Module Catalogue
for the Subject

Physics

as vertieft studiertes Fach (studied with a focus on the scientific discipline)
with the degree "Erste Staatsprüfung für das Lehramt an Gymnasien"

Examination regulations version: 2015
Responsible: Faculty of Physics and Astronomy
Contents

The subject is divided into 4
Abbreviations used, Conventions, Notes, In accordance with 5
Scientific Discipline 6
Compulsory Courses 7
Classical Physics 8
    Classical Physics 1 (Mechanics) 9
    Classical Physics 2 (Heat and Electromagnetism) 11
Optics and Quantum Physics I 13
    Optics and Quantum Physics 14
Optics and Quantum Physics II 16
    Optics and Waves - Exercises 17
    Modern Physics 1 - Exercises (Atoms and Quantum Physics) 18
Modern Physics 19
    Modern Physics 2 (Molecule and Solid State Physics) 20
    Modern Physics 3 (Nuclear, Particle and Astrophysics) 21
    General Concepts of Physics 22
Theoretical Physics I 23
    Theoretical Physics 1 and 2 for Pre Service Teachers - Fundamentals 24
Theoretical Physics II 25
    Theoretical Physics 1 for Pre Service Teachers - Exercises 26
    Theoretical Physics 2 for Pre Service Teachers - Exercises 27
Computational Methods 28
    Mathematical Methods of Physics 29
Laboratory Course I 30
    Laboratory Course Physics A(Mechanics, Heat, Electromagnetism) 31
    Data and Error Analysis 32
    Laboratory Course Physics B (Electricity, Circuits, Atomic and Nuclear Physics) 33
    Advanced Laboratory Course 34
Laboratory Course II 35
    Demonstration Laboratory Course 1 36
    Demonstration Laboratory Course 2 37
    Practical Training in Student Lab 38
Teaching 39
Compulsory Courses 40
    Physics Teaching Concepts 1 41
    Physics Teaching Concepts 2 42
    Physics Teaching Concepts Seminar 43
    Student Lab Preparation Course (Physics) German Gymnasium 44
Thesis 45
Physics: Practical Training and Theory of Classroom 46
Freier Bereich (general as well as subject-specific electives) 47
Physics 48
    Teaching Seminar Fundamental Principles 49
    Selected Topics in Physics Didactics 50
    Preparatory Course Mathematics 51
    Student Lab Supervision (Physics) 52
    Low Cost - High Impact. Low-budget Experiments for Science Courses (Physics) 53
    Teaching Science with Hands-on-Exhibits (Physics) 54
    Astrophysics 55
Principles of Energy Technologies  56
Current Topics of Teaching Concepts in Physics  57
Scientific Work in Teaching Concepts  58
Current Topics in Physics  59
Selected Topics of Physics  60
Thesis  61
Thesis in Physics (Teaching Degree at German Gymnasium)  62
The subject is divided into

<table>
<thead>
<tr>
<th>section / sub-section</th>
<th>ECTS credits</th>
<th>starting page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific Discipline</td>
<td>92</td>
<td>6</td>
</tr>
<tr>
<td>Compulsory Courses</td>
<td>92</td>
<td>7</td>
</tr>
<tr>
<td>Classical Physics</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>Optics and Quantum Physics I</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Optics and Quantum Physics II</td>
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<td>16</td>
</tr>
<tr>
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<td>17</td>
<td>19</td>
</tr>
<tr>
<td>Theoretical Physics I</td>
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<tr>
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<td>25</td>
</tr>
<tr>
<td>Computational Methods</td>
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<td>28</td>
</tr>
<tr>
<td>Laboratory Course I</td>
<td>14</td>
<td>30</td>
</tr>
<tr>
<td>Laboratory Course II</td>
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<td>35</td>
</tr>
<tr>
<td>Teaching</td>
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<td>39</td>
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<tr>
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<td>Thesis</td>
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<tr>
<td>Freier Bereich (general as well as subject-specific electives)</td>
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<td>47</td>
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<tr>
<td>Physics</td>
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<td>48</td>
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<tr>
<td>Thesis</td>
<td>10</td>
<td>61</td>
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</table>
Abbreviations used

Course types: \( E = \) field trip, \( K = \) colloquium, \( O = \) conversatorium, \( P = \) placement/lab course, \( R = \) project, \( S = \) seminar, \( T = \) tutorial, \( \dot{U} = \) exercise, \( V = \) lecture

Term: \( SS = \) summer semester, \( WS = \) winter semester

Methods of grading: \( \text{NUM} = \) numerical grade, \( B/NB = \) (not) successfully completed

Regulations: \( (L)\text{ASPO} = \) general academic and examination regulations (for teaching-degree programmes), \( FSB = \) subject-specific provisions, \( SFB = \) list of modules

Other: \( A = \) thesis, \( LV = \) course(s), \( PL = \) assessment(s), \( TN = \) participants, \( VL = \) prerequisite(s)

Conventions

Unless otherwise stated, courses and assessments will be held in German, assessments will be offered every semester and modules are not creditable for bonus.

Notes

Should there be the option to choose between several methods of assessment, the lecturer will agree with the module coordinator on the method of assessment to be used in the current semester by two weeks after the start of the course at the latest and will communicate this in the customary manner.

Should the module comprise more than one graded assessment, all assessments will be equally weighted, unless otherwise stated below.

Should the assessment comprise several individual assessments, successful completion of the module will require successful completion of all individual assessments.

In accordance with

the general regulations governing the degree subject described in this module catalogue:

\( \text{LASPO2015} \)

associated official publications (FSB (subject-specific provisions)/SFB (list of modules)):

\( 20-\text{Oct-2015 (2015-218)} \)

This module handbook seeks to render, as accurately as possible, the data that is of statutory relevance according to the examination regulations of the degree subject. However, only the FSB (subject-specific provisions) and SFB (list of modules) in their officially published versions shall be legally binding. In the case of doubt, the provisions on, in particular, module assessments specified in the FSB/SFB shall prevail.
Scientific Discipline
(92 ECTS credits)
Compulsory Courses
(92 ECTS credits)
Classical Physics

(16 ECTS credits)
Module title: Classical Physics 1 (Mechanics)
Abbreviation: 11-E-M-152-m01

Module coordinator: Managing Director of the Institute of Applied Physics
Module offered by: Faculty of Physics and Astronomy

ECTS: 8
Method of grading: Only after succ. compl. of module(s)
Numerical grade: --

Duration: 1 semester
Module level: undergraduate
Other prerequisites: Admission prerequisite to assessment: completion of exercises (approx. 13 exercise sheets per semester). Students who successfully completed approx. 50% of exercises will qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the semester.

Contents
1. Principles: Physical quantities, prefactors, derived quantities, dimensional analysis, time / length / mass (definition, measurement procedures, SI), importance of metrology;
2. Point Mechanics: Kinematics, motion in 2D and 3D / vectors, special cases: Uniform and constant accelerated motion, free fall, slate litter; circular motion in polar coordinates;
3. Newton's laws: Forces and momentum definition, weight vs. mass forces on the pendulum, forces on an atomic scale, isotropic and anisotropic friction. Preparation of the equations of motion and solutions;
4. Work and energy: (Kinetic) performance, examples;
5. Elastic, inelastic and super-elastic collision: Energy and momentum conservation, surges in centre of mass and balance system, rocket equation;
6. Conservative and non-conservative force fields: Potential, potential energy; law, weight scale, field strength and potential of gravity (general relations);
7. Rotational motion: Angular momentum, angular velocity, torque, rotational energy, moment of inertia, analogies to linear translation, applications, satellites (geostationary and interstellar), escape velocities, trajectories in the central potential;
8. Tidal forces: Inertial system, reference systems, apparent forces, Foucault pendulum, Coriolis force, centrifugal force;
9. Galilean transformation: Brief digression to Maxwell’s equations, ether, Michelson interferometer, Einstein’s postulates, problem of simultaneity, Lorentz transformation, time dilation and length contraction, relativistic impulse;
10. Rigid body and gyroscope: Determining the centre of mass, inertia tensor and -ellipsoid, principal axes and their stability, tensor on the example of the elasticity tensor, physics of the bike; gyroscope: Precession and nutation, the Earth as a spinning top;
11. Friction: Static and dynamic friction, stick-slip motion, rolling friction, viscous friction, laminar flow, eddy formation;
12. Vibration: Representation by means of complex e-function, equation of motion (DGL) on forces, torque and power approach, Taylor expansion, harmonic approximation; spring and pendulum, physical pendulum, damped vibration (resonant case, Kriechfall, aperiodic limit), forced vibration, Fourier analysis;
13. Coupled vibrations: Eigenvalues and eigenfunctions, double pendulum, deterministic vs. chaotic motion, non-linear dynamics and chaos;
14. Waves: Wave equation, transverse and longitudinal waves, polarisation, principle of superposition, reflection at the open and closed end, speed of sound; interference, Doppler effect; phase and group velocity, dispersion relation;
15. Elastic deformation of solid bodies: Elastic modulus, general Hooke’s law, elastic waves;
16. Fluids: Hydrostatic pressure and buoyancy, surface tension and contact angle, capillary forces, steady flows, Bernoulli equation; Boyle-Mariotte, gas laws, barometric height formula, air pressure, compressibility and compressive modulus;
17. Kinetic theory of gases: ideal and real gas, averages, distribution functions, equipartition theorem, Brownian motion, collision cross section, mean free path, diffusion and osmosis, degrees of freedom, specific heat
## Intended learning outcomes

