Humboldt University of Berlin
Faculty of Mathematics and Natural Sciences
Institute of Physics

Course Schedule and List of Modules of the
Master program in Optical Sciences

Translation of the German original
**Course Schedule**

In this table, you can find the apportionment of the modules across different semesters for a sample curriculum (which is not mandatory). This particular curriculum is only possible if you enroll in the winter semester.

<table>
<thead>
<tr>
<th>Nr. of Module/Name</th>
<th>1. Semester</th>
<th>2. Semester</th>
<th>3. Semester</th>
<th>4. Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mandatory Modules</strong></td>
<td>P30: Fundamentals of Optical Sciences</td>
<td>P32: Advanced Optical Sciences</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12 ECTS credits</td>
<td>12 ECTS credits</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P31: Optical Sciences Laboratory</td>
<td></td>
<td>P33: Advanced Optical Sciences Laboratory</td>
<td>15 ECTS credits</td>
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<tr>
<td></td>
<td>8 ECTS credits</td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>P34: Introduction to Independent Scientific Research</td>
<td>15 ECTS credits</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>Master Thesis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30 ECTS credits</td>
</tr>
<tr>
<td><strong>Elective Subject(^1)</strong></td>
<td>P.35.x.b</td>
<td>P.35.x.a, P.35.x.c</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 ECTS credits</td>
<td>6 ECTS credits each</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>General Electives(^2)</strong></td>
<td>General Elective Module I</td>
<td>General Elective Module II</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 ECTS credits</td>
<td>5 ECTS credits</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ECTS credits per semester</strong></td>
<td>31</td>
<td>29</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

**Notes:**

\(^1\): You have to choose one of four possible elective subjects: *Quantum Optics* (P35.1), *Nonlinear Photonics* (P35.2), *Theoretical Optics* (P35.3), or *Short-Wavelength Optics* (P35.4). For each elective subject, there is one mandatory module (P35.x.a) and two further modules can be chosen from a variety of modules. Note that several modules can be counted towards more than one elective subject. For instance, while the mandatory modules for *Nonlinear Photonics* and *Theoretical Optics* are, respectively, "Physics of Ultrafast Processes" (P35.2.a) and "Computational Photonics" (P35.3.a), the module "Nonlinear Dynamics in Photonics" can be counted towards both elective subjects, i.e., as P35.2.b/c or P35.3.b/c.

\(^2\): General elective modules can be chosen from all modules offered at HU Berlin, e.g., German language modules (depending on your level of proficiency), scientific writing, philosophy, neuroscience, advanced quantum mechanics etc.
### Descriptions of Modules

Below, you can find a detailed description of the modules listed in the above Course Schedule.

<table>
<thead>
<tr>
<th>Nr. P30, Fundamentals of Optical Sciences</th>
<th>ECTS credits: 12</th>
</tr>
</thead>
</table>

**Educational and qualification objectives:** The students are able to systematize the fundamentals and the theoretical concepts of optics and can apply them towards the solution of corresponding problems.

**Prerequisites for participation in the module or specific courses within the module:**
None

<table>
<thead>
<tr>
<th>Type of course</th>
<th>Time of attendance, Workload in hours</th>
<th>ECTS credits and requirements for their issuance</th>
<th>Topics, Content</th>
</tr>
</thead>
</table>
| Lecture        | 6 hours/week                          | 6 credits                                     | • Fundamentals of modern optics (Electrodynamics & Special Relativity, Quantum mechanics, Atom and Solid-State Physics)  
                  | 180 hours                             |                                               | • Wave optics and light propagation (Resonators, Photonic Crystals and Metamaterials)  
                  | 70 hours attendance                  |                                               | • Light-matter interaction (semi-classical description)  
                  | 110 hours pre- and post-processing of the course |                                               | • Optical amplification and Laser  
                  |                                       |                                               | • Types of Lasers and other coherent radiation sources  
                  |                                       |                                               | • Applications (Frequency conversion, Laser spectroscopy, ultrafast processes)  
                  |                                       |                                               | • Nano-optics and plasmonics  
                  |                                       |                                               | • Quantization of the electromagnetic field (Fock-, thermal and coherent states, properties of coherence)  
                  |                                       |                                               | • Quantum mechanical light-matter interaction (Jaynes-Cummings model) |
| Exercises      | 2 hours/week                          | 4 credits, participation                      | Content of the lecture |
|                | 120 hours                             |                                               |                  |
|                | 25 hours attendance                   |                                               |                  |
|                | 95 hours pre- and post-processing of the course |                                               |                  |
| Module exam    | 30 hours                              | 2 credits, pass                              |                  |
|                | Written exam, 120 minutes or oral examination, 30 minutes, and preparation |                  |                  |
| Duration of module | ☑ 1 Semester | ☐ 2 Semester |
| Begin of module | ☑ Winter semester | ☐ Summer semester |
**Nr. P31, Optical Sciences Laboratory**  
ECTS credits: 8

