

A COURSE SYLLABUS – DOCTORAL SCHOOL
REGARDING THE QUALIFICATION CYCLE FROM 2025 TO 2029
AND
REGARDING THE QUALIFICATION CYCLE FROM 2024 TO 2028.

GENERAL INFORMATION ABOUT COURSE				
Course title	OPTIONAL SPECIALISED SUBJECT: Optical Physics			
Name of the unit running the course	Doctoral School at the University of Rzeszów			
Type of course (<i>obligatory, optional</i>)	Optional specialised			
Year and semester of studies	year I and year II/ semester: II and IV			
Discipline	physical sciences			
Language of Course	Polish language/English language			
Name of Course coordinator	Dr Wojciech Szajna, Prof. UR			
Name of Course lecturer	Dr Wojciech Szajna, Prof. UR			
Prerequisites	Well-established and in-depth knowledge in the field of physical sciences, with particular emphasis on optics, classical electrodynamics and quantum mechanics. Ability to freely use mathematical apparatus appropriate for wave physics and quantum mechanics. Knowledge of English at the B2 CEFR level, enabling work with specialist literature and fluent conversation using specialist vocabulary.			
BRIEF DESCRIPTION OF COURSE (100-200 words)				
<p>The optional specialist subject Optical Physics aims to organise, deepen and integrate the doctoral student's knowledge of modern optics, with particular emphasis on the theoretical requirements for describing the nature of light and its interaction with matter. The subject matter covers the analysis of the nature of light, the processes related to its propagation in various media, and the mechanisms of interaction between electromagnetic radiation and matter in classical and quantum terms. The issues discussed are presented in three complementary theoretical approaches: geometric optics, wave optics and quantum optics. The main emphasis of the course will be on understanding and in-depth explanation of the phenomena characteristic of each of these approaches, taking into account their assumptions, scope of applicability, and formal and interpretative limitations.</p>				
COURSE LEARNING OUTCOMES AND METHODS OF EVALUATING LEARNING OUTCOMES				
Learning outcome	The description of the learning outcome defined for the course	Relation to the degree programme outcomes (symbol)	Learning Format (Lectures, classes,...)	Method of assessment of learning outcomes (e.g. test, oral exam, written exam, project,...)
Knowledge (NO.)	<i>Knows and understands, expresses knowledge</i>			
P8S_WG1	They have extensive theoretical knowledge supported by their own research experience and are familiar with the current achievements in the field of modern optics. They are able to objectively refer to existing paradigms on optics and the physical laws applicable in geometric, wave and	P8S_WG	seminar	class participation, presentation, project

	quantum optics.			
P8S_WG2	He is familiar with global trends in the development of physical sciences with a focus on optics in the broad sense and understands the need for continuous discovery and updating of knowledge related to contemporary optics.	P8S_WG	seminar	class participation, presentation, project
P8S_WG3	Possesses interdisciplinary knowledge in the field of physics, including contemporary optics, and knows and understands the terminology used in the discipline of physical sciences, including geometric, wave and quantum optics.	P8S_WG	seminar	class participation, presentation, project
P8S_WK1	Has knowledge of the impact of technical progress and technology on the advancement of civilisation, including the discovery of new possibilities related to the discipline of physical sciences in the field of contemporary optics.	P8S_WK	seminar	class participation, presentation, project
Skills (no.)	<i>Able to</i>			
P8S_UW1	Based on interdisciplinary knowledge in the field of exact and natural sciences, is able to formulate and set ambitious scientific goals related to research on the nature of light and physical phenomena occurring in geometric, wave and quantum optics. Is able to identify and improve research methods, techniques and tools, as well as draw constructive conclusions based on the results of research work.	P8S_UW	seminar	class participation, presentation, project
P8S_UW2	Based on available global publications, they are able to diagnose and solve research and scientific problems related to the nature of light and its interaction with matter from a theoretical and conceptual perspective, taking into account various models of description (geometric, wave and quantum), and apply the appropriate course of action to create new elements of scientific achievement.	P8S_UW	seminar	class participation, presentation, project
P8S_UW3	Can impartially refer to arguments formulated on the basis of an analysis of scientific research results, expert works and other specialist studies in the field of optical physics, including geometric, wave and quantum optics.	P8S_UW	seminar	class participation, presentation, project
P8S_UK6	Is able to present research work based on the available literature on the subject and their own research results in the field of geometric, wave and quantum optics, is able to actively participate in the exchange of ideas in	P8S_UK	seminar	class participation, presentation, project

