

Module title		Abbreviation
Classical Physics 2 (Heat and Electromagnetism)		11-E-E-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)
8	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		
<ol style="list-style-type: none"> <li>1. Thermodynamics (linked to 11-E-M); temperature and quantity of heat, thermometer, Kelvin scale;</li> <li>2. Heat conduction, heat transfer, diffusion, convection, radiant heat;</li> <li>3. Fundamental theorems of thermodynamics, entropy, irreversibility, Maxwell's demon;</li> <li>4. Heat engines, working diagrams, efficiency, example: Stirling engine;</li> <li>5. Real gases and liquids, states of matter (also solids), van der Waals, critical point, phase transitions, critical phenomena (opalescence), coexistence region, Joule-Thomson;</li> <li>6. Electrostatics, basic concepts: Electrical charge, forces; electric field, reps. field concept, field lines, field of a point charge;</li> <li>7. Gaussian sentence, related to Coulomb's law, definition of "river"; Gaussian surface, divergence theorem; special symmetries; divergence and GS in differential form;</li> <li>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;</li> <li>9. Matter in the E-field, charge in a homogeneous field, Millikan experiment, Braun tube; electron: Field emission, thermionic emission, dipole in homogeneous and inhomogeneous field; induction, Faraday cage;</li> <li>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;</li> <li>11. Electricity, introduction, current density, drift velocity, conduction mechanisms;</li> <li>12. Resistance and conductivity, resistivity, temperature dependence; Ohm's law; realisations (resistive and non-ohmic, NTC, PTC);</li> <li>13. Circuits, electrical networks, Kirchhoff's rules (meshes, nodes); internal resistance of a voltage source, measuring instruments; Wheatstone bridge;</li> <li>14. Power and energy in the circuit; Capacitor charge; galvanic element; thermovoltage;</li> <li>15. Transfer mechanisms, conduction in solids: Band model, semiconductor; line in liquids and gases;</li> <li>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;</li> <li>17. Vector potential, formal derivation, analogous to electric scalar potential; calculation of fields, examples, Helmholtz coils;</li> <li>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: <math>e / m</math> determination;</li> <li>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;</li> <li>20. induction, Faraday's law of induction, Lenz's rule, flux change, eddy electric field, Waltenhofen's pendulum; inductance, self-induction; applications: Transformer, generator;</li> <li>21. Maxwell's displacement current, choice of integration area, displacement current; Maxwell's extension, wave equation; Maxwell equations;</li> <li>22. AC: Fundamentals, sinusoidal vibrations, amplitude, period and phase; power and RMS value, ohmic resistance; Capacitive &amp; inductive resistor, capacitor and coil, phase shift and frequency dependence; impedance: Complex resistance; performance of the AC;</li> </ol>		

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)

**Module appears in**

Bachelor' degree (1 major) Physics (2015)  
 Bachelor' degree (1 major) Nanostructure Technology (2015)  
 Bachelor' degree (1 major) Mathematical Physics (2015)  
 Bachelor's degree (1 major, 1 minor) Physics (Minor, 2015)  
 First state examination for the teaching degree Grundschule Physics (2015)  
 First state examination for the teaching degree Realschule Physics (2015)  
 First state examination for the teaching degree Gymnasium Physics (2015)  
 First state examination for the teaching degree Mittelschule Physics (2015)  
 Bachelor' degree (1 major) Mathematical Physics (2016)  
 First state examination for the teaching degree Grundschule Physics (2018)  
 First state examination for the teaching degree Realschule Physics (2018)  
 First state examination for the teaching degree Gymnasium Physics (2018)  
 First state examination for the teaching degree Mittelschule Physics (2018)  
 Bachelor' degree (1 major) Physics (2020)  
 Bachelor' degree (1 major) Nanostructure Technology (2020)  
 Bachelor' degree (1 major) Mathematical Physics (2020)  
 Bachelor's degree (1 major, 1 minor) Physics (Minor, 2020)  
 First state examination for the teaching degree Grundschule Physics (2020)  
 First state examination for the teaching degree Gymnasium Physics (2020)



First state examination for the teaching degree Realschule Physics (2020)  
First state examination for the teaching degree Mittelschule Physics (2020)