**Educational and qualification objectives:** The students solve complex experimental problems of modern optics via largely independent practical activities. They are able to assess the usage of experimental principles, techniques, and devices and are able to appraise and document their results.

Prerequisites for participation in the module or specific courses within the module:  
None

<table>
<thead>
<tr>
<th>Type of course</th>
<th>Time of attendance, Workload in hours</th>
<th>ECTS credits and requirements for their issuance</th>
<th>Topics, Content</th>
</tr>
</thead>
</table>
| Seminar        | 1 hour/week  
30 hours  
15 hours attendance, 15 hours pre- and post-processing of the course | 1 credit, participation | Introduction into the different experiments including safety training |
| Laboratory     | 8 hours/week  
150 hours  
90 hours attendance, 60 hours pre- and post-processing of the course | 5 credits, participation | Experiments from the following areas of optics:  
- Spectroscopy  
- Microscopy  
- Nano-Optics  
- Quantum Optics  
- Further areas of optics  
Programming exercises for the evaluation of data from or the simulation/design of experiments |
| Module exam    | 60 hours  
Portfolio of laboratory reports for every experiment, about 10 pages each | 2 credits, pass | The laboratory reports will be appraised by way of a point-based scheme. The final module grade is determined by the total number of points obtained. |

**Duration of module**  
☑️ 1 Semester  
☐ 2 Semester

**Begin of module**  
☑️ Winter semester  
☑️ Summer semester
**Nr. P32, Advanced Optical Sciences**

<table>
<thead>
<tr>
<th>Type of course</th>
<th>Time of attendance, Workload in hours</th>
<th>ECTS credits and requirements for their issuance</th>
<th>Topics, Content</th>
</tr>
</thead>
</table>
| **Lecture**    | 3 hours/week 60 hours 35 hours attendance, 25 hours pre- and post-processing of the course | 2 credits | • Key experiments of modern optics (e.g., Works that have led to Nobel prizes with direct reference to optics).
• Theoretical foundations of these key experiments |
| **Exercises**  | 1 hours/week 60 hours 15 hours attendance, 45 hours pre- and post-processing of the course | 2 credits, participation | Content of the lecture |
| **Seminar**    | 2 hours/week 180 hours 25 hours attendance, 155 hours pre- and post-processing of the course | 6 credits, Participation and talk with subsequent discussion, about 45 minutes | • Independent compilation of scientific talks on current topics of optics under the supervision of a faculty member
• Acquisition and critical evaluation of scientific presentation skills
• Constructive participation in scientific discussions |
| **Module exam**| 60 hours Written exam, 120 minutes, or oral exam, 30 minutes, and preparations | 2 credits, pass | |

Duration of module: ☑ 1 Semester ☐ 2 Semester

Begin of module: ☑ Winter semester ☐ Summer semester
**Educational and qualification objectives:** The students are acquainted with independent research. The module serves as an orientation phase regarding the Master Thesis and can thus be completed within the periphery of the future Master Thesis.

