Appendix 3

Scope of Topics for the Entrance Examination for Candidates Applying for Admission to the Second-Cycle Studies in Technical Physics

1) Fundamental mechanical units and derived units.
2) Newton’s laws of motion: formulation and applications to the description of physical phenomena.
3) Similarities and differences between the description of translational motion of a material point and rotational motion of a rigid body.
4) Conservation laws: mass, momentum, angular momentum, energy, and charge — examples of applications.
5) The continuity equation and local conservation laws.
6) The undamped and damped harmonic oscillator.
7) The physical and mathematical pendulum. The small-oscillations approximation.
8) Forced oscillations. The resonance phenomenon.
9) Motion of charged particles in electric and magnetic fields.
10) Motion of particles in a gravitational field. Kepler’s laws.
11) Scalar and vector quantities.
12) Differential operators in the description of scalar and vector fields: gradient, divergence, curl; potential, and solenoidal fields.
13) Maxwell’s equations — properties of electric and magnetic fields.
14) Electromagnetic waves — properties and spectrum.
15) Polarization of electromagnetic waves, refraction, reflection, and birefringence.
16) The wave equation, wave interference, standing waves, Lissajous figures.
17) Waves in the description of quantum phenomena: wave packets and interference of quantum states.
18) Wave dispersion. Phase and group velocity. The Doppler effect.
19) Special theory of relativity: spacetime and relativistic effects.
20) Equivalence of mass and energy; nuclear energy.
21) Structure of matter: elementary particles and fundamental interactions in nature.
22) Brownian motions.
23) Phase space and Liouville’s theorem.
24) The concept of thermodynamic equilibrium; quasi-static processes.
25) Basic concepts and laws of thermodynamics.
26) Entropy as a state function and its definