Technology
Arts Sciences
TH Köln

Course
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
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

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

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Lecture

Learning goals

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
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

Separate exam

none

Practical training

Learning goals

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

Separate exam

Exam Type

working on projects assignment with your team e.g. in a lab)

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.