**Prerequisites for participation in the module or specific courses within the module:** None

<table>
<thead>
<tr>
<th>Type of course</th>
<th>Time of attendance, Workload in hours</th>
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<th>Topics, Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seminar</td>
<td>2 hours/week &lt;br&gt;60 hours &lt;br&gt;25 hours attendance, 65 hours pre- and post-processing of the course</td>
<td>2 credits, participation</td>
<td>Current research topics of the research group</td>
</tr>
<tr>
<td>Laboratory</td>
<td>7 hours/week &lt;br&gt;300 hours &lt;br&gt;80 hours attendance, 220 hours pre- and post-processing of the course</td>
<td>10 credits, participation</td>
<td>Research topics in preparation of the Master Thesis</td>
</tr>
<tr>
<td>Module exam</td>
<td>90 hours &lt;br&gt;Term paper in report form (about 10 pages) or oral examination in form of talk in the research seminar of the research group with subsequent discussion, about 45 minutes</td>
<td>3 credits, pass</td>
<td>Compilation of the current state-of-the-art of research in a topics, preferably the topic of the Master Thesis, within the research seminar of the research group</td>
</tr>
</tbody>
</table>

**Duration of module:**
- ☑ 1 Semester
- ☐ 2 Semester

**Begin of module:**
- ☑ Winter semester
- ☑ Summer semester
**Nr. P34, Introduction into Independent Scientific Research**  
ECTS credits: 15

**Educational and qualification objectives:** The students will acquire the skills required for the successful independent handling of the topic of the Master Thesis. This module serves as a preparation for the Master Thesis.

Prerequisites for participation in the module or specific courses within the module: None

<table>
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<tr>
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<th>Topics, Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seminar</td>
<td>2 hours/week 60 hours 25 hours attendance, 65 hours pre- and post-processing of the course</td>
<td>2 credits, participation</td>
<td>Current research topics of the research group</td>
</tr>
<tr>
<td>Laboratory</td>
<td>7 hours/week 300 hours 80 hours attendance, 220 hours pre- and post-processing of the course</td>
<td>10 credits, participation</td>
<td>Independent execution of research work in immediate preparation of the Master Thesis under the supervision of a faculty member</td>
</tr>
<tr>
<td>Module exam</td>
<td>90 hours Term paper in report form (about 10 pages) or oral examination in form of talk in the research seminar of the research group with subsequent discussion, about 45 minutes</td>
<td>3 credits, participation</td>
<td>Acquisition of scientific methods, their demonstration and the presentation of scientific results in the form of a talk or a report (about 10 pages)</td>
</tr>
</tbody>
</table>

**Duration of module**  
☑ 1 Semester  ☐ 2 Semester

**Begin of module**  
☑ Winter semester  ☐ Summer semester
**Nr. P35.1.a, Quantum Optics**

**ECTS credits:** 6

**Educational and qualification objectives:** The students are able to systematize the fundamentals and the theoretical description of quantum optics and are further able to apply them towards the solution of pertinent problems.

**Prerequisites for participation in the module or specific courses within the module:** Knowledge of optics, quantum mechanics, and laser physics

<table>
<thead>
<tr>
<th>Type of course</th>
<th>Time of attendance, Workload in hours</th>
<th>ECTS credits and requirements for their issuance</th>
<th>Topics, Content</th>
</tr>
</thead>
</table>
| Lecture        | 3 hours/week 60 hours 35 hours attendance, 25 hours pre- and post-processing of the course | 2 credits | - Fundamentals of quantum optics  
- Quantum-optical 3-level systems (electromagnetically induced transparency, slow light etc.)  
- Quasi-probability distributions (Wigner, Husimi, Glauber-Sudarshan)  
- System-reservoir interaction (Markov approximation, Wigner-Weisskopf theory, fluctuation-dissipation theorem)  
- Cavity Quantum Electrodynamics  
- Laser theory (semi-classical and fully quantized)  
- Quantum optical tests of quantum mechanics  
- Fundamentals of atom optics (matter waves) |
| Exercises      | 1 hours/week 60 hours 15 hours attendance, 45 hours pre- and post-processing of the course | 2 credits, participation | Content of the lecture |
| Module exam    | 60 hours Written exam, 120 minutes, or oral exam, 30 minutes, and preparations | 2 credits, pass | |

**Duration of module**:  
- ☑ 1 Semester  
- ☐ 2 Semester

**Begin of module**:  
- ☐ Winter semester  
- ☑ Summer semester
**Nr. P35.1.b, Quantum Optics Specialization I**  
ECTS credits: 6

**Educational and qualification objectives:** The students are able to systematize the fundamentals of current topics of quantum optics and are further able to apply them towards the solution of pertinent problems.

