Course "Optical System Design"

Field of study: Design of optical systems
Course level: Master
Specialization: 200400.68 Optical Design

Semester	Hours						
	Workload	Lectures	Practical work	Lab.	Seminar	Independent studies	Tests
Autumn	216	17	-	85	57	57	Exam

Abstract

Course "Optical system design" covers the range of issues related to basic principles of designing of optical system, embracing synthesis, optimization and estimating the manufacturability. The course includes such topics as classification of aberrations that would be necessary during the analysis of the aberration properties of different optical schemes and the theory of third order aberration that may be useful for finding an initial optical scheme. The discipline also includes theoretical basis of optimization (automated correction) using special professional software, analysis and evaluation of image quality of optical systems and estimating of technological parameters for optical system fabrication.

Goals and Objectives of the Course

Knowledge of
- Theory of third order aberration
- Different criteria of image quality
- Mathematical basics of optimization

Theoretical Skills
- Knows how to create "starting" optical system for different optical devices
- Knows how to estimate the image quality of optical systems of different types
- Knows how to evaluate system sensitivity to the inaccuracy of manufacturing and to define tolerances

Practical Skills

- be able to design simple optical systems of different types, evaluate their image quality and tolerances .

Course prerequisites:

Knowledge in physics (geometric and wave optics, theory of interference and diffraction), higher mathematics (differential and integral calculus); ability to assess adequacy of modelling and designing results using knowledge of physics and mathematics, skills of working with personal computer.

Course structure

Volume of the course: 6.0 ECTS credits, 216 hours

Chapter	Types of activities					Total in hours
	Lectures	Practical work	Laboratory work	Seminar	Independent studies	
Methods of synthesis of optical systems.	4	-	25	11	11	51
Designing of the optical systems of different types	9	-	45	23	23	100
Estimating the technological parameters of optical systems and tolerancing	4	-	15	23	23	65
Total:	17	-	85	57	57	216

Section 1. «Methods of synthesis of optical systems».
    1.1 Methods of designing of optical systems.
    1.2 Methods of optimization (automatized correction)
    1.3 Choosing the functions for correction and variable parameters.
    1.4 Using constraints for the variable parameters.

Section 2. «Designing of the optical systems of different types».
    2.1 Optical system for working in visible spectral range .
    2.2 Optical schemes of telescopic systems. Objectives and oculars.
    2.3 Design methods for objectives and oculars of telescopic systems
    2.4 Requirements to the image quality of the telescopic systems. Longitudinal chromatic aberration. Astigmatism and image curvature. Pupil aberrations.
    2.5 Designing of the telescopic systems with the lens and prism inverting system

2.6 Optical systems of microscopes. Objectives and oculars in microscopes

2.7 Design of the microscope objectives. Chromatic aberration compensation. Secondary spectrum correction.

2.8 Microscopic oculars. Compensatory oculars.

2.9 Illumination systems for microscopes. Kohler and Abbe systems. Collectors and condensers.

2.10 Photoobjectives. Properties.

2.11 Designing of the photographic lenses. Requirements to the image quality.

2.12 Optical systems for the IR and UV spectral range. Materials for the IR and UV spectral range.

Section 3. « Estimating the technological parameters of optical systems and tolerancing».

3.1 Estimating the sensitivity to the variation of the parameters

3.2 Estimating the manufacturability of the optical systems.

3.3 Aberrations induced by decentering.

3.4 Methods of compensating the aberrations caused by manufacturing errors.

3.5 Defining the tolerance for manufacturing of the optical system

Lectures

Hours	Theme
2	Classification of aberration.
2	Synthesis of optical system using theory of third order aberrations
2	Synthesis of optical system using database and the method of composition.
2	Optimization of image quality of optical system: main ideas
2	Mathematics of optimization of optical system: Newton's method, least-squares method
2	Diffraction image quality and geometrical image quality of optical systems
2	Modulation transfer function, Encircled Energy, Strehl ratio, Rayleigh criterion.
3	Manufacturability of optical system. Estimating the sensitivity to the deviation of system parameters from their design value.

Laboratory work

Hours	Theme
2	Analysis of the third order spherical aberration
2	Analysis of the third order coma
2	Analysis of the third order astigmatism
2	Analysis of the third order image curvature
2	Analysis of the axial chromatic aberration and secondary spectrum
2	Analysis of the chromatic aberration of magnification
4	Design and analysis of doublet lens
6	Two-mirror system
10	Galilee telescope design
6	Designing the scheme for testing aspherical surfaces by conjugate focii method
6	Design and analysis of the system for IR range
8	Synthesis of the Petzval objective with Smith lens
4	Designing and researching the single lens with aspherical surface
6	Evaluating the sensitivity of the objective to the manufacturing errors.

Independent studies

- Preparing for laboratory works
- Writing reports
- Home work

Assessment Methods

- Test;
- Laboratory work;
- Personal skills of a student are estimated;
- Exam