The students understand the basic contexts and principles of mechanics, vibration, waves and kinetic theory of gases. They are able to apply mathematical methods to the formulation of physical contexts and autonomously apply their knowledge to the solution of mathematical-physical tasks.

### Courses

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of weekly contact hours</th>
<th>Language(s)</th>
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</thead>
<tbody>
<tr>
<td>V</td>
<td>(4)</td>
<td>German or English</td>
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<tr>
<td>Ü</td>
<td>(2)</td>
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</tbody>
</table>

Module taught in: Ü: German or English

### Method of assessment

- **written examination (approx. 120 minutes)**
- **Language of assessment:** German and/or English

### Allocation of places

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### Additional information

Registration: If a student registers for the exercises and obtains the qualification for admission to assessment, this will be considered a declaration of will to seek admission to assessment pursuant to Section 20 Subsection 3 Sentence 4 ASPO (general academic and examination regulations). If the module coordinators subsequently find that the student has obtained the qualification for admission to assessment, they will put the student’s registration for assessment into effect. Only those students that meet the respective prerequisites can successfully register for an assessment. Students who did not register for an assessment or whose registration for an assessment was not put into effect will not be admitted to the respective assessment. If a student takes an assessment to which he/she has not been admitted, the grade achieved in this assessment will not be considered.

### Referred to in LPO I

- § 53 I Nr. 1 a)
- § 77 I Nr. 1 a)
### Module title

Classical Physics 2 (Heat and Electromagnetism)

### Abbreviation

11-E-E-152-m01

### Module coordinator

Managing Director of the Institute of Applied Physics

### Module offered by

Faculty of Physics and Astronomy

### ECTS

8

### Method of grading

numerical grade

### Only after succ. compl. of module(s)

--

### Duration

1 semester

### Module level

undergraduate

### Other prerequisites

Admission prerequisite to assessment: completion of exercises (approx. 13 exercise sheets per semester). Students who successfully completed approx. 50% of exercises will qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the semester.

### Contents

1. Thermodynamics (linked to 11-E-M); temperature and quantity of heat, thermometer, Kelvin scale;
2. Heat conduction, heat transfer, diffusion, convection, radiant heat;
3. Fundamental theorems of thermodynamics, entropy, irreversibility, Maxwell’s demon;
4. Heat engines, working diagrams, efficiency, example: Stirling engine;
5. Real gases and liquids, states of matter (also solids), van der Waals, critical point, phase transitions, critical phenomena (opalescence), coexistence region, Joule-Thomson;
6. Electrostatics, basic concepts: Electrical charge, forces; electric field, reps. field concept, field lines, field of a point charge;
7. Gaussian sentence, related to Coulomb’s law, definition of "river"; Gaussian surface, divergence theorem; special symmetries; divergence and GS in differential form;
8. Electrical potential, working in the E-box, electric. potential, potential difference, voltage; potential equation, equipotential surfaces; several important examples: Sphere, hollow sphere, capacitor plates, electric dipole; lace effects, Segner wheel;
9. Matter in the E-field, charge in a homogeneous field, Millikan experiment, Braun tube; electron: Field emission, dipole in homogeneous and inhomogeneous field; induction, Faraday cage;
10. Capacitor, mirror charge, definition, capacity; plate and spherical capacitor; combination of capacitors; media in the capacitor; electrical polarisation, displacement and orientation polarisation, microscopic image; dielectric displacement; electrolytic capacitor; Piezoelectric effect;
11. Electricity, introduction, current density, drift velocity, conduction mechanisms;
12. Resistance and conductivity, resistivity, temperature dependence; Ohm’s law; realisations (resistive and non-ohmic, NTC, PTC);
13. Circuits, electrical networks, Kirchhoff’s rules (meshes, nodes); internal resistance of a voltage source, measuring instruments; Wheatstone bridge;
14. Power and energy in the circuit; Capacitor charge; galvanic element; thermovoltage;
15. Transfer mechanisms, conduction in solids: Band model, semiconductor; line in liquids and gases;
16. Magnetostatics, fundamental laws; permanent magnet, field properties, definitions and units; Earth’s magnetic field; Amper’s Law, analogous to e-box, magn. river, swirl;
17. Vector potential, formal derivation, analogous to electric scalar potential; calculation of fields, examples, Helmholtz coils;
18. Moving charge in the static magnetic field, current balance, Lorentz force, right-hand rule, electric motor; dipole field; movement paths, mass spectrometer, Wien filters, Hall effect; electron: e / m determination;
19. matter in the magnetic field, effects of the field on matter, relative permeability, susceptibility; para-, dia-, ferromagnetism; magn. moment of the electron, behaviour at interfaces;
20. Induction, Faraday’s law of induction, Lenz’s rule, flux change, eddy electric field, Waltenhofen’s pendulum; inductance self-induction; applications: Transformer, generator;
21. Maxwell’s displacement current, choice of integration area, displacement current; Maxwell’s extension, wave equation; Maxwell equations;
22. AC: Fundamentals, sinusoidal vibrations, amplitude, period and phase; power and RMS value, ohmic resistance; Capacitive & inductive resistor, capacitor and coil, phase shift and frequency dependence; impedance: Complex resistance; performance of the AC;
23. Resonant circuits, combinations of RLC; series and parallel resonant circuit; forced vibration, damped harmonic oscillator (related to 11-E-M);
24: Hertz dipole, characteristics of irradiation, near field, far field; Rayleigh scattering; accelerated charge, synchrotron radiation, X-rays; 25. Electromagnetic waves: Principles, Maxwell’s determination to electromagnetism, radiation pressure (Poynting vector, radiation pressure).

**Intended learning outcomes**
The students understand the basic principles and contexts of thermodynamics, science of electricity and magnetism. They know relevant experiments to observe and measure these principles and contexts. They are able to apply mathematical methods to the formulation of physical contexts and autonomously apply their knowledge to the solution of mathematical-physical tasks.

**Courses**
(type, number of weekly contact hours, language — if other than German)
V (4) + Ü (2)
Module taught in: Ü: German or English

**Method of assessment**
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
written examination (approx. 120 minutes)
Language of assessment: German and/or English

**Allocation of places**
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**Additional information**
Registration: If a student registers for the exercises and obtains the qualification for admission to assessment, this will be considered a declaration of will to seek admission to assessment pursuant to Section 20 Subsection 3 Sentence 4 ASPO (general academic and examination regulations). If the module coordinators subsequently find that the student has obtained the qualification for admission to assessment, they will put the student’s registration for assessment into effect. Only those students that meet the respective prerequisites can successfully register for an assessment. Students who did not register for an assessment or whose registration for an assessment was not put into effect will not be admitted to the respective assessment. If a student takes an assessment to which he/she has not been admitted, the grade achieved in this assessment will not be considered.