**Prerequisites for participation in the module or specific courses within the module:** Knowledge of optics, quantum mechanics, and laser physics

<table>
<thead>
<tr>
<th>Type of course</th>
<th>Time of attendance, Workload in hours</th>
<th>ECTS credits and requirements for their issuance</th>
<th>Topics, Content</th>
</tr>
</thead>
</table>
| Lecture        | 3 hours/week  
60 hours  
35 hours attendance,  
25 hours pre- and post-processing of the course | 2 credits | Semester-wise varying lectures with varying topics of quantum optics. Among others, lectures with the following topics are regularly offered:  
- Quantum Information  
- Quantum Dynamics in Strong Laser Fields  
- Laser Cooling  
- Nano Optics  
- Fluctuation-Induced Phenomena |
| Exercises      | 1 hours/week  
60 hours  
15 hours attendance,  
45 hours pre- and post-processing of the course | 2 credits, participation | Content of the lecture |
| Module exam    | 60 hours  
Written exam, 120 minutes, or oral exam, 30 minutes, and preparations | 2 credits, pass | |

**Duration of module**  
- ☐ 1 Semester  
- ☐ 2 Semester

**Begin of module**  
- ☐ Winter semester  
- ☐ Summer semester
**Nr. P35.1.c, Quantum Optics Specialization II**

**ECTS credits:** 6

**Educational and qualification objectives:** The students are able to systematize the fundamentals of current topics of quantum optics and are further able to apply them towards the solution of pertinent problems.

**Prerequisites for participation in the module or specific courses within the module:**
Knowledge of optics, quantum mechanics, and laser physics

<table>
<thead>
<tr>
<th>Type of course</th>
<th>Time of attendance, Workload in hours</th>
<th>ECTS credits and requirements for their issuance</th>
<th>Topics, Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>3 hours/week</td>
<td>2 credits</td>
<td>Semester-wise varying lectures with varying topics of quantum optics. Among others, lectures with the following topics are regularly offered:</td>
</tr>
<tr>
<td></td>
<td>60 hours</td>
<td></td>
<td>- Quantum Information</td>
</tr>
<tr>
<td></td>
<td>35 hours attendance,</td>
<td></td>
<td>- Quantum Dynamics in Strong Laser Fields</td>
</tr>
<tr>
<td></td>
<td>25 hours pre- and post- processing of the course</td>
<td></td>
<td>- Laser Cooling</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Nano Optics</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Fluctuation-Induced Phenomena</td>
</tr>
<tr>
<td>Exercises</td>
<td>1 hours/week</td>
<td>2 credits, participation</td>
<td>Content of the lecture</td>
</tr>
<tr>
<td></td>
<td>60 hours</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>15 hours attendance,</td>
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</tr>
<tr>
<td></td>
<td>45 hours pre- and post- processing of the course</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Module exam</td>
<td>60 hours</td>
<td>2 credits, pass</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Written exam, 120 minutes, or oral exam, 30 minutes, and preparations</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Duration of module**
- 1 Semester
- 2 Semester

**Begin of module**
- Winter semester
- Summer semester
**Nr. P35.2.a,  Physics of Ultrafast Processes**  

**ECTS credits:** 6

**Educational and qualification objectives:** Introduction in the generation of ultrashort light pulses, measurement processes of short pulse spectroscopy, and the physics of ultrafast light-induces processes in atoms, molecules and solids.

**Prerequisites for participation in the module or specific courses within the module:** Knowledge of optics, quantum mechanics, and laser physics

<table>
<thead>
<tr>
<th>Type of course</th>
<th>Time of attendance, Workload in hours</th>
<th>ECTS credits and requirements for their issuance</th>
<th>Topics, Content</th>
</tr>
</thead>
</table>
| Lecture        | 3 hours/week 60 hours 35 hours attendance, 25 hours pre- and post-processing of the course | 2 credits | • Generation of ultrashort light pulses  
• Frequency conversion of ultrashort pulses  
• Temporal beam shaping  
• Measurement processes of short pulse spectroscopy  
• Ultrafast processes in isolated systems  
• Ultrafast dynamics of molecular systems in the condensed phase  
• Dynamics of elementary excitations in solids  
• Ultrafast structural changes |
| Exercises      | 1 hours/week 60 hours 15 hours attendance, 45 hours pre- and post-processing of the course | 2 credits, participation | Content of the lecture |
| Module exam    | 60 hours Written exam, 120 minutes, or oral exam, 30 minutes, and preparations | 2 credits, pass | |