	various environments using their native language and a foreign language at B2 CEFR level, is able to engage in practical cooperation with the international scientific and professional community.					
Social competence (no.)	Ready to					
P8S_KK3	Is ready to exchange ideas, conduct substantive scientific discussions and solve cognitive and practical problems using their knowledge of the scientific discipline of physics, with particular emphasis on modern optics.		P8S_KK	seminar	class participation, presentation, project	
LEARNING FORMAT – NUMBER OF HOURS						
Semester (no.)	Lectures	Seminars	Lab classes	Internships	others	ECTS
II and IV	-	15 hrs.	-	-	-	2
METHODS OF INSTRUCTION						
- seminars; - discussion; - presentation.						
COURSE CONTENT						
<p>Substantive description of the subject matter of the classes:</p> <p>Geometric optics: Basic principles of light propagation in a radial approximation and their application to the analysis of optical images.</p> <ol style="list-style-type: none"> 1. Propagation of light rays in homogeneous and inhomogeneous media. 2. Reflection and refraction of light – the law of reflection, Snell's law, total internal reflection, fibre optics. 3. Mirrors and lenses – image construction, magnification, focusing, ... 4. Optical instruments and systems: the eye, microscope, telescope, ... 5. Optical aberrations and their correction. <p>Wave optics: The wave nature of light and explanation of the phenomena of interference, diffraction and polarisation.</p> <ol style="list-style-type: none"> 1. Wave equation and its solutions – harmonic wave, plane wave, spherical wave, waves in homogeneous and inhomogeneous media. 2. Basic laws of electromagnetic theory – Maxwell's equations. 3. Light as an electromagnetic wave – energy and momentum, light intensity, inverse square law. 4. Light interference – coherence conditions, Young's experiment, interferometers. 5. Diffraction – diffraction gratings, limits of applicability of optical instruments. 6. Polarisation – mathematical description, methods of generating and measuring polarisation, applications in experimental optics. 7. Light scattering and absorption – Rayleigh scattering, Lambert-Beer law. 8. Resolving power of optical systems in wave terms. <p>Quantum optics: The quantum nature of light and the application of quantum concepts to explain optical phenomena that are not accessible in classical wave optics.</p> <ol style="list-style-type: none"> 1. Photons and the wave-particle duality of light. 2. Electromagnetic spectrum of photons – wavelengths, frequencies, energies and applications in optics and quantum physics. 3. Quantisation of radiation energy – theory of black body radiation. 						

4. The photoelectric effect – theory and experimental interpretation.
5. The Compton effect and other interactions of photons with matter.
6. Spontaneous and stimulated emission – principles of laser operation.

COURSE ASSESSMENT CRITERIA

The examination takes place after each semester of the course (semesters: 2, 4, 6).

Examination conditions: The examination in Optical Physics covers material from three sections: geometric, wave and quantum optics, in terms of theory, description and interpretation of phenomena, and the application of mathematical and physical apparatus to describe the effects of light interaction with matter. The examination is intended to demonstrate the doctoral student's high level of competence in combining classical and quantum approaches, with particular emphasis on understanding the limits of applicability of individual models. As part of the examination, the doctoral student prepares a presentation on a topic indicated by the teacher from the range of issues related to the subject.

In addition, the following will be assessed

- the doctoral student's activity and regularity of work;
- the ability to lead discussions and draw constructive conclusions;
- the doctoral student's attendance at classes.

Requirements corresponding to individual grades:

Very good grade:

- complete, in-depth presentation, flawless use of the mathematical apparatus applied, creative interpretation of results; conclusions are correct and fully constructive;
- high level of substantive activity and engagement during classes;
- visible ability to lead discussions and draw constructive conclusions;
- attendance at least 4/5 of the total number of classes;
- active use of the recommended literature, expanded and deepened on one's own.

Good plus grade:

- presentation covering most aspects of the problem; correct use of mathematical and physical apparatus; accurate interpretation of results;
- significant activity during classes;
- attendance at least 4/5 of the total number of classes;
- visible satisfactory ability to lead discussions and draw conclusions;
- active use of the recommended literature.

Good grade:

- presentation covers the main issues, correct use of tools, logical conclusions; clear and coherent presentation;
- satisfactory substantive activity during classes;
- attendance at least 4/5 of the total number of classes;
- moderate ability to lead discussions and draw conclusions;
- satisfactory use of the recommended literature.

Pass with distinction:

- presentation partially complete, interpretation of results partially correct; presentation understandable, though incomplete;
- moderate level of substantive activity during classes;
- attendance at least 3/5 of the total number of classes;
- moderately poor ability to lead discussions and draw conclusions;
- moderate use of the suggested literature.

Satisfactory grade:

- minimal (limited) participation, discusses selected aspects; general conclusions, partially correct;
- low level of activity during classes;
- attendance at least 3/5 of the total number of classes;

- poor ability to lead discussions and draw conclusions;
 - sporadic use of the recommended literature.
- Fail:**
- incomplete or factually incorrect presentation; does not cover key aspects of the problem, incorrect use of mathematical and physical apparatus, inadequate interpretation of results and conclusions or lack of conclusions;
 - lack of activity during classes;
 - lack of ability to conduct discussions and draw conclusions;
 - absence from more than 3/5 of the total number of classes;
 - failure to use the recommended literature.

**TOTAL PhD STUDENT WORKLOAD REQUIRED TO ACHIEVE THE INTENDED LEARNING OUTCOMES
– NUMBER OF HOURS AND ECTS CREDITS**

Activity	Number of hours
Scheduled course contact hours	15
Other contact hours involving the teacher (consultation hours, examinations)	1
Non-contact hours – student’s own work (preparation for classes or examinations, project, etc.)	44
Total number of hours	60
Total number of ECTS credits	2

INSTRUCTIONAL MATERIALS

Compulsory literature:	<ol style="list-style-type: none"> 1. E. Hecht, <i>Optics</i>. 5th ed., Boston, Pearson Education, 2017. 2. M. Born, E. Wolf, <i>Principles of Optics</i>, 7th ed., Cambridge University Press, Cambridge, 2019. 3. Ling, Samuel J., Jeff Sanny, and William Moebis. <i>University Physics Volume 3</i>. Houston, TX: OpenStax, 2016. https://openstax.org/books/university-physics-volume-3/pages/1-introduction
Complementary literature:	<ol style="list-style-type: none"> 1. Halliday, David, Robert Resnick, and Jearl Walker. <i>Fundamentals of Physics</i>. 10th ed. Vol. 4. Hoboken, NJ: Wiley, 2014.

**(1 erts credit correspondes to 25–30 hours of total workload of the doctoral student, needed to achieve the intended outcomes)*

.....
Date and signature of the subject instructor

.....
Approval of the Head of the Unit or an authorized person