Technology
Arts Sciences
TH Köln

Course
TO - Technical optics

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General information

Long name	Technical optics
Approving CModule	TO_BaET, TO_BaOPT
Responsible	Prof. Dr. Stefan Altmeyer Professor Fakultät IME
Level	Bachelor
Semester in the year	summer semester
Duration	Semester
Hours in self-study	78
ECTS	5
Professors	Prof. Dr. Stefan Altmeyer Professor Fakultät IME
Requirements	mathematics: differntial calculus integral calculus physics / optics: basics of geometrical optics basics of wave optics
Language	German
Separate final exam	Yes

Final exam

Details

Standard for this lecture is a written exam.

If the number of participants is not too high, an oral examination is preferred over written exams.

Lowest competence level checked is knowledge. Questions could address the sign convention, the structure of the imaging equation in dependence of light direction, the definition of the principal ray or the labelling of optical components conforming to industry standards.

The next competence level is related to skills. Examination could be done by the task to draw the optical path of rays of optical systems whereas the qualitative correct position of functional planes is important. Furthermore calculations can be performed, e.g. the resolution of optical systems, the image shift in systems with regions of differing refractive indices, of the overall focal length of a compund system.

The highest competence level adressed is methodical expertise. It can be checked by a real world task: E.g. the design of a microscope with an own light source where some application paramters to achieve are given or some off the shelf components are given. In a guided discussion or guided calculation 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

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Lecture

Learning goals

Knowledge

maginification
reproduction scale
angular magnification
magnifier magnification
axial magnification

cardinal planes and points
node points and focal points in optical systems with asymmetric refrective indices

intendes shift of principal planes
telephoto lens
reverse telephot lens, laser material processing

multi lens systems
analytical calculation of a doublet
focal group of a camera
acessory lenses for macro photos
calculation of multi lens systems by repeated doublet calculation
approach of lens grouping in objectives

image shift
under water photography
special microscopy objectives foruse with cover glass
optical aberrations of plane-parallel glass sheets

Principle of Fermat
derivation of the law of refraction
wave-optical explaination of the properties of a lens
derivation of the sine condition

Aperture and F# number
aperture
of a glass fiber
of an optical imaging system
F# number
written F# number
effective F# number
relation of aperture and (effective) F# number
object- and image-related apertures and F# numbers
image brightness and exposure time

diffraction at a circular apertur
mathematical description
criteria for resolution
Rayleigh criterium
Sparrow criteriium
size of the Airy disc
smallest resolvable distance
in the object and in the image
in terms of the apertures and F# numbers
beneficial and empty magnification
technical examples: optical lithography, microscope, optical pickup for CD/DVD/blu-ray

lenses
imaging lens: glass and plastics
field lens: suitability of Fresnel lenses, requirements regarding dust

hard apertures and images of them
aperture stop and field stop
pupils and portholes
principal rays
complementary roles of aperture- and field-stops in imaging- and lighting-raypaths
principles of construction for optical devices with own light sources. Examples: overheadprojector, beamer, microscope

Microscopes
simple and joint
with and without field lens
reflection and transmission
Köhler illumination
interwoven light ptahs of imaging and illumination path

If there is enough time in the semester:

Abbe's theory of imaging
Decomposition of any object into gratings, Fourier decomposition
Diffraction orders: number of and phas-relationship
limiting resolution
contrast
off-axis illumination
how to build
resolution enhancement
decrease of contrast
principles of construction of a lithography machine

Skills

Analyse, calculate and design multi lens optical systems paraxially

Shift the principal planes to intended locations in optical systems.

Convert Apertured and F# numbers on the object- and image side.

Calculate imaging resolution of optical systems on the object- and image side.

Calculate the image shift.

Calculate the resolution loss due to angular dependent image shift of high aperture systems.

Design raypaths of optical systems with integrated illumination

Transfer the principles of construction of different microscope types to other optical devices.

Calculate the contrast of optical on- and off-axis systems

Expenditure classroom teaching

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

Separate exam

none

Practical training

Learning goals

Skills

- Build and align a Gallilei and a Kepler telescope

- Determine the focal lenght of an objective with the method of Abbe, Bessel or different

- Determine the principal planes with the method of Abbe of by extrapolation of the reproduction scale

- Determine the resolution of a microscope with Köhler illumination

- Determine image brightness in a microscope in dependence of reproduction scale and aperture.

- Watch and compare the object and the diffraction image in the Fourier plane in a diffraction apparatus. Perform intended image manipulations by modifications in the Fourier plane. Achieve e.g. a spatial frequency doubling.

- write scientific report
describe the task
descirbe the idea of the solution
explain 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.