**Duration of Module**
- ☑ 1 Semester
- ☐ 2 Semester

**Begin of module**
- ☑ Summer semester  
- ☐ Winter semester
**Nr. P35.2.b, Nonlinear Photonics Specialization I**

ECTS credits: 6

**Educational and qualification objectives:** The students are able to systematize the fundamentals of current topics of nonlinear photonics and are further able to apply them towards the solution of pertinent problems.

**Prerequisites for participation in the module or specific courses within the module:**
Knowledge of optics, quantum mechanics, and laser physics

<table>
<thead>
<tr>
<th>Type of course</th>
<th>Time of attendance, Workload in hours</th>
<th>ECTS credits and requirements for their issuance</th>
<th>Topics, Content</th>
</tr>
</thead>
</table>
| Lecture        | 3 hours/week                          | 2 credits                                       | Semester-wise varying lectures with varying topics of nonlinear photonics. Among others, lectures with the following topics are regularly offered:  
- Nonlinear Optics  
- Nonlinear Dynamics in Photonics  
- THz Spectroscopy  
- Quantum Dynamics in Strong Laser Fields  
- Physics of Ultrafast Processes |
|                | 60 hours                              |                                                 |                 |
|                | 35 hours attendance, 25 hours pre- and post-processing of the course |                                                 |                 |
| Exercises      | 1 hours/week                          | 2 credits, participation                        | Content of the lecture |
|                | 60 hours                              |                                                 |                 |
|                | 15 hours attendance, 45 hours pre- and post-processing of the course |                                                 |                 |
| Module exam    | 60 hours                              | 2 credits, pass                                 |                 |
|                | Written exam, 120 minutes, or oral exam, 30 minutes, and preparations |                                                 |                 |

**Duration of Module**
- ☑ 1 Semester
- ☐ 2 Semester

**Begin of module**
- ☑ Winter semester
- ☐ Summer semester
Nr. P35.2.c, Nonlinear Photonics Specialization II  

**ECTS credits:** 6

**Educational and qualification objectives:** The students are able to systematize the fundamentals of current topics of nonlinear photonics and are further able to apply them towards the solution of pertinent problems.

**Prerequisites for participation in the module or specific courses within the module:**
Knowledge of optics, quantum mechanics, and laser physics

<table>
<thead>
<tr>
<th>Type of course</th>
<th>Time of attendance, Workload in hours</th>
<th>ECTS credits and requirements for their issuance</th>
<th>Topics, Content</th>
</tr>
</thead>
</table>
| **Lecture**    | 3 hours/week  
60 hours  
35 hours attendance,  
25 hours pre- and post-processing of the course | 2 credits | Semester-wise varying lectures with varying topics of nonlinear photonics. Among others, lectures with the following topics are regularly offered:
- Nonlinear Optics
- Nonlinear Dynamics in Photonics
- THz Spectroscopy
- Quantum Dynamics in Strong Laser Fields
- Physics of Ultrafast Processes |
| **Exercises**  | 1 hours/week  
60 hours  
15 hours attendance,  
45 hours pre- and post-processing of the course | 2 credits, participation | Content of the lecture |
| **Module exam** | 60 hours  
Written exam, 120 minutes, or oral exam, 30 minutes, and preparations | 2 credits, pass | |

**Duration of module**
- ☑ 1 Semester
- ☑ 2 Semester

**Begin of module**
- ☑ Winter semester
- ☑ Summer semester
**Educational and qualification objectives:** The students acquire the fundamentals of computational photonics, i.e., the current research areas, the methodologies and techniques, and the open scientific questions. The students are further able to apply this knowledge towards the solution of pertinent problems.