**Referred to in LPO I**
(examination regulations for teaching-degree programmes)
§ 53 I Nr. 1 a)
§ 77 I Nr. 1 a)
Optics and Quantum Physics I
(4 ECTS credits)
Module title | Abbreviation
--- | ---
Optics and Quantum Physics | 11-L-OAV-152-m01

<table>
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<th>Module coordinator</th>
<th>Module offered by</th>
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<tbody>
<tr>
<td>Managing Director of the Institute of Applied Physics</td>
<td>Faculty of Physics and Astronomy</td>
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</tbody>
</table>

ECTS | Method of grading | Other prerequisites
--- | --- | ---
4 | numerical grade | -- |

Duration | Module level | Other prerequisites
--- | --- | ---
2 semester | undergraduate | -- |

Contents

1. Light: (linked to 11-E-E): Basic concepts, the speed of light, Huygens-Fresnel principle, reflection, refraction;
2. Light in matter: Propagation velocity in the medium; dispersion, complex and frequency-dependent dielectric constant; absorption, Kramers-Kronig relation, interfaces, Fresnel equations, polarisation, generation by absorption, birefringence, optical activity (dipole);
3. Geometrical optics: Basic concepts, Fermat's principle, optical path, Gaussian optics, reflection, refraction, plane interfaces, Snell's law, total reflection, optical tunneling, evanescent waves, prism; normal and anomalous dispersion, curved interfaces, thin and thick lenses, lens systems, lens grinder formula, aberrations, imaging errors (spherical & chromatic aberration, astigmatism, coma, distortion, correction approaches);
4. Optical instruments: Characteristics, camera, eye, magnifying glass, microscope, telescope types, bundle beam vs. image construction (electron lenses, electron microscope), confocal microscopy;
5. Wave optics: spatial and temporal coherence, double slit, Young's experiment, interference pattern (intensity profile), thin layers, parallel layers, wedge-shaped layers, phase shift, Newton rings, interferometer (Michelson, Mach-Zender, Fabry-Perot);
6. Diffraction in the far field: Fraunhofer diffraction, single slit, intensity distribution, apertures, resolving power: Rayleigh & Abbé criterion, Fourier optics, optical grating, n-fold slit, intensity distribution, grating spectrometer and resolution, diffraction off atomic lattices, convolution theorem;
7. Diffraction in the near field: Fresnel diffraction, near-field diffraction at circular apertures/disks, Fresnel zone plate, near-field microscopy, holography, Huygens-Fresnel concept; white light hologram;
8. Failure of classical physics I - from light wave to photon: Black body radiation and Planck's quantum hypothesis; photoelectric effect and Einstein's explanation, Compton effect, light as a particle, wave-particle duality, quantum structure of nature;
9. Failure of classical physics II - particles as waves: De Broglie's matter wave concept; diffraction of particle waves (Davidson-Germer-experiment, double slit interference);
10. Wave mechanics: Wave packets, phase and group velocity (recap of 11-EM), uncertainty principle, Nyquist-Shannon theorem, wave function as probability amplitude, probability of residence, measurement process in quantum mechanics (double-slit experiment & which-way information, collapse of the wave function, Schrödinger's cat);
11. Mathematical concepts of quantum mechanics: Schrödinger equation as wave equation, conceptual comparison to wave optics, free particle and particles in a potential, time-independent Schrödinger equation as eigenvalue equation, simple examples in 1D (potential step, potential barrier and tunnel effect, box potential and energy quantisation, harmonic oscillator), box potential in higher dimensions and degeneracy, formal theory of QM (states, operators, observables).

Intended learning outcomes

The students understand the basic principles and contexts of radiation, wave and quantum optics and quantum phenomena as well as Atomic and Molecular Physics. They understand the theoretical concepts and know the structure and application of important optical instruments and measuring methods. They understand the ideas and concepts of quantum theory and Astrophysics and the relevant experiments to observe and measure quantum phenomena. They are able to discuss their knowledge and to integrate it into a bigger picture.

Courses (type, number of weekly contact hours, language — if other than German)

V (4) + V (3)
<table>
<thead>
<tr>
<th>Method of assessment</th>
<th>Language of assessment: German and/or English</th>
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<td>oral examination of one candidate each (approx. 30 minutes)</td>
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<tr>
<td>Allocation of places</td>
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<tr>
<td>Additional information</td>
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</tbody>
</table>

Referred to in LPO I (examination regulations for teaching-degree programmes)

§ 53 I Nr. 1 a) (2 ECTS credits) und b) (2 ECTS credits)
§ 77 I Nr. 1 a) (2 ECTS credits) und c) (2 ECTS credits)
Optics and Quantum Physics II
(10 ECTS credits)
<table>
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<th>Module title</th>
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<tr>
<td>Optics and Waves - Exercises</td>
<td>11-E-OA-152-m01</td>
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<th>Module offered by</th>
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<td>Managing Director of the Institute of Applied Physics</td>
<td>Faculty of Physics and Astronomy</td>
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<th>Method of grading</th>
<th>Only after succ. compl. of module(s)</th>
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<tbody>
<tr>
<td>1 semester</td>
<td>undergraduate</td>
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</table>

**Contents**

Exercises in Optics according to the content of 11-E-OAV. Among others Basic concepts, Fermat's principle, optical path, light in matter, polarization, Geometrical Optics, Optical instruments, wave optics, interference, thin films, interferometers, Fraunhofer diffraction optical grating, Fresnel diffraction, holography, wave packets, wave equation and Schrödinger equation, quantum structure of nature, etc.

**Intended learning outcomes**

The students understand the basic principles and contexts of radiation, wave and quantum optics. They are able to apply mathematical methods to the formulation of physical contexts and autonomously apply their knowledge to the solution of mathematical-physical tasks.

**Courses** (type, number of weekly contact hours, language — if other than German)

| Ü (2) |

Module taught in: Ü: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

- written examination (approx. 120 minutes)
- Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 53 I Nr. 1 a)
§ 77 I Nr. 1 a)
<table>
<thead>
<tr>
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<th>Abbreviation</th>
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</thead>
<tbody>
<tr>
<td>Modern Physics 1 - Exercises (Atoms and Quantum Physics)</td>
<td>11-L-AA-152-m01</td>
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<tbody>
<tr>
<td>1 semester</td>
<td>undergraduate</td>
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</table>

**Contents**

Exercises in Atomic and Quantum Physics according to the contents of 11-L-OAV. Among others: Fundamental experiments: Atoms: Specification of atomic values, masses and energies, Rutherford scattering; photons: Radiation laws, photoelectric effect, Compton effect; electrons: Elementary charge, e/m determination, interference experiments, matter wave, Schrödinger equation, uncertainty relation, simple quantum mechanical systems, questions of interpretation, recent experiments; quantum mechanics of hydrogen atoms, magnetic moment and spin, atomic structure, Periodic Table of the Elements

**Intended learning outcomes**

The students understand the basic principles and contexts of quantum phenomena as well as Atomic and Molecular Physics. They are able to mathematically formulate physical contexts of Atomic and Quantum Physics and to autonomously apply their knowledge to the solution of mathematical-physical tasks.

**Courses**

(type, number of weekly contact hours, language — if other than German)

Ü (2)

Module taught in: Ü: German or English

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 120 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 77 I Nr. 1 b)
Modern Physics
(17 ECTS credits)
<table>
<thead>
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<th>Module title</th>
<th>Abbreviation</th>
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<tr>
<td>Modern Physics 2 (Molecule and Solid State Physics)</td>
<td>11-L-M2-152-m01</td>
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</table>

**Module coordinator**  
Managing Director of the Institute of Applied Physics  
**Module offered by**  
Faculty of Physics and Astronomy

**ECTS**  
5

**Method of grading**  
Only after succ. compl. of module(s)

**Duration**  
2 semester

**Module level**  
undergraduate

**Other prerequisites**  
--

### Contents
Mechanical, dielectric and magnetic properties of molecules, rotational, vibrational and electronic excitation of molecules, measuring methods, structure of solids, scattering methods, lattice vibrations, thermal properties of insulators.

