



## COURSE UNIT (MODULE) DESCRIPTION

| Course unit (module) title                    | Code |
|---|------|
| <b>Optical information processing methods</b> |      |

| Lecturer(s)                                     | Department(s) where the course unit (module) is delivered |
|---|---|
| <b>Coordinator:</b> assoc. prof. Vytautas Jukna | Laser Research Center, Faculty of Physics                 |
| <b>Other(s):</b>                                |   |

| 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  |  |
|--|--|
| <b>Prerequisites:</b><br>Courses of Optics, Laser Physics (or Quantum Electronics) | <b>Additional requirements (if any):</b> |

| Course (module) volume in credits | Total student's workload | Contact hours | Self-study hours |
|-----------------------------------|--------------------------|---------------|------------------|
| <b>5</b>                          | <b>140</b>               | <b>64</b>     | <b>76</b>        |

| Purpose of the course unit (module): programme competences to be developed   |                               |                    |
|--|-------------------------------|--------------------|
| <p>This course provides an overview and analysis of optical information formation, transmission, control, detection, storage methods; mathematical and physical methods for characterization and analysis of optical fields; peculiarities of light field propagation and transformation in optical systems; problems and trends in modern information optics.</p> <p>Upon completion of the course students will gain a comprehensive understanding of the capabilities of optical information management and processing using modern optical techniques. Students will be able to: understand the essence of various effects of light transmission through optical systems; analyze these processes by applying the knowledge gained during the course; understand the problems of modern optics; solve practical problems in optical physics.</p> |                               |                    |
| Learning outcomes of the course unit (module)  | Teaching and learning methods | Assessment methods |
| Conception of optical information formation, description, transmission, control, detection, storage  | Lectures                      | Exam               |

| 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                             |
| <b>1. Introduction to Optical Information Processing:</b> Methods of formation, transmission, detection storage of optical information; optical | 3             |           | 1        |           |                 |                 |                                       | 2                | Reading of lecture notes and textbooks. |

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| fields and signals; optical systems and their effects on optical fields; analog and digital information processing.  |   |  |   |  |  |  |  |  |
| <b>2. Description of Optical Processes:</b> Geometric and wave optics approximations; mathematical description of optical fields; types of optical signals and their parameters; complex optical signals; approximations in optics.                  | 3 |  | 1 |  |  |  |  | 2<br>Reading of lecture notes and textbooks. |
| <b>3. Mathematical methods in optics:</b> integral optical transformations; Fourier transform; signal convolution, correlation, pulse response function; signal sampling; discrete Fourier transform.  | 3 |  | 1 |  |  |  |  | 2<br>Reading of lecture notes and textbooks. |
| <b>4. Methods of analysis of optical systems:</b> linear and nonlinear optical systems; principles of linearity and superposition; system impulse response; point spread function; frequency transfer characteristics of linear systems.             | 3 |  | 1 |  |  |  |  | 2<br>Reading of lecture notes and textbooks. |
| <b>5. Light Field Waveguide Optics:</b> The Fresnel and Huygens principle and its application; approximations of Fresnel and Fraunhofer; light field propagation in free space; free space transfer function; spatial propagation of Gaussian beam.  | 3 |  | 1 |  |  |  |  | 2<br>Reading of lecture notes and textbooks. |
| <b>6. Ray optics of light fields:</b> structural elements of optical systems; principles of image formation; matrix description of ray propagation; operating principles of basic optical systems.   | 3 |  | 1 |  |  |  |  | 2<br>Reading of lecture notes and textbooks. |
| <b>7. Transformations by optical elements:</b> complex transfer functions; lens transfer function; apertures in optical systems; periodic structures; diffractive elements.  | 3 |  | 1 |  |  |  |  | 2<br>Reading of lecture notes and textbooks. |
| <b>8. Fourier Optics:</b> Spatial frequencies; formation of spatial spectrum; Abe's theory of image formation; spatial frequency filtering; spatial filtration applications.   | 4 |  | 1 |  |  |  |  | 2<br>Reading of lecture notes and textbooks. |
| <b>9. Optical holography:</b> interference application; the principle of holography; types of holograms; holographic spatial filters; holographic elements.  | 4 |  | 1 |  |  |  |  | 3<br>Reading of lecture notes and textbooks. |
| <b>10. Characteristics of optical fields:</b> coherent and non-coherent light sources; temporal and spatial coherence; the propagation of partially coherent light through space; image formation under coherent and incoherent lighting conditions. | 4 |  | 1 |  |  |  |  | 3<br>Reading of lecture notes and textbooks. |
| <b>11. Quality of optical systems:</b> quality criteria; geometric and wave optics aberrations of optical systems; optical transmission function; optical systems resolution; the possibilities of super-resolution.                                 | 4 |  | 1 |  |  |  |  | 4<br>Reading of lecture notes and textbooks. |
| <b>12. Optical information detection:</b> measurement of light field parameters; detection of temporal, spectral, spatial parameters; apparatus for recording and storing optical information; optical sensors and their operation.                  | 4 |  | 2 |  |  |  |  | 4<br>Reading of lecture notes and textbooks. |
| <b>13. Optical signal control:</b> acoustic and electro-optical devices; spatial light modulators; fully optical control; optical logic units; optical calculations; optical networks; optical communication.  | 4 |  | 2 |  |  |  |  | 4<br>Reading of lecture notes and textbooks. |
| <b>14. Digital processing of optical information: digital image processing;</b> encoding and recognition of optical information; digital filtering,  | 3 |  | 1 |  |  |  |  | 2<br>Reading of lecture notes and textbooks. |

