COURSE UNIT (MODULE) DESCRIPTION

Course unit (module) title	Code
Nonlinear Optics	

Lecturer(s)	Department(s) where the course unit (module) is delivered
Coordinator: assoc. prof. Rytis Butkus **Other(s):**	Laser Research Center, Faculty of Physics

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

Mode of delivery	Period when the course unit (module) is delivered	Language(s) of instruction
	Autumn semester	Lithuanian

Requirements for students	
Prerequisites: Courses of Optics, Laser Physics (or Quantum Electronics)	**Additional requirements (if any):**

Course (module) volume in credits	Total student's workload	Contact hours	Self-study hours
5	**140**	**48**	**92**

Purpose of the course unit (module): programme competences to be developed		
General: training of critical thinking, ability to work in a team Specific: to understand and explain propagation principles of light in fibers and waveguides, basis of fiber communication principles and architectures, fiber manufacturing, fiber components, sensors and lasers; understanding nonlinear phenomena in fibers and their applications.		
Learning outcomes of the course unit (module)	**Teaching and learning methods**	**Assessment methods**
After this course the students will learn about different types of fibers, main fiber parameters and fiber components. The students will also learn about key practical applications of fibers in data transmission, sensors and lasers.	Lectures and seminars	Cumulative mark: evaluation of presentation during seminar and moderating another seminar, exam evaluation.

Content: breakdown of the topics	Contact hours							Self-study work: time and assignments	
	Lectures	Tutorials	Seminars	Exercises	Laboratory work	Internship/work placement	**Contact hours**	**Self-study hours**	**Assignments**
1. Early optical communications. Development of fibers and their initial applications. The use of fiber in data transmission systems. The main parameters of	4		2				**6**	**7**	Reading of lecture notes, textbooks and scientific literature

fibers.									
2. Propagation of light in fibers: geometrical and wave optics approach. Numerical aperture. Modes in fibers. Types of fibers. Index profile and photonic crystal fibers. Doped fibers and fibers made from different materials. Testing techniques for different fiber features.	4		2				**6**	**7**	Reading of lecture notes, textbooks and scientific literature
3. Losses in fibers: physical origins and causes. Impact of impurities and lowest possible losses. Macro and micro bending losses, fiber connection types and their losses. Manufacturing techniques of fibers.	4		2				**6**	**7**	Reading of lecture notes, textbooks and scientific literature
4. Fiber optics communications cables and lines. Different types of dispersion and its impact on data transmission rate. Zero dispersion region dispersion parameter. Management of fiber dispersion. Principles of data coding and data bandwidth.	4		2				**6**	**7**	Reading of lecture notes, textbooks and scientific literature
5. Elements of integrated optics. Types of waveguides and their applications. Fiber couplers, multiplexers and demultiplexers, phase controllers and electro-optic modulators, polarizers and polarization controllers.	4		2				**6**	**7**	Reading of lecture notes, textbooks and scientific literature
6. Fiber sensors. Hybrid and intrinsic sensors based on intensity, phase, polarization and spectral change. Physical variables. Fiber sensor multiplexing. Examples of fiber sensor applications.	4		2				**6**	**7**	Reading of lecture notes, textbooks and scientific literature
7. Fiber lasers and amplifiers. Pumping schemes, double-clad fibers, large-mode-area fiber lasers and fiber-rods. CW and pulsed regimes, techniques of Q-switching and mode-locking. Lasers utilizing different glasses as host materials and different dopants. Fiber laser energy combining.	4		2				**6**	**7**	Reading of lecture notes, textbooks and scientific literature
8. Fiber nonlinear optics. Main nonlinear phenomena observed in fibers. Nonlinear susceptibility, advantages and disadvantages of fibers. Four-wave mixing, resonant scattering phenomena, self-phase modulation and supercontinuum generation. Applications of nonlinear phenomena.	4		2				**6**	**7**	Reading of lecture notes, textbooks and scientific literature
9. Preparation for the exam								**36**	
Total	**32**		**16**				**48**	**92**	

Assessment strategy	**Weight,%**	**Deadline**	**Assessment criteria**
Seminar presentation moderation of another seminar	25	By the end of semester	One presentation must be given during the course of seminars related to the subject of the lectures. The assessment of the presentation is based on whether the material is properly related to the selected topic of a presentation, whether or not the material is consistent and is explained clearly and are the questions of the attendees answered properly. Part of the assessment is related to quality of moderation of another seminar.
Exam	75	By the end of the course	Exam in written form, Questions and exercises from any subject of the course. Assessment is based on the correctness of the answers and are the exercises solved properly.
Overall	100		The overall mark is the sum of the above items and is rounded.

Author	**Year of public**	**Title**	**Issue of a periodical or volume of a**	**Publishing place and house or web link**

	ation		publication	
Compulsory reading				
1. F. Mitschke	2016	Fiber Optics	Second Edition	Springer, Heidelberg
2. D. Čiplys, A. Krotkus, V. Smilgevičius	2008	Šviesolaidžių optika		Vilniaus universiteto leidykla, Vilnius
Optional reading				
1. J. Crisp, B. Elliott	2005	Introduction to Fiber Optics	Third edition	Elsevier, Oxford
2. S. Gistvik	2005	Optical Fiber Theory for Communication Networks	Third edition	John Wiley & Sons, New York