### Intended learning outcomes
Understanding of the structure of molecules and chemical bonding, knowledge of experimental methods for the examination of molecules, understanding of the structure of crystalline solids, their modelling as translation-invariant lattices and the consequences.

### Courses

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of weekly contact hours</th>
<th>Language — if other than German</th>
<th>Module taught in:</th>
<th>Language of assessment: German and/or English</th>
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</thead>
<tbody>
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<td>V</td>
<td>3</td>
<td>--</td>
<td>Ü: German or English</td>
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</table>

**Method of assessment**
written examination (approx. 90 to 120 minutes)  
Language of assessment: German and/or English

**Allocation of places**
--

**Additional information**
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**Referred to in LPO I**
( examination regulations for teaching-degree programmes)  
§ 77 I Nr. 1 b)
Module title | Abbreviation
---|---
Modern Physics 3 (Nuclear, Particle and Astrophysics) | 11-L-M3-152-m01

Module coordinator | Module offered by
Managing Director of the Institute of Applied Physics | Faculty of Physics and Astronomy

ECTS | Method of grading | Only after succ. compl. of module(s)
6 | numerical grade | --

Duration | Module level | Other prerequisites
2 semester | undergraduate | --

Contents
Nuclear Physics: experimental methods, detectors, structure of the atomic nucleus, radioactivity, nuclear fission, technical and medical applications, radiation protection. Elementary Particle Physics: Particle accelerator, classification of elementary particles, fundamental interactions. Astrophysics: Stellar development, structure of the Sun, cosmology.

Intended learning outcomes
The students have structured knowledge of the aforementioned terms; they know relevant key concepts and experiments as well as measuring methods and dimensions of central values; they are able to work on simple relevant problems in a quantitative manner.

Courses (type, number of weekly contact hours, language — if other than German)
V (3) + Ü (1)
Module taught in: Ü: German or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
written examination (approx. 90 to 120 minutes)
Language of assessment: German and/or English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
§ 77 I Nr. 1 b)
Module title  | Abbreviation
---|---
General Concepts of Physics  | 11-L-GKP-152-m01

**Module coordinator**
Managing Director of the Institute of Applied Physics

**Module offered by**
Faculty of Physics and Astronomy

**ECTS**  | **Method of grading**  | **Only after succ. compl. of module(s)**
---|---|---
6  | numerical grade  | --

**Duration**  | **Module level**  | **Other prerequisites**
---|---|---
1 semester  | undergraduate  | --

**Contents**
This module focuses on important concepts and applications that constitute interconnections between the sub-disciplines of Physics (and partly other Natural Sciences). When it comes to concepts, these interconnections are structural, they are elements of the physical terminology and belong to the mental structure of the subject. Applied Physics: synergetic interconnections between elements of knowledge of the corresponding subdiscipline and beyond which are necessary for the solution of many important problems. On both levels, the specific contents and the resulting interconnections have the same significance. Structures and concepts: Dimensional analysis, scaling, similitude theory; fields; interactions; symmetries and conserved quantities, wave equation, waves; multipoles among other mode analysis; non-linear dynamics, self-organisation, deterministic chaos; analogies of transport phenomena; Virial theorem as a structural element; microscopic modelling of macroscopic phenomena; scattering and structure determination; aspects of the history of ideas of important concepts and their controversies (e.g. atomism, determinism); Applied and Technical Physics: Physics and information/communication technology; rules and process technology, sensors; medical technology; climate and weather; Biophysics; ecology; energy; celestial mechanics, satellites, GPS; measuring devices; el. light sources; displays

**Intended learning outcomes**
Their understanding of important shared concepts enables the students to connect different subdisciplines of Physics, they know the similarities and differences of different usage contexts and therefore have in-depth knowledge of these concepts and are able to mathematically describe and process relevant problems on the level of Theoretical Physics; they understand complex systems of nature and engineering and are able to connect their own physical knowledge in a synergetic manner by analysing the solutions to selected, complex problems, they are able to explain the interactions of knowledge of different disciplines for the solution of complex problems on the basis of selected examples.

**Courses**
(type, number of weekly contact hours, language — if other than German)

V (2) + Ü (1) + S (2)
Module taught in: Ü: German or English

**Method of assessment**
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes)
Language of assessment: German and/or English

**Allocation of places**
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**Additional information**
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**Referred to in LPO I**
(examination regulations for teaching-degree programmes)
§ 77 I Nr. 1 b)
Theoretical Physics I

(4 ECTS credits)
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>Theoretical Physics 1 and 2 for Pre Service Teachers - Fundamentals</td>
<td>11-L-T12-152-m01</td>
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<tr>
<td>Managing Director of the Institute of Theoretical Physics and Astrophysics</td>
<td>Faculty of Physics and Astronomy</td>
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<th>Duration</th>
<th>Module level</th>
<th>Other prerequisites</th>
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<tr>
<td>2 semester</td>
<td>undergraduate</td>
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</table>

**Contents**

Basic physical laws and elementary methods of theoretical physics.
Quantum Mechanics: Schrödinger equation, one-dimensional quantum mechanics, quantum mechanics Abstract (operator formalism), angular momentum, spin.
Electrodynamics: Maxwell equations, electrostatics, magnetostatics, dynamic electromagnetic fields, Special Theory of Relativity.
Thermodynamics: Heat, entropy, thermal equilibrium, measured variables, efficiency, Thermodynamic potentials, phase transitions.

**Intended learning outcomes**

The students know the basic principles, contexts and elementary methods of Theoretical Physics, theoretical mechanics, quantum mechanics, thermodynamics, electrodynamics and Statistical Physics. They are able to discuss the acquired theoretical concepts and to attribute them to bigger physical contexts.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + V (4)
Module taught in: Ü: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

oral examination of one candidate each (approx. 30 minutes)
Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 77 I Nr. 1 c)
Theoretical Physics II
(10 ECTS credits)
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<td>Theoretical Physics 1 for Pre Service Teachers - Exercises</td>
<td>11-L-T1A-152-m01</td>
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**Module coordinator**
Managing Director of the Institute of Theoretical Physics and Astrophysics

**Module offered by**
Faculty of Physics and Astronomy

**ECTS** | **Method of grading** | **Only after succ. compl. of module(s)** |
---|---|---|
5 | numerical grade | -- |

**Duration** | **Module level** | **Other prerequisites**
---|---|---
1 semester | undergraduate | Admission prerequisite to assessment: completion of exercises (approx. 13 exercise sheets per semester). Students who successfully completed approx. 50% of exercises will qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the semester.

**Contents**
Exercises in Theoretical Mechanics and Quantum Mechanics. Among others Newton's laws Physical quantities and conservation laws, systems of mass points, reference systems, dimensional motion, Lagrange equations, applications, Hamiltonian dynamics; Schrödinger equation, one-dimensional quantum mechanics, quantum mechanics Abstract (operator formalism), angular momentum, spin

**Intended learning outcomes**
The students are able to independently apply the methods of Theoretical Physics to the solution of problems of theoretical mechanics and quantum mechanics and to interpret the solutions.

**Courses** (type, number of weekly contact hours, language — if other than German)

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<td>Module taught in: Ü: German or English</td>
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**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

- written examination (approx. 120 minutes)
- Language of assessment: German and/or English

**Allocation of places**
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**Additional information**
Registration: If a student registers for the exercises and obtains the qualification for admission to assessment, this will be considered a declaration of will to seek admission to assessment pursuant to Section 20 Subsection 3 Sentence 4 ASPO (general academic and examination regulations). If the module coordinators subsequently find that the student has obtained the qualification for admission to assessment, they will put the student’s registration for assessment into effect. Only those students that meet the respective prerequisites can successfully register for an assessment. Students who did not register for an assessment or whose registration for an assessment was not put into effect will not be admitted to the respective assessment. If a student takes an assessment to which he/she has not been admitted, the grade achieved in this assessment will not be considered.

