COURSE UNIT (MODULE) DESCRIPTION

Course unit (module) title	Code
Lasers	

Lecturer(s)	Department(s) where the course unit (module) is delivered
Coordinator: dr. Julius Vengelis (lectures, seminars, laboratory works) **Other(s): Arūnas Čiburys (laboratory works)**	VU FF Laser Research Center

Study cycle	Type of the course unit (module)
First	Mandatory

Mode of delivery	Period when the course unit (module) is delivered	Language(s) of instruction
Auditorium	4 semester (spring)	Lithuanian/English

Requirements for students	
Prerequisites: Optics	**Additional requirements (if any):**

Course (module) volume in credits	Total student's workload	Contact hours	Self-study hours
5	141	66	75

Purpose of the course unit (module): programme competences to be developed		
The course provides the fundamentals of laser operation and the basics of their practical implementation. A considerable part of the course is devoted to pulsed laser operation: Q-switching and mode locking regimes and their practical realization, with particular emphasis given to femtosecond pulse generation, amplification and methods for measurement of pulse duration. Miscellaneous lasers and laser systems (solid state, gas, semiconductor and other), specifics of their operation and fields of their practical applications are briefly overviewed. Finally, the basics of the nonlinear optics and general nonlinear optical methods for laser frequency conversion are introduced. By accomplishing the course the students are expected to be able to: (i) understand and explain the principles and design considerations of various (solid state, gas and semiconductor) lasers, modes of their operation, trends of development of modern lasers and areas of their application, (ii) understand the principles of ultrashort pulse generation and amplification, and nonlinear optical methods of frequency conversion, (iii) gain the basic skills of practical work with lasers.		
Learning outcomes of the course unit (module)	**Teaching and learning methods**	**Assessment methods**
Understand and explain the principles and design considerations of various (solid state, gas and semiconductor) lasers, modes of their operation, trends of development of modern lasers and areas of their application	Lectures, laboratory works, seminars	The final mark is cumulative and consists of the exam mark (60%) and assessment of the laboratory practice (30%) and seminar presentation (10%).
Basic skills of practical work with lasers	Laboratory works	

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. **Introduction.** Historical retrospect. Modern lasers and trends of their development. Laser safety classes.	2						**2**		
2. **Properties of laser radiation.** Photons and electromagnetic waves. Laser beams and laser pulses. Diffraction and dispersion. Temporal, spatial and spatiotemporal coherence.	2				4		**6**	**4**	Preparation for laboratory work No. KE-4: Research of laser radiation properties
3. **Optical resonators.** Rays and ray matrices. Mode stability criteria. Types of optical resonators. Longitudinal and transverse modes. Hermite-Gaussian beams. Losses in optical resonators.	4				4		**8**	**4**	Preparation for laboratory work No. KE-6: Research of laser Gaussian beams
4. **Interaction of radiation and atomic systems.** Einstein`s treatment of spontaneous and induced transitions. Gain coefficient. Homogeneous and inhomogeneous line broadening. Gain bandwidth.	2						**2**		
5. **Principles of laser operation.** Dynamic equations. Three and four level lasers. Pump sources. Laser oscillation condition.	2				8		**10**	**8**	Preparation for laboratory works No. KE-2: Research of free-running solid-state Nd:YAG laser; No. KE-5: Research of longitudinal diode pumped Nd:YVO4 laser
6. **Pulsed laser operation.** Free running mode, Q-switching. Methods of Q-switching. Mode locking. Active and passive mode locking. Methods of mode locking.	4				4		**8**	**4**	Preparation for laboratory work No. KE-3: Research on passively Q-switched Nd:YAG laser
7. Generation and amplification of femtosecond light pulses. Dispersion management and pulse compression. Chirped pulse amplification. Laser	4						**4**		

amplifiers. Correlation methods for pulse width measurements.									
8. Lasers and laser systems. Solid state lasers. Ions and laser hosts. Gas lasers. Excimer lasers. Chemical lasers. Semiconductor lasers.	3		5		8		**16**	**11**	Preparation for laboratory works No. KE-1: Research of He-Ne laser; No. KE-7: Research of semiconductor laser. Preparation of presentation in the seminar; each student makes 10 min. long presentation on the selected topic on lasers
9. **Laser frequency conversion using nonlinear optics.** Short introduction to nonlinear optics. Nonlinear crystals. Second harmonic, sum and difference frequency generation. Principles of the optical parametric generation and amplification. Optical parametric oscillators. Optical parametric amplifiers.	4				4		**8**	**4**	Preparation for laboratory work No. 8: Second optical harmonic generation
10. **Exam**							**2**	**40**	
Total	**27**		**5**		**32**		**66**	**75**	

Assessment strategy	**Weight, %**	**Deadline**	**Assessment criteria**
Exam	60	Session	Exam mode – written answers to 6 selected topics, each topic carries 1 mark.
Laboratory woks	30	In the course of semester	Assessment of laboratory works (theory and results), cumulative mark between 0 and 3
Seminar	10	In the course of semester	Assessment of presentation at the seminar: 1 mark , 0 mark if no presentation made

Author	**Year of public ation**	**Title**	**Issue of a periodical or volume of a publication**	**Publishing place and house or web link**
Compulsary reading				
1. A. Yariv	1989	Quantum Electronics		Wiley
2. E. Gaižauskas, V. Sirutkaitis	2008	Solid state lasers		Vilnius university press
Optional reading				

1. F. Trager ed.	2007	Springer Handbook of lasers and optics		Springer
2. B. E. A. Saleh and M. C. Teich	1991	Fundamentals of photonics		Wiley
3. C. C. Davis	1996	Lasers and Electrooptics		Cambridge University Press