knowledge required to understand and solve practical problems in semiconductor optics; ability to analyse related scientific literature; ability to present and explain selected topics; ability to conduct some most popular experimental measurements, to analyse and interpret measurement results.	Lectures	Several multiple choice tests

Content: breakdown of the topics	Contact hours							Self-study work: time and assignments	
	Lectures	Tutorials	Seminars	Exercises	Laboratory work	Internship/work	**Contact hours**	**Self-study hours**	**Assignments**
Basic Concepts in Crystals: direct and reciprocal lattices, energy bands and Bloch function, effective mass approximation, occupation probability and density of states, classification of solids, electrons and holes	4						**4**	**6**	Repetition for exam; presentation preparation.
Basic Concepts of Optical Response: Dispersion Relation, Oscillator Model, Kramers-Kronig Transformations, Experimental Techniques to Obtain Optical Constants, Plasmons and Surface Plasmons	3		1				**4**	**6**	Repetition for exam; presentation preparation.
Optical Properties of Phonons: Optical and Acoustical Phonons, Optical Excitation of Phonons, Phonon Polaritons, Light Scattering, Coherent Raman Spectroscopy	3		1				**4**	**6**	Repetition for exam; presentation preparation.
Linear Optical Properties of Semiconductors. Free Electron-Hole pairs: Direct and Indirect semiconductors, Free Electron-hole Pair Absorption, Direct and Indirect Transitions, Pressure and Temperature Dependence of the Bandgap	2		2				**4**	**6**	Repetition for exam; presentation preparation.
Linear Optical Properties of Semiconductors. Excitons: The Wannier Equation, Exciton Absorption, Exciton Luminescence, Bound Excitons, Exciton Polaritons	4		4				**8**	**6**	Repetition for exam; presentation preparation.
Low-Dimensional Semiconductor Structures: Density of States and Critical Points in Various Dimensions, Quantum Wells and Superlattices, Monolayer Semiconductors, Optical Absorption in Two Dimensions, Excitons in Two Dimensions, Quantum Wires and Nanorods, Quantum Dots	4		4				**8**	**8**	Repetition for exam; presentation preparation.
Electronic Defects and Disorder: Defects, Defect States and Doping, Donors and Acceptors in Bulk Semiconductors, Shallow Defect Related Radiative Transitions, Deep Defects and Related Radiative Transitions, Defects and Doping in Quantum Wells, Disordered Systems and Localization, Anderson Model of Localization, Realizations of Disorder in Semiconductors, Weak Localization and Percolation	4		4				**8**	**6**	Repetition for exam; presentation preparation.
Electro-Optical Properties of Semiconductors: Franz-Keldysh Effect, DC-Stark Effect, Electric Field Effects in Two Dimensions: Quantum-Confined Franz-Keldysh and Quantum-Confined Stark Effects	2		2				**4**	**6**	Repetition for exam; presentation preparation.
Two-Photon Absorption Spectroscopy: Selection Rules for Two-Photon Spectroscopy, Examples of Two-Photon Absorption Spectra in Bulk Semiconductors, Quantum-Well Structures, Quantum Dots	2		2				**4**	**6**	Repetition for exam; presentation preparation.

Semiconductor Optical Nonlinearities: Classification of Optical Nonlinearities, Plasma Screening, Exciton Ionization, Bandfilling, Bandgap Renormalization, Optical Nonlinearities of Quantum Wells and Quantum Dots, Thermal Nonlinearities, Transient Nonlinearities: Optical Stark Effect	2		2				**4**	**6**	Repetition for exam; presentation preparation.
Measurement Techniques of Optical Nonlinearities: Pump-Probe Spectroscopy, Nonlinear Interferometry, Beam-Distortion Technique, Four-Wave Mixing	2		2		8		**12**	**6**	Repetition for exam; presentation preparation.
Total	**32**		**24**		**8**		**64**	**76**	

Assessment strategy	Weight, %	Deadline	Assessment criteria
Seminars rating	20	All course	Presentation clarity and ability to highlight the major points; ability to answer relevant questions.
Tests	40	All course	2 multiple choice tests each including both problem solving and theory, and providing up to 20% to the final grade.
Exam (written form)	40	During the exam session	20 open questions requiring short answers. Assessment of answer particularity, consistency and mistakes.

Author	Year of publi cation	Title	Issue of a periodical or volume of a publication	Publishing place and house or web link
Compulsory reading				
M. Fox	2010	Optical Properties of Solids, 2nd edition		Oxford University Press. Full text (from VU network): https://virtualibiblioteka.vu.lt/permalink/f/1ferss/TN_cdi_askewsholts_vlebooks_9780191576720
Optional reading				
N. Peyghambarian, S. W. Koch, A. Mysyrowicz	1993	Introduction to Semiconductor Optics		Prentice Hall
Claus F. Klingshirn	2012	Claus F. Klingshirn, 4th edition		Springer
M. Kira, S. W. Koch	2012	Semiconductor Quantum Optics		Cambridge University Press. Full text (from VU network): https://virtualibiblioteka.vu.lt/permalink/f/1ferss/TN_cdi_askewsholts_vlebooks_9781139235013
W. Schäfer, M. Wegener	2002	Semiconductor Optics and Transport Phenomena		Springer