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 77 I Nr. 1 c)
Module title | Abbreviation
---|---
Theoretical Physics 2 for Pre Service Teachers - Exercises | 11-L-T2A-152-m01

Module coordinator | Module offered by
Managing Director of the Institute of Theoretical Physics and Astrophysics | Faculty of Physics and Astronomy

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<th>ECTS</th>
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Duration | Module level | Other prerequisites
---|---|---
1 semester | undergraduate | Admission prerequisite to assessment: completion of exercises (approx. 13 exercise sheets per semester). Students who successfully completed approx. 50% of exercises will qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the semester.

Contents

Exercises in Statistical Physics, thermodynamics and electrodynamics. Among others: Maxwell equations, electrostatics, magnetostatics, dynamic electromagnetic fields, special theory of relativity; heat, entropy, thermal equilibrium, measured variables, efficiency, thermodynamic potentials, phase transitions

Intended learning outcomes

The students are able to independently apply the methods of Theoretical Physics to the solution of problems of thermodynamics, electrodynamics and Statistical Physics and to interpret the solutions.

Courses (type, number of weekly contact hours, language — if other than German)

Ü (2)
Module taught in: Ü: German or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 120 minutes)
Language of assessment: German and/or English

Allocation of places

--

Additional information

Registration: If a student registers for the exercises and obtains the qualification for admission to assessment, this will be considered a declaration of will to seek admission to assessment pursuant to Section 20 Subsection 3 Sentence 4 ASPO (general academic and examination regulations). If the module coordinators subsequently find that the student has obtained the qualification for admission to assessment, they will put the student’s registration for assessment into effect. Only those students that meet the respective prerequisites can successfully register for an assessment. Students who did not register for an assessment or whose registration for an assessment was not put into effect will not be admitted to the respective assessment. If a student takes an assessment to which he/she has not been admitted, the grade achieved in this assessment will not be considered.

Referred to in LPO I (examination regulations for teaching-degree programmes)

§ 77 I Nr. 1 c)
Computational Methods
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<td>Mathematical Methods of Physics</td>
<td>11-M-MR-152-m01</td>
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**Contents**

Principles of mathematics and basic calculation methods beyond the school curriculum, especially for the introduction to and preparation of the modules of Theoretical Physics and Classical or Experimental Physics.

**Intended learning outcomes**

The students have knowledge of the principles of mathematics and elementary calculation methods which are required in Theoretical and Experimental Physics.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (1) + V (2) + Ü (1)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) exercises (successful completion of approx. 50% of approx. 13 exercise sheets) or b) talk (approx. 15 minutes)

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 53 I Nr. 1 a)  
§ 77 I Nr. 1 a)
Laboratory Course I
(14 ECTS credits)
**Module title**
Laboratory Course Physics A (Mechanics, Heat, Electromagnetism)

**Abbreviation**
11-P-LA-152-m01

**Module coordinator**
Managing Director of the Institute of Applied Physics

**Module offered by**
Faculty of Physics and Astronomy

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<td>Only after succ. compl. of module(s)</td>
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**Duration**
1 semester

**Module level**
undergraduate

**Contents**
Measurement tasks in mechanics, thermodynamics and electricity theory, e.g. measurement of voltages and currents, heat capacity, calorimetry, density of bodies, dynamic viscosity, elasticity, surface tension, spring constant, drafting of graphs and drafting of measurement protocols.

**Intended learning outcomes**
The student has knowledge and mastery of physical measuring instruments and experimental techniques. He/She is able to plan experiments independently and to perform well in cooperation with others, and to document the measurement results in a measurement protocol.

**Courses**
(P (2))

**Method of assessment**
practical assignment with talk (approx. 30 minutes)
Preparing, performing and evaluating (record of readings or lab report) the experiments will be considered successfully completed if a Testat (exam) is passed. Exactly one experiment that was not successfully completed can be repeated once. After completion of all experiments, talk (with discussion; approx. 30 minutes) to test the candidate's understanding of the physics-related contents of the module. Talks that were not successfully completed can be repeated once. Both components of the assessment have to be successfully completed.

**Allocation of places**
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**Additional information**
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**Referred to in LPO I**
(examination regulations for teaching-degree programmes)
§ 53 I Nr. 1 c)
§ 77 I Nr. 1 d)
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<tr>
<th>Module title</th>
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<tr>
<td>Data and Error Analysis</td>
<td>11-P-FR1-152-m01</td>
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<tr>
<td>1 semester</td>
<td>undergraduate</td>
<td>Admission prerequisite to assessment: completion of exercises (approx. 13 exercise sheets per semester). Students who successfully completed approx. 50% of exercises will qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the semester.</td>
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</table>

**Contents**

Types of errors, error approximation and propagation, graphic representations, linear regression, mean values and standard deviation.

**Intended learning outcomes**

The students are able to evaluate measuring results on the basis of error propagation and of the principles of statistics and to draw, present and discuss the conclusions.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (1) + Ü (1)  
Module taught in: Ü: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 120 minutes)  
Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

Registration: If a student registers for the exercises and obtains the qualification for admission to assessment, this will be considered a declaration of will to seek admission to assessment pursuant to Section 20 Subsection 3 Sentence 4 ASPO (general academic and examination regulations). If the module coordinators subsequently find that the student has obtained the qualification for admission to assessment, they will put the student’s registration for assessment into effect. Only those students that meet the respective prerequisites can successfully register for an assessment. Students who did not register for an assessment or whose registration for an assessment was not put into effect will not be admitted to the respective assessment. If a student takes an assessment to which he/she has not been admitted, the grade achieved in this assessment will not be considered.

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 53 I Nr. 1 c)  
§ 77 I Nr. 1 d)
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>Laboratory Course Physics B (Electricity, Circuits, Atomic and Nuclear Physics)</td>
<td>11-P-LB-152-m01</td>
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<td>Faculty of Physics and Astronomy</td>
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<tr>
<td>2 semester</td>
<td>undergraduate</td>
<td>Students are highly recommended to complete modules 11-P-LA and 11-P-FR1 prior to completing module 11-P-LB.</td>
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</tbody>
</table>

### Contents
Physical laws of the science of electricity, circuits with electrical components and Atomic and Nuclear Physics.

### Intended learning outcomes
The students have knowledge and skills of physical measuring instruments and experimental techniques. They are able to independently plan and conduct experiments in cooperation with others, and to document the results in a measurement protocol.

### Courses
(type, number of weekly contact hours, language — if other than German)

- P (2) + P (2)

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

- practical assignment with talk (approx. 30 minutes)
- Preparing, performing and evaluating (record of readings or lab report) the experiments will be considered successfully completed if a Testat (exam) is passed. Exactly one experiment that was not successfully completed can be repeated once. After completion of all experiments, talk (with discussion; approx. 30 minutes) to test the candidate's understanding of the physics-related contents of the module. Talks that were not successfully completed can be repeated once. Both components of the assessment have to be successfully completed.

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)

- § 53 I Nr. 1 b) (3 LP) und c) (2 LP)
- § 53 I Nr. 1 c)
- § 77 I Nr. 1 d)
Module title | Abbreviation
---|---
Advanced Laboratory Course | 11-P-LFP-152-m01

Module coordinator | Module offered by
Managing Director of the Institute of Applied Physics | Faculty of Physics and Astronomy

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<th>Other prerequisites</th>
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<tbody>
<tr>
<td>1 semester</td>
<td>undergraduate</td>
<td>Students are highly recommended to complete module 11-P-LB prior to completing module 11-P-LFP.</td>
</tr>
</tbody>
</table>

Contents

Experiments of modern physics (Atom and Molecular Physics, Solid-State Physics, Nuclear Physics).

Intended learning outcomes

The students have knowledge of conducting an experiment and of analysing and documenting the experimental results. They have basic knowledge of modern evaluation systems. They have gained insights into the experimental methods of modern Physics.

Courses (type, number of weekly contact hours, language — if other than German)
P (4)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

practical assignment with talk (approx. 30 minutes)
Preparing, performing and evaluating (record of readings or lab report) the experiments will be considered successfully completed if a Testat (exam) is passed. Exactly one experiment that was not successfully completed can be repeated once. After completion of all experiments, talk (with discussion; approx. 30 minutes) to test the candidate’s understanding of the physics-related contents of the module. Talks that were not successfully completed can be repeated once. Both components of the assessment have to be successfully completed.

