Electrostatics in vacuum and steady currents.
Conductors and insulators; Coulomb's law; the unit of charge in the IS; conservation of charge. Definition of the electrostatic field E and the electrostatic potential V; superposition principle for E and V. Electric dipole, and potential field created by a dipole, mechanical actions on a dipole.
Electrostatic energy of a system of charges.
Lines of force and equipotential surfaces. Flux of the electric field; the Gauss theorem; examples of calculation of the electrostatic field by the Gauss theorem: layer and double-layer, indefinite wire.
Equations of electrostatics in the vacuum in differential and integral form; Poisson and Laplace equations.
Electrostatic properties of conductors, electrostatic induction, hollow conductors, electrostatic shield, Coulomb's theorem. Capacitors, capacitors connected in series or in parallel; energy of a charged capacitor. Energy density and pressure of the electrostatic field.
Electrostatic properties of dielectrics. Polarization and dielectric displacement.
Current - definition of current intensity and current density; continuity equation. Steady currents; resistance of a conductor and Ohm's law, resistors connected in series or in parallel; electromotive force; power dissipation and Joule's law. Complex circuits: knots, branches and nets, Kirchhoff's laws. Charge and discharge of an RC circuit.
Magnetostatics.
The discoveries of Oersted and Ampere; definition of the magnetic field; absence of magnetic monopoles. Mechanical actions on a magnetic dipole and potential energy of a magnetic dipole. Magnetic force on a current-carrying circuit; Lorentz force; motion of a charge in a magnetic field, the Hall effect.
The magnetic field generated by steady currents: the indefinite straight wire, the circular loop and the indefinite solenoid. The magnetic dipole moment of a current loop.
The circulation of the magnetic field, Ampere's theorem; examples for the computation of magnetic fields by means of Ampere's circulation theorem.
Differential and integral form of the equations of magnetostatics in vacuum. Magnetic properties of matter, the magnetization vector; the phenomenology of diamagnetism, paramagnetism and ferromagnetism; the hysteresis loop of ferromagnetic materials.
Time-dependent electric and magnetic fields
The discoveries of Faraday and the Faraday-Neumann-Lenz law. The case of the "cut flux"; generators of AC e.m.f.
Self-induction and mutual induction; opening and closing extra current in a RL circuit. Preliminaries on AC circuits, resonance of an RLC circuit.
Magnetic energy of a current-carrying solenoid; density of magnetic field energy.
Contradiction between Ampere's circulation theorem and the conservation of the current, introduction of the "displacement current".
Maxwell's equations for the electromagnetic field. Solutions of Maxwell's equations in vacuum, electromagnetic waves that propagate with the speed of light. Density of energy of the electromagnetic field, the Poynting vector, energy flux of the electromagnetic field. Plane waves and monochromatic waves.
The special theory of relativity.
Constancy of the speed of light: a revision of the concept of simultaneous events. Lorentz transformations; length contraction, time dilation. The transformation law of the velocity. Introduction of the four-velocity.
Conservation of momentum and energy and the Lorentz transformations. Momentum and energy in the relativistic case. Energy of a particle at rest, transformation of mass into energy or vice versa; examples.