Technology
Arts Sciences
TH Köln

Course Manual ABT

Theory of imaging

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General information

Long name	Theory of imaging
Approving CModule	ABT_BaET, ABT_BaOPT
Responsible	Prof. Dr. Stefan Altmeyer Professor Fakultät IME
Valid from	winter semester 2022/23
Level	Bachelor
Semester in the year	winter semester
Duration	Semester
Hours in self-study	78
ECTS	5
Professors	Prof. Dr. Stefan Altmeyer Professor Fakultät IME
Requirements	series expansion differential calculus multidimensional integral calculus basics of Fourier Transform geometrical optics basics of wave optics
Language	German
Separate final exam	Yes

Literature

Pedrotti, Pedrotti, Bausch, Schmidt: Optik für Ingenieure. Grundlagen (Springer)

Hecht: Optik (Oldenbourg)

Perez: Optik (Spektrum Akademischer Verlag)

Goodman: Introduction to Fourier Optics (Roberts and Co. Publishers)

Kurz, Lauterborn: Coherent Optics (Springer)

Final exam

Details	As long as the number of participants is not too high, oral examination is preferred of written exams. Lowest competence level checked is knowledge. This could be e.g. the names of the five Seidel aberrations, the reason of their occurance, the structure of their point spread functions and strategy of tackling them. The next competence level is related to skills. Examination could be done by showing a sketch of an optical setup and it has to be devided into functional groups and in each functional group the critical apsects regarding imaging quality have to be identified. Another skill to be tested could be the the calculation of the incoherent optical transfer function from a given coherent optical transfer function. The highest competence level adressed is methodical expertise. It can be checked by the task to do configure an optical imaging system or an analytical measurement setup for an optical imaging system. Alternatively a given system which does not meet the desired specifications has to be optimzied: in a guided discussion it can be found out easily, if the underlying principles are understood and can be applied proactively, if intellectual transfer is made and if there is sufficient overview.

Minimum standard	Correct answer of at least 50 % of the questions
Exam Type	EN mündliche Prüfung, strukturierte Befragung

Lecture / Exercises

Learning goals

Goal type	Description
Knowledge	mathematics twodimensional Fourier transform linearity theorem similarity theorem shift theorem convolution theorem autocorrelation theorem Fourier transform of some special functions Hilber space inner product norm expansion in basis vectors completness Delta functionals definition in multidimensional space, shifted sifting property mathematically equivalent representations coherence representation as correlation function temporal coherence and Wiener-Chintschin theorem spatial coherence and Van-Cittert-Zernike theorem two dimensional linear system theory applied to optical systems Point Spread Function (PSF) of electrical fields and of intensities Optical Transfer Function (OTF) for electrical fields and intensities Modulation Transfer Function (MTF) as amplitude of the OTF Phase Transfer Function (PTF) as phase of the OTF relation of OTF and PSF relation to pupil function relation to wave front aberration function mathematical relation of coherent and incoherent optical transfer function coherent and incoherent resolution limit relation of coherence and incoherence to fields and intensities Aberrations

Special requirements

none

Accompanying material	lecture notes as downloadable file
Separate exam	No

	Seidel aberrations point spread functions phase representations in the pupil plane causes of the aberrations strategies of prevention and compensation of the aberrations Zernike polynomials Methods for measuring phases Shack-Hartmann sensor shearing plate
Skills	calculate Fourier transforms with extensive use of the Fourier theorems safely analyse optical systems identify coherent and incoherent optical systems make use and apply coherent and incoherent optical system theory safely recognize and name aberrations design optical setups for the measurement of optical phases determination of aberrations

Expenditure classroom teaching

Type	Attendance (h/Wk.)
Lecture	2
Tutorial (voluntary)	0

Practical training

Learning goals

Goal type	Description
Skills	plan and build optical setups adjust optical setups use commercial software packages to analyse measured data to graph data measure impulse response function and transfer function calculate impuls response function from a given transfer function calculate transfer function from a given impulse response function build a light source with adjustable degree of coherence measure and interpret the transfer function of an objective in dependence of the degree of coherence measure and interpret the modulation transfer function of an objective in dependence of the aperture write scientific reports describe the task explain the idea of the solution illustrate the experimental setup explain the data processing make error analysis present the results and make a critical discussion

Expenditure classroom teaching

Type	Attendance (h/Wk.)
Practical training	2
Tutorial (voluntary)	0

Special requirements

none

Accompanying material	Instrcutions for the experiments as downloadable files. Operating manuals for complex equipment as downloadable files.
Separate exam	Yes

Separate exam

Exam Type	EN Projektaufgabe im Team bearbeiten (z.B. im Praktikum)

Details	1) Written examination questions related to the experiment have to be prepared at home and shown at the beginning of the laboratory. 2) The underlying ideas of the experiment have to be explained at the beginning of the laboratory. 3) Make the experiment alone (preferred) or in a team of two. - Build up and adjust your own setup - Acquire / measure date with this setup 4) Write a documentation on the experiment. It will be checked wih regard to - completness - scientific and precise language - correctness - understanding of the interrellations and interpretation of the results
Minimum standard	All written tasks must have been delt with. The basic ideas of the experiment must have been understood. All experiments must have been performed. The reports must be free of systematical errors.