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
§ 77 I Nr. 1 d)
Laboratory Course II

(11 ECTS credits)
<table>
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<td>Demonstration Laboratory Course 1</td>
<td>11-P-DP1-152-m01</td>
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<tr>
<td>holder of the Chair of Physics and its Didactics</td>
<td>Faculty of Physics and Astronomy</td>
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<td>1 semester</td>
<td>undergraduate</td>
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</table>

**Contents**

Fundamental experiments of physics education in primary and secondary level I, knowledge of tools typically used in school, goal setting and didactic potential of demonstration experiments, student experiments, free-hand experiments, model experiments, etc.; computer-aided experiments; measured value acquisition, interactive screen experiments, etc.; presentation of experiments; safety in physics education, presentation competencies.

**Intended learning outcomes**

Competencies in working with teaching tools and experimenting materials used in commerce and school; systematic analysis of error sources of own experiments; identification of categories of experiments, their functions and their didactic potential; experience in choosing, constructing and presenting experiments according to the learning goals and group of pupils, experience in using computerised demonstration and pupils experiments; safety standards of Physics classes.

**Courses**

(type, number of weekly contact hours, language — if other than German)

P (4)

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) oral examination of one candidate each (approx. 10 minutes) or b) oral examination in groups (groups of 2, approx. 10 minutes per candidate)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

§ 53 I Nr. 1 c)
§ 77 I Nr. 1 d)
<table>
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<tr>
<td>Demonstration Laboratory Course 2</td>
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</table>

**Contents**

Fundamental experiments of physics education, especially for secondary level II. Subject media, acquisition and handling of information.

**Intended learning outcomes**

The students have experiences in presenting sophisticated phenomena and experiments and in using multimedia in view of didactic-methodological aspects and know the potentials and limits of different types of media; they have experiences in working with systems for physical modelling and with methods of contemporary information acquisition (internet sources, virtual libraries).

**Courses** (type, number of weekly contact hours, language — if other than German)

| P (4) |

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) oral examination of one candidate each (approx. 10 minutes) or b) oral examination in groups (groups of 2, approx. 10 minutes per candidate)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 77 I Nr. 1 d)
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>Practical Training in Student Lab</td>
<td>11-P-LLL-152-m01</td>
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<tr>
<td>holder of the Chair of Physics and its Didactics</td>
<td>Faculty of Physics and Astronomy</td>
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<tbody>
<tr>
<td>1 semester</td>
<td>undergraduate</td>
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</table>

## Contents

The module gives an overview of applicable physical experiments that provide an introduction to science and can be performed in teaching-learning-laboratories (M!ND center). In these experiments, different working methods are employed.

## Intended learning outcomes

The students know how to prepare and follow-up a visit in a teaching-learning-laboratory (M!ND-Center) and have gained an overview of current didactic research topics and further possibilities for development in the field of subject-didactic research. They are able to evaluate and assess the (affective) learning achievements of pupils, to hold scientific-propaedeutic classes, to positively influence the motivation of pupils in the subject of Physics and to raise their interest for current physical research questions. The students are able to select, set up or build pupils experiments in a target-oriented manner, and to supervise pupils while experimenting.

## Courses

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## Method of assessment

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<td>a) oral examination of one candidate each (approx. 10 minutes) or b) oral examination in groups (groups of 2, approx. 10 minutes per candidate) or c) term paper (6 to 12 pages) or d) portfolio (10 to 15 hours total)</td>
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Language of assessment: German and/or English

## Allocation of places

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## Additional information

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## Referred to in LPO

§ 77 I Nr. 1 d)
Teaching
(10 ECTS credits)
Compulsory Courses
(10 ECTS credits)
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<td>Physics Teaching Concepts 1</td>
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<tr>
<td>1 semester</td>
<td>undergraduate</td>
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</table>

**Contents**
Subject-didactic study of technical contents of the basic studies, student preconceptions and subject-didactic teaching concepts. Student preconceptions and typical learning difficulties in school physics, corresponding teaching methods, and techniques to change student preconceptions; epistemological and working methods of physics.

**Intended learning outcomes**
In-depth understanding of school-relevant areas of Physics; knowledge of typical student preconceptions and learning difficulties; knowledge of how to change student preconceptions; knowledge of alternative teaching approaches for selected topics; knowledge of epistemological methods of Physics; knowledge of the legitimation and goals of the school subject Physics; knowledge of elementarising and teaching methods; knowledge of physical teaching and working tools.

**Courses** (type, number of weekly contact hours, language — if other than German)
V (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
a) written examination (approx. 45 minutes) or b) oral examination of one candidate each (approx. 10 minutes) or c) oral examination in groups (groups of 2, approx. 10 minutes per candidate)
Language of assessment: German and/or English

**Allocation of places**
--

**Additional information**
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)
§ 53 I Nr. 2
§ 36 I Nr. 7
§ 77 I Nr. 2
§ 38 I Nr. 1
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<td>1 semester</td>
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</table>

**Contents**

Extension of the basic knowledge of subject didactics. Justification/legitimation of physics education, educational goals of physics, qualification models and educational standards: elementarisation and didactic reconstruction of physical contents, methods of physics education, media in physics education and their application to support learning.

**Intended learning outcomes**

In-depth understanding of school-relevant areas of Physics; knowledge of typical student preconceptions and learning difficulties; knowledge of how to change student preconceptions; knowledge of alternative teaching approaches for selected topics; knowledge of epistemological methods of Physics; knowledge of the legitimation and goals of the school subject Physics; knowledge of elementarising and teaching methods; knowledge of physical teaching and working tools.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (1)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 45 minutes) or b) oral examination of one candidate each (approx. 10 minutes) or c) oral examination in groups (groups of 2, approx. 10 minutes per candidate) or d) term paper (approx. 8 pages)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 53 I Nr. 2
§ 36 I Nr. 7
§ 77 I Nr. 2
§ 38 I Nr. 1
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<td>Physics Teaching Concepts Seminar</td>
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</table>

**Contents**

Different topics of current subject-didactic research; examples: Interest and physics education, girls in physics education, evaluation, task culture, interdisciplinary classes, language in physics education, effects of subject media and their application for learning support, especially regarding computers, epistemological and working methods, new teaching methods.

**Intended learning outcomes**

Knowledge of selected methods of didactic physical research, evaluation of didactic physical research projects, knowledge of didactic physical literature. Ability to critically evaluate Physics classes in view of different aspects and to discuss different prioritizations and approaches.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 45 minutes) or b) oral examination of one candidate each (approx. 10 minutes) or c) oral examination in groups (groups of 2, approx. 10 minutes per candidate) or d) term paper (approx. 8 pages)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 77 I Nr. 2
<table>
<thead>
<tr>
<th>Module title</th>
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<tr>
<td>Student Lab Preparation Course (Physics) German Gymnasium</td>
<td>11-L-L3SGY-152-m01</td>
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</table>

**Contents**

The module gives an overview of applicable physical experiments that provide an introduction to science and can be performed in teaching-learning-laboratories (M!ND center). In these experiments, different working methods are employed.