**Prerequisites for participation in the module or specific courses within the module:**
Knowledge of optics, quantum mechanics, and laser physics

<table>
<thead>
<tr>
<th>Type of course</th>
<th>Time of attendance, Workload in hours</th>
<th>ECTS credits and requirements for their issuance</th>
<th>Topics, Content</th>
</tr>
</thead>
</table>
| Lecture        | 3 hours/week, 60 hours 60 hours attendance, 35 hours attendance, 25 hours pre- and post-processing of the course | 2 credits | • Finite-difference techniques  
• Treatment of dispersive materials via auxiliary differential equations  
• Treatment of open systems via perfectly matched layers (PMLs)  
• Beam propagation method  
• Photonic band structure computations  
• Rigorous Coupled Wave Analysis  
• Advanced time-stepping approaches (Operator exponentials etc.)  
• Advanced spatial discretization (Finite element methods) |
| Exercises      | 1 hours/week, 60 hours 60 hours attendance, 15 hours attendance, 45 hours pre- and post-processing of the course | 2 credits, participation | Content of the lecture |
| Module exam    | 60 hours Written exam, 120 minutes, or oral exam, 30 minutes, and preparations | 2 credits, pass | |

**Duration of Module**
- ☑ 1 Semester
- ☐ 2 Semester

**Begin of module**
- ☑ Summer semester
- ☐ Winter semester
**Nr. P35.3.b, Theoretical Optics Specialization I**  
ECTS credits: 6

*Educational and qualification objectives:* The students are able to systematize the fundamentals of current topics of theoretical optics and are further able to apply them towards the solution of pertinent problems.

Prerequisites for participation in the module or specific courses within the module:  
Knowledge of optics, quantum mechanics, and laser physics

<table>
<thead>
<tr>
<th>Type of course</th>
<th>Time of attendance, Workload in hours</th>
<th>ECTS credits and requirements for their issuance</th>
<th>Topics, Content</th>
</tr>
</thead>
</table>
| Lecture        | 3 hours/week  
60 hours  
35 hours attendance,  
25 hours pre- and post-processing of the course | 2 credits | Semester-wise varying lectures with varying topics of theoretical optics. Among others, lectures with the following topics are regularly offered:  
- Quantum Optics  
- Fluctuation-induced Phenomena  
- Quantum Information  
- Quantum Dynamics in Strong Laser Fields  
- Nonlinear Dynamics in Photonics |
| Exercises      | 1 hours/week  
60 hours  
15 hours attendance,  
45 hours pre- and post-processing of the course | 2 credits, participation | Content of the lecture |
| Module exam    | 60 hours  
Written exam, 120 minutes, or oral exam, 30 minutes, and preparations | 2 credits, pass | |

**Duration of Module**  
☑ 1 Semester  
☐ 2 Semester

**Begin of module**  
☑ Winter semester  
☐ Summer semester
**Nr. P35.3.c, Theoretical Optics Specialization II**  
ECTS credits: 6

**Educational and qualification objectives:** The students are able to systematize the fundamentals of current topics of theoretical optics and are further able to apply them towards the solution of pertinent problems.

**Prerequisites for participation in the module or specific courses within the module:**  
Knowledge of optics, quantum mechanics, and laser physics

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</thead>
</table>
| Lecture        | 3 hours/week 60 hours 35 hours attendance, 25 hours pre- and post-processing of the course | 2 credits | Semester-wise varying lectures with varying topics of theoretical optics. Among others, lectures with the following topics are regularly offered:  
  - Quantum Optics  
  - Fluctuation-induced Phenomena  
  - Quantum Information  
  - Quantum Dynamics in Strong Laser Fields  
  - Nonlinear Dynamics in Photonics |
| Exercises      | 1 hours/week 60 hours 15 hours attendance, 45 hours pre- and post-processing of the course | 2 credits, participation | Content of the lecture |
| Module exam    | 60 hours Written exam, 120 minutes, or oral exam, 30 minutes, and preparations | 2 credits, pass | |

**Duration of module**  
- ☑ 1 Semester  
- ☐ 2 Semester

**Begin of module**  
- ☐ Winter semester  
- ☑ Summer semester
**Nr. P35.4.a, Fourier Optics and X-Ray Microscopy**  

**ECTS credits: 6**

*Educational and qualification objectives:* The students acquire the fundamentals of microscopy with X-rays, i.e., the current research topics, the methodologies and techniques, and the open scientific questions. They are further able to apply this knowledge towards the solution of pertinent problems.

