

Course

TO - Technical optics

Version: 1 | Last Change: 19.09.2019 15:08 | Draft: 0 | Status: vom verantwortlichen Dozent freigegeben

^ General information

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|-----------------------------|--|
| Long name | Technical optics |
| Approving CModule | <u>TO_BaET</u> , <u>TO_BaOPT</u> |
| 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: differential 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 compound system.

The highest competence level addressed 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 parameters 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

Exam Type

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^ Lecture

Learning goals

Knowledge

magnification

reproduction scale

angular magnification

magnifier magnification

axial magnification

cardinal planes and points

node points and focal points in optical systems with asymmetric refractive indices

intended shift of principal planes
telephoto lens
reverse telephoto lens, laser material processing

multi lens systems
analytical calculation of a doublet
focal group of a camera
accessory 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 focus with cover glass
optical aberrations of plane-parallel glass sheets

Principle of Fermat
derivation of the law of refraction
wave-optical explanation 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 aperture
mathematical description
criteria for resolution
Rayleigh criterium
Sparrow criterium
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: overhead projector, beamer, microscope

Microscopes
simple and joint
with and without field lens
reflection and transmission
Köhler illumination
interwoven light paths 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 phase-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 Aperture 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

^ Practical training

Learning goals

Skills

- Build and align a Gallilei and a Kepler telescope
- Determine the focal length 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
 - describe 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 data with this setup

4) Write a documentation on the experiment. It will be checked with regard to

- completeness
- scientific and precise language
- correctness
- understanding of the interrelations and interpretation of the results

Minimum standard

All written tasks must have been dealt with.

The basic ideas of the experiment must have been understood.

All experiments must have been performed.

The reports must be free of systematic errors.