**Intended learning outcomes**

The students know how to prepare and follow-up a visit in a teaching-learning-laboratory (M!ND-Center) and have gained an overview of current didactic research topics and further possibilities for development in the field of subject-didactic research. They are able to evaluate and assess the (affective) learning achievements of pupils, to hold scientific-propaedeutic classes, to positively influence the motivation of pupils in the subject of Physics and to raise their interest for current physical research questions. The students are able to select, set up or build pupils experiments in a target-oriented manner, and to supervise pupils while experimenting.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 45 minutes) or b) oral examination of one candidate each (approx. 10 minutes) or c) oral examination in groups (groups of 2, approx. 10 minutes per candidate) or d) term paper (approx. 8 pages)

Language of assessment: German and/or English

**Allocation of places**

--

**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 77 I Nr. 2
Thesis
(4 ECTS credits)

Students studying for a teaching degree Gymnasium must complete a practical training in didactics and teaching methodology (studienbegleitendes fachdidaktisches Praktikum) which refers to one of the subjects they selected as vertieft studiertes Fach (subject studied with a focus on the scientific discipline) pursuant to Section 34 Subsection 1 No. 4 LPO I (examination regulations for teaching-degree programmes). The obligatory accompanying tutorial is offered by the respective subject. The ECTS credits obtained are counted in the subject Erziehungswissenschaften pursuant to Section 10 Subsection 3 LASPO (general academic and examination regulations for teaching-degree programmes).
### Module title

**Physics: Practical Training and Theory of Classroom**

### Abbreviation

11-L-SBPGY-152-m01

### Module coordinator

holder of the Chair of Physics and its Didactics

### Module offered by

Faculty of Physics and Astronomy

### ECTS

4

### Method of grading

Only after succ. compl. of module(s)

### (not) successfully completed

--

### Duration

1 semester

### Module level

undergraduate

### Other prerequisites

--

### Contents

The module introduces teaching practice. The students gain insights into the pedagogical, didactic and methodical practice of Physics by observing and discussing classes. They consolidate their knowledge by preparing and holding classes themselves. In the corresponding seminar, the following topics (among others) will be discussed in agreement with the teachers: Introduction to the curriculum of Gymnasium; criteria to observe and analyse classes; basics of general school and class pedagogics; subject-specific work methods; planning of class sequences and models; introduction to the usage of modern media; development of blackboard pictures and transparency sketches. The main focus will be on class practice, the corresponding seminar also helps the students in developing own classes.

### Intended learning outcomes

The students have gained deep insights into the main steps of planning, preparing and organising classes; they are able to implement the contents of the curricula for different grades in a practical manner; they are able to select and use media, methods and social forms according to learning goals; they are able to connect findings of school pedagogics and learning psychology with subject-didactic knowledge and to integrate these findings into the organisation of classes.

### Courses

(type, number of weekly contact hours, language — if other than German)

\[ P (0) + S (2) \]

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

term paper (15 to 20 pages)

Contents and duration of placement as specified in Section 34 Subsection 1 Sentence 1 No. 4 LPO I (examination regulations for teaching-degree programmes); participation in mandatory teaching practice, completion of all set tasks as specified by placement school.

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

§ 34 I 1 Nr. 4
Freier Bereich (general as well as subject-specific electives)
(0-15 ECTS credits)

Teaching degree students must take modules worth a total of 15 ECTS credits in the area Freier Bereich (general as well as subject-specific electives) (Section 9 LASPO (general academic and examination regulations for teaching-degree programmes)). To achieve the required number of ECTS credits, students may take any modules from the areas below.

Freier Bereich -- interdisciplinary: The interdisciplinary additional offer for a teaching degree can be found in the respective Annex "Ergänzende Bestimmungen für den "Freien Bereich" im Rahmen des Studiums für ein Lehramt".
Physics

(ECTS credits)

(Freier Bereich (general as well as subject-specific electives) -- subject specific)
<table>
<thead>
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<th>Abbreviation</th>
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<tr>
<td>Teaching Seminar Fundamental Principles</td>
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**Module coordinator**  
holder of the Chair of Physics and its Didactics

**Module offered by**  
Faculty of Physics and Astronomy

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**Duration**  
1 semester  
**Module level**  
undergraduate  
**Other prerequisites**  
--

**Contents**

Physical and interdisciplinary aspects of selected topics of physics education, corresponding student preconceptions and typical learning difficulties, elementarisation and didactic reconstruction of physical contents based on specific contents of physics education, verbalisation of physical contents, possible teaching methods, typical school experiments and suitable media.

**Intended learning outcomes**

Advanced, qualitative knowledge of school-relevant areas of Physics; knowledge of common methods, typical student preconceptions and special media on relevant topics; awareness of the differences between teaching Physics at university and school regarding contents and methods.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) term paper (approx. 8 pages) or b) presentation (approx. 45 minutes) or c) written examination (approx. 45 minutes) or d) oral examination of one candidate each (approx. 15 minutes) or e) oral examination in groups (groups of 2, approx. 15 minutes per candidate)

Language of assessment: German and/or English

**Allocation of places**  
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**Additional information**  
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 22 II Nr. 1 h)  
§ 22 II Nr. 2 f)  
§ 22 II Nr. 3 f)
Module title | Abbreviation
--- | ---
Selected Topics in Physics Didactics | 11-L-EL2-152-m01

Module coordinator | Module offered by
Managing Director of the Institute of Applied Physics | Faculty of Physics and Astronomy

ECTS | Method of grading | Only after succ. compl. of module(s)
--- | --- | ---
3 | (not) successfully completed | --

Duration | Module level | Other prerequisites
1 semester | undergraduate | --

Contents
Current topics in physics education.

Intended learning outcomes
The students have knowledge of a current subdiscipline of physics education and are able to classify the acquired knowledge according to subject-specific contexts and implement it into classes.

Courses (type, number of weekly contact hours, language — if other than German)
S (2)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
a) term paper (approx. 8 pages) or b) presentation (approx. 45 minutes) or c) written examination (approx. 45 minutes) or d) oral examination of one candidate each (approx. 15 minutes) or e) oral examination in groups (groups of 2, approx. 15 minutes per candidate)
Language of assessment: German and/or English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
§ 22 II Nr. 1 h)
§ 22 II Nr. 2 f)
§ 22 II Nr. 3 f)
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<td>Preparatory Course Mathematics</td>
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<td>Managing Directors of the Institute of Applied Physics and the Institute of Theoretical Physics and Astrophysics</td>
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</table>

**Contents**

Principles of mathematics and elementary calculation methods from school and partially beyond, especially for the introduction to and preparation for the modules of Experimental and Theoretical Physics.

1. Basic geometry and algebra
2. Coordinate systems and complex numbers
3. Vectors - vectored values
4. Differential calculus
5. Integral calculus

**Intended learning outcomes**

The students know the principles of mathematics and elementary calculation methods which are required for successfully studying Theoretical and Experimental Physics.

**Courses** (type, number of weekly contact hours, language — if other than German)

T (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) exercises (successful completion of approx. 50% of approx. 6 exercise sheets) or b) talk (approx. 15 minutes)

Assessment offered: Once a year, winter semester

**Allocation of places**

--

**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 22 II Nr. 1 h)
§ 22 II Nr. 2 f)
§ 22 II Nr. 3 f)
**Module title**  
Student Lab Supervision (Physics)  
**Abbreviation**  
11-L-L3B-152-m01

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</table>

**Contents**

The module provides an introduction to successful supervision of pupils independently carrying out experiments in the teaching-learning-laboratory.

**Intended learning outcomes**

The students learn to classify different groups of pupils according to their subject-specific and experimental level of performance, to support the pupils according to their needs and age and to help them during independent experimenting (supervision competencies in open classroom situations). The students are able to methodically and critically evaluate their own actions. A lecturer gives individual feedback to the students to avoid negative behaviour patterns and to support the students' strengths. The students develop professional behaviour patterns by repeatedly working on the same topic with different groups of pupils (reflection competencies and self-control competencies).

**Courses** (type, number of weekly contact hours, language — if other than German)

P (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 45 minutes) or b) oral examination of one candidate each (approx. 10 minutes) or c) oral examination in groups (groups of 2, approx. 10 minutes per candidate) or d) term paper (approx. 8 pages)

**Allocation of places**

--

**Additional information**

This module is designed for students studying at least one subject in the natural sciences.

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 22 II Nr. 1 h)  
§ 22 II Nr. 2 f)  
§ 22 II Nr. 3 f)
Module title | Abbreviation
--- | ---
Low Cost - High Impact. Low-budget Experiments for Science Courses (Physics) | 11-MIND-Ph1-152-m01

Module coordinator | Module offered by
holder of the Chair of Physics and its Didactics | Faculty of Physics and Astronomy

ECTS | Method of grading | Only after succ. compl. of module(s)
2 | (not) successfully completed | --

Duration | Module level | Other prerequisites
1 semester | undergraduate | --

Contents
Conception and realisation of experimental stations with ordinary and inexpensive consumables for classes of Grundschule and secondary level I.

