RĪGAS TEHNISKĀ UNIVERSITĀTE

RTU Course "Physics of Optical Information Processing"

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General data

Code	RDE417
Course title	Physics of Optical Information Processing
Course status in the programme	Compulsory/Courses of Limited Choice
Responsible instructor	Jurģis Poriņš
Academic staff	Toms Salgals
Volume of the course: parts and credits points	1 part, 4.0 Credit Points, 6.0 ECTS credits
Language of instruction	LV, EN
Annotation	The study course is designed to introduce students to the fundamentals of optoelectronics and optical communications. Topics cover waveguide optics, nanophotonics, metamaterials, holography, nature of light and its properties, general concepts of optical information processing and transmission, laser technology and nonlinear optics, atmospheric laser communications, FOTS information multiplexing in WDM, OTDM, SDM optical fibre transmission systems and computer simulations.
Goals and objectives of the course in terms of competences and skills	The goal of the course is to enable students to develop their knowledge and understanding of optical information processing and management techniques, physical principles of these techniques, development trends and perspectives, as well as to provide students with an in-depth understanding of optical concepts related to optical information processing and management. Tasks of the study course: - to introduce information optical processing systems; - to develop skills in qualitative and quantitative analysis of optical systems; - to provide knowledge about holography, waveguide optics and nonlinear optics; - to develop skills in laser technology.
Structure and tasks of independent studies	Extensive reading of scientific and technical literature (authorized access to IEEE and SCOPUS databases and literature available in RTU library), laboratory measurements and computer simulation studies (e.g. Matlab Simulink, RSoft OptSim simulation software), seminars, making reports and delivering individual or group work presentations related to subject topics.
Recommended literature	Obligātā/Obligatory: 1. Фриман Р. Волоконно-оптические системы связи. Москва: Техносфера. 2004. 495 с. 2. Poriņš J., Ozols A., Eimuss J., Ivanovs Ģ. Nonlinear optical losses in telecommunication fibres. Riga: Latvian Journal of Physics and Technical Sciences, 2004, Vol. 3, p. 48-57. 3. T. Salgals, J. Alnis, R. Murnieks, I. Brice, J. Porins, A. V. Andrianov, E. A. Anashkina, S. Spolitis, and V. Bobrovs, "Demonstration of a fiber optical communication system employing a silica microsphere-based OFC source," Opt. Express 29, 10903-10913 (2021). 4. X. Pang, A. Udalcovs, R. Schatz, V. Bobrovs, G. Jacobsen, S. Popov, and O. Ozolins "Short Reach Communication Technologies for Client-Side Optics Beyond 400 Gbps," IEEE Photonics Technology Letters, 1-1, (2021). 5. S. Spolitis, R. Murnieks, L. Skladova, T. Salgals, A. V. Andrianov, M. P. Marisova, G. Leuchs, E. A. Anashkina, and V. Bobrovs, "IM/DD WDM-PON Communication System Based on Optical Frequency Comb Generated in Silica Whispering Gallery Mode Resonator, " IEEE Access, 1-1, (2021). 6. E. A. Anashkina, V. Bobrovs, T. Salgals, I. Brice, J. Alnis, and A. V. Andrianov, "Kerr Optical Frequency Combs With Multi-FSR Mode Spacing in Silica Microspheres, " IEEE Photonics Technology Letters, 1-1, (2021). 7. Agrawal G. P. Nonlinear fiber optics. 6th Edition, Academic Press 2019, 728 p. 8. Agrawal G. P. Nonlinear fiber optics. San Diego: Academic Press, 2001. 452 p. 9. Bass M., Stryland E. van. Fiber Optic Handbook. New York: Mc Graw-Hill, 2002. 398 p. 10. Bobrovs V., Poriņš J., Ivanovs Ģ. Influence of Nonlinear Optical Effects on the NRZ and RZ Modulation Signals in WDM System. Kaunas: Electronics and electrical engineering, 2007, Vol. 4, No. 76, p. 55-58. Papildu/Additional: 1. Шен И.Р. Принципы нелинейной оптики. Москва: Наука, 1989. 560с. 2. Гауэр Дж. Оптические системы связи. Москва: Радио и связь, 1989. 501 с. 3. Shapiro S.L. Ultrafast Light Pulses. Berlin: Springer, 1977. 460 p. 4. Agrawal G. P. Nonlinear Fiber Optics. 2nd ed. New York: New Acad
Course prerequisites	Students are expected to have knowledge of physics, fibre optic transmission systems.

Course contents

Content	Full- and part-time intramural studies		Part time extramural studies	
	Contact Hours	Indep. work	Contact Hours	Indep. work
General concepts of optical information processing and transmission. Physical foundations of optoelectronics and optics.	2	2	0	0
Nature of light and its properties. Photonic theory of light and wave theory of light.	2	2	0	0
Maxwell’s equations in isotropic medium. Poynting’s theorem. Intensity of light. Photometry.	2	2	0	0

Polarization of light. Jones vectors and matrices. Stokes parameters, Stokes vectors. Poincare sphere. Mueller matrices.	2	2	0	0
Refraction of light. Attenuation and absorption of light in the matter. Dispersion of light in the matter.	4	6	0	0
Reflection of light. Fresnel formulas, amplitudes, phases of reflected and transmitted waves. Total internal reflection.	2	2	0	0
Propagation of light in anisotropic insulators. Electro-optic modulators and deflectors of light. Isolators.	2	2	0	0
Interference of light as the manifestation of the correlation of stochastic light vibrations. Interference in thin films.	2	3	0	0
Resolving power of optical instruments. Super-resolution. Acousto-optical modulators and deflectors.	2	3	0	0
Classification of optical waveguides. Optical fibres as cylindrical optical waveguides. Optical fibre sensors.	4	6	0	0
Notion of nanophotonics. Photonic crystals. Photonic crystal fibres and microstructured fibres.	2	3	0	0
Metamaterials with a negative refractive index.	2	3	0	0
Optical image and the phase problem in optics. Holographic recording and readout methods of Gabor, Leith – Upatnieks.	2	3	0	0
Hologram types, properties and parameters.	2	3	0	0
Spontaneous, stimulated and relaxational quantum transitions.	2	3	0	0
Optical feedback. Resonators. Continuous wave (CW) and pulsed operation of lasers. Types of lasers and their comparison.	4	6	0	0
Stationary and non-stationary, coherent and incoherent nonlinear optical processes. Nonlinear polarization of matter.	2	3	0	0
Harmonic and parametric generation of light. Photorefraction and self-focusing.	2	3	0	0
Stimulated (Raman and Mandelstam-Brillouin) light scattering.	2	3	0	0
Solitons in optical fibre communication systems.	2	3	0	0
Mechanisms of laser damage of matter.	2	3	0	0
Information multiplexing in WDMA, TDMA and CDMA optical fibre transmission systems.	10	14	0	0
Computer simulations in studies of optical fibre transmission systems.	6	16	0	0
Total:	64	96	0	0

Learning outcomes and assessment

Learning outcomes	Assessment methods
Is able to independently analyse and discuss current issues in the field of telecommunications, using various sources of information.	Tests and reports. Exam.
Is able to demonstrate their knowledge of field-related terms and understanding of optical information processing principles.	Tests and reports. Exam.
Is able to demonstrate their comprehension of physical optics concepts, fundamentals of Fourier optics, basics of holography, fundamentals of optical waveguides, principles of laser technology and technical capabilities, basics of nonlinear optics and nanophotonics.	Tests and reports. Exam.
Is able to demonstrate their knowledge of optical information processing systems, Fourier optics and holography; to carry out qualitative and quantitative analysis of optical systems.	Tests and reports. Exam.
Is able to demonstrate their understanding of waveguide optics, nonlinear optics and nanophotonics, laser technology, WDM technology and its applications. Is able to apply their knowledge in the field of telecommunications.	Tests and reports. Exam.

Evaluation criteria of study results

Criterion	%
Tests and reports	50
Exam	50
Total:	100

Study subject structure

Part	CP	Hours per Week			Tests		
		Lectures	Practical	Lab.	Test	Exam	Work
1.	4.0	3.0	1.0	0.0		*	