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| holographic methods; computer modeling of optical phenomena. |    |  |    |  |  |  |  |           |   |
| <b>15. Preparation for the exam</b>                          |    |  |    |  |  |  |  | <b>36</b> | Reading of lecture notes and textbooks. |
| <b>In total</b>  | 48 |  | 16 |  |  |  |  | <b>76</b> |   |

| Assessment strategy | Weight, % | Deadline                 | Assessment criteria  |
|---------------------|-----------|--------------------------|--|
| Exam                | 100       | By the end of the course | Exam in written and oral form, 2 questions from the whole course.<br>The mark definitions:<br><5 below threshold<br>5 – weak<br>6 – satisfactory<br>7 – average<br>8 – good<br>9 – very good<br>10 – excellent |

| Author                          | Year of publication | Title  | Issue of a periodical or volume of a publication | Publishing place and house or web link |
|---------------------------------|---------------------|--|--|--|
| <b>Compulsory reading</b>       |                     |  |  |  |
| B.E.A. Saleh, M.C. Teich        | 1991                | Fundamentals of Photonics                                  |  | J.Wiley & Sons, Inc., 966 p.           |
| J.W. Goodman                    | 1996                | Introduction to Fourier Optics                             | 2 nd. Ed.  | McGraw-Hill, 441 p.                    |
| <b>Optional reading</b>         |                     |  |  |  |
| K. Iizuka                       | 2008                | Engineering Optics   |  | Springer, 525 p.                       |
| E.G. Steward                    | 2004                | Fourier Optics: An Introduction                            |  | Dover Publ. 270p.                      |
| W.J. Smith                      | 2008                | Modern Optical Engineering (The Design of Optical Systems) | 4 th Ed.   | McGraw-Hill, 754 p.                    |
| E. Hecht                        | 2002                | Optics   |  | Addison Wesley, 698 p.                 |
| H. Gross                        | 2005                | Handbook of Optical Systems                                |  | Wiley, 690 p.                          |
| F.T.S. Yu, S. Jutamulia, S. Yin | 2001                | Introduction to Information optics                         |  | Academic Press, 734 p.                 |
| K. Iizuka                       | 2002                | Elements of Photonics                                      | Vol I  | Wiley-Interscience, 645 p.             |
| B. G. Boone                     | 1998                | Signal Processing Using Optics                             |  | Oxford University, 394 p.              |
| A. Vanderlugt                   | 1992                | Optical signal processing                                  |  | Wiley-Interscience, 632 p.             |
| H. Caulfield                    | 2002                | Optical Information Processing                             |  | SPIE Press, 368 p.                     |