Intended learning outcomes
The students develop simple scientific experimenting stations to use for the transition from primary to secondary level I for small groups from different types of schools. In doing so, they learn to simplify and convey scientific contents relevant to the curriculum in due consideration of the target group.

Courses (type, number of weekly contact hours, language — if other than German)
S (2)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
a) written examination (approx. 45 minutes) or b) oral examination of one candidate each (approx. 10 minutes) or c) oral examination in groups (groups of 2, approx. 20 minutes) or d) term paper (approx. 8 pages)

Allocation of places
--

Additional information
This module is designed for students studying at least one subject in the natural sciences.

Referred to in LPO I (examination regulations for teaching-degree programmes)
§ 22 II Nr. 1 h)  
§ 22 II Nr. 2 f)  
§ 22 II Nr. 3 f)
### Module title
Teaching Science with Hands-on-Exhibits (Physics)

### Abbreviation
11-MIND-Ph2-152-m01

### Module coordinator
holder of the Chair of Physics and its Didactics

### Module offered by
Faculty of Physics and Astronomy

### ECTS
2

### Method of grading
Only after succ. compl. of module(s)

### (not) successfully completed
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### Duration
1 semester

### Module level
undergraduate

### Other prerequisites
--

### Contents
Designing and creating hands-on exhibits for STEM subjects.

### Intended learning outcomes
The students evaluate the advantages and disadvantages of the hands-on approach for teaching scientific contents in and out of school. They plan and implement an interdisciplinary science exhibition as an example of project-oriented work with pupils of secondary level I and II.

### Courses
(type, number of weekly contact hours, language — if other than German)

S (2)

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 45 minutes) or b) oral examination of one candidate each (approx. 10 minutes) or c) oral examination in groups (groups of 2, approx. 20 minutes) or d) term paper (approx. 8 pages)

### Allocation of places
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### Additional information
This module is designed for students studying at least one subject in the natural sciences.

### Referred to in LPO I
(examination regulations for teaching-degree programmes)

§ 22 II Nr. 1 h)  
§ 22 II Nr. 2 f)  
§ 22 II Nr. 3 f)
Module title | Abbreviation
--- | ---
Astrophysics | 11-AP-152-m01

Module coordinator
Managing Director of the Institute of Theoretical Physics and Astrophysics

Module offered by
Faculty of Physics and Astronomy

ECTS | Method of grading | Only after succ. compl. of module(s)
--- | --- | ---
6 | numerical grade | --

Duration | Module level | Other prerequisites
--- | --- | ---
1 semester | undergraduate | --

Contents
History of astronomy, coordinates and time measurement, the Solar System, exoplanets, astronomical scales, telescopes and detectors, stellar structure and atmospheres, stellar evolution and end stages, interstellar medium, molecular clouds, structure of the milky way, the local universe, the expanding universe, galaxies, active galactic nuclei, large-scale structures, cosmology.

Intended learning outcomes
The students are familiar with the modern world view of Astrophysics. They know methods and tools for astrophysical observations and evaluations. They are able to use these methods to plan and analyse own observations. They are familiar with the physics and development of the main astrophysical objects such as stars and galaxies.

Courses (type, number of weekly contact hours, language — if other than German)
V (2) + R (2)
Module taught in: German or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).
If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.
Language of assessment: German and/or English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
§ 22 II Nr. 1 h)  
§ 22 II Nr. 2 f)  
§ 22 II Nr. 3 f)
### Module title

**Principles of Energy Technologies**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>11-ENT-152-m01</th>
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### Module coordinator

Managing Director of the Institute of Applied Physics

### Module offered by

Faculty of Physics and Astronomy

### ECTS

6

### Method of grading

Only after succ. compl. of module(s)

### Duration

1 semester

### Module level

Graduate

### Other prerequisites

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### Contents


### Intended learning outcomes

The students know the principles of different methods of energy technology, especially energy conversion, transport and storage. They understand the structures of corresponding installations and are able to compare them.

### Courses

(V (3) + R (1))

Module taught in: German or English

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

- a) written examination (approx. 90 to 120 minutes) or
- b) oral examination of one candidate each (approx. 30 minutes) or
- c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or
- d) project report (approx. 8 to 10 pages) or
- e) presentation/talk (approx. 30 minutes).

If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.

Assessment offered: Once a year, winter semester

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

- § 22 II Nr. 1 h)
- § 22 II Nr. 2 f)
- § 22 II Nr. 3 f)
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<tr>
<td>1 semester</td>
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**Contents**

Current topics in physics education.

**Intended learning outcomes**

The students have knowledge of a current subdiscipline of physics education and are able to classify the acquired knowledge according to subject-specific contexts and implement it into classes.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 45 minutes) or b) oral examination of one candidate each (approx. 10 minutes) or c) oral examination in groups (groups of 2, approx. 10 minutes per candidate) or d) term paper (approx. 8 pages) or e) talk (30 to 45 minutes) with discussion

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 22 II Nr. 1 h)  
§ 22 II Nr. 2 f)  
§ 22 II Nr. 3 f)
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<td>1 semester</td>
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</table>

**Contents**

Current topics in scientific work in physics education

**Intended learning outcomes**

The students have knowledge of a current subdiscipline of physics education and are able to process questions of physics education on the basis of scientific methods.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Talk (30 to 45 minutes)

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 22 II Nr. 1 h)  
§ 22 II Nr. 2 f)  
§ 22 II Nr. 3 f)
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<td>Faculty of Physics and Astronomy</td>
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**Contents**

Current topics in physics.

**Intended learning outcomes**

The students have knowledge of a current subdiscipline of Physics and understand the measuring and/or calculation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.

**Courses**

(type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 22 II Nr. 1 h)
§ 22 II Nr. 2 f)
§ 22 II Nr. 3 f)
## Module Catalogue for the Subject
### Physics

#### LA Gymnasien

<table>
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### Contents

Current topics in experimental physics. Credited academic achievements, e.g. in case of change of university or study abroad.

### Intended learning outcomes

The students have advanced competencies corresponding to the requirements of a module of Experimental Physics of the Bachelor's programme. They have knowledge of a current subdiscipline of Experimental Physics and understand the measuring and/or evaluation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.

### Courses (type, number of weekly contact hours, language — if other than German)

V (2) + R (1)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

- a) written examination (approx. 90 to 120 minutes) or
- b) oral examination of one candidate each (approx. 30 minutes) or
- c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or
- d) project report (approx. 8 to 10 pages) or
- e) presentation/talk (approx. 30 minutes).

If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

- § 22 II Nr. 1 h)
- § 22 II Nr. 2 f)
- § 22 II Nr. 3 f)
Thesis
(10 ECTS credits)

Preparation of a written Hausarbeit (thesis) in accordance with the provisions of Section 29 LPO I (examination regulations for teaching-degree programmes) is a prerequisite for teaching degree students to be admitted to the Erste Staatsprüfung (First State Examination). In accordance with the provisions of Section 29 LPO I, students studying for a teaching degree Gymnasium may write this thesis in one of the subjects they selected as vertieft studiertes Fach (subject studied with a focus on the scientific discipline) or in the subject Erziehungswissenschaften (Educational Science). Pursuant to Section 29 Subsection 1 Sentence 2 LPO I, students may also choose to write an interdisciplinary thesis.
<table>
<thead>
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<th>Module title</th>
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<td>Thesis in Physics (Teaching Degree at German Gymnasium)</td>
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**Contents**

Independent processing of a topic of Physics and/or Didactics of Physics, chosen in consultation with a lecturer.

**Intended learning outcomes**

The students are able to independently work on a predetermined physical topic while applying the knowledge and methods acquired in the teaching degree programme. They are able to present their results in written form in due consideration of didactic aspects.

**Courses** (type, number of weekly contact hours, language — if other than German)

No courses assigned to module

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Hausarbeit (thesis) pursuant to Section 29 LPO I (examination regulations for teaching-degree programmes) (approx. 40 pages)

Language of assessment: German; exceptions pursuant to Section 29 Subsection 4 LPO I (examination regulations for teaching-degree programmes)

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

§ 29