Prerequisites for participation in the module or specific courses within the module: Knowledge of optics, quantum mechanics, and laser physics

<table>
<thead>
<tr>
<th>Type of course</th>
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</thead>
</table>
| Lecture        | 3 hours/week  
|                | 60 hours  
|                | 35 hours attendance,  
|                | 25 hours pre- and post-processing of the course | 2 credits |  
|                | • Introduction to X-ray optics  
|                | • Composition of microscopes  
|                | • X-ray sources  
|                | • Contrast mechanisms  
|                | • Applications in material science and the life sciences |
| Exercises      | 1 hours/week  
|                | 60 hours  
|                | 15 hours attendance,  
|                | 45 hours pre- and post-processing of the course | 2 credits, participation | Content of the lecture |
| Module exam    | 60 hours  
|                | Written exam, 120 minutes, or oral exam, 30 minutes, and preparations | 2 credits, pass |

Duration of Module  
- ☐ 1 Semester  
- ☐ 2 Semester

Begin of module  
- ☐ Winter semester  
- ☑ Summer semester
**Nr. P35.4.b, Short-Wavelength Optics Specialization I**

**ECTS credits:** 6

**Educational and qualification objectives:** The students are able to systematize the fundamentals of current topics of short-wavelength optics and are further able to apply them towards the solution of pertinent problems.

**Prerequisites for participation in the module or specific courses within the module:** Knowledge of optics, quantum mechanics, and laser physics

<table>
<thead>
<tr>
<th>Type of course</th>
<th>Time of attendance, Workload in hours</th>
<th>ECTS credits and requirements for their issuance</th>
<th>Topics, Content</th>
</tr>
</thead>
</table>
| Lecture        | 3 hours/week 60 hours 35 hours attendance, 25 hours pre- and post-processing of the course | 2 credits | Semester-wise varying lectures with varying topics of short-wavelength optics. Among others, lectures with the following topics are regularly offered:  
- Modern X-Ray Optics  
- Introduction to Electron Microscopy  
- Synchrotron Radiation  
- Physics of Ultrafast Processes |
| Exercises      | 1 hours/week 60 hours 15 hours attendance, 45 hours pre- and post-processing of the course | 2 credits, participation | Content of the lecture |
| Module exam    | 60 hours Written exam, 120 minutes, or oral exam, 30 minutes, and preparations | 2 credits, pass | |

**Duration of Module**  
- 1 Semester
- 2 Semester

**Begin of module**  
- Winter semester
- Summer semester
**Nr. P35.4.c, Short-Wavelength Optics Specialization II**  
ECTS credits: 6

**Educational and qualification objectives:** The students are able to systematize the fundamentals of current topics of short-wavelength optics and are further able to apply them towards the solution of pertinent problems.

**Prerequisites for participation in the module or specific courses within the module:** Knowledge of optics, quantum mechanics, and laser physics

| Type of course | Time of attendance,  
|                | Workload in hours | ECTS credits and  
|                |                   | requirements for  
|                |                   | their issuance |
| Lecture        | 3 hours/week      | 2 credits         | Semester-wise varying lectures with varying topics of short-wavelength optics. Among others, lectures with the following topics are regularly offered:  
|                | 60 hours          |                   | • Modern X-Ray Optics  
|                | 35 hours attendance, |                   | • Introduction to Electron Microscopy  
|                | 25 hours pre- and post- |                   | • Synchrotron Radiation  
|                | processing of the course |                   | • Physics of Ultrafast Processes  
|                |                    |                   | Content of the lecture |
| Exercises      | 1 hours/week      | 2 credits,  
|                | 60 hours          | participation     | |
|                | 15 hours attendance, |                   | |
|                | 45 hours pre- and post- |                   | |
|                | processing of the course |                   | |
| Module exam    | 60 hours          | 2 credits, pass  |
|                | Written exam, 120 minutes, or oral exam, 30 minutes, and preparations | |

**Duration of module**  
- ☑ 1 Semester
- ☐ 2 Semester

**Begin of module**  
- ☑ Winter semester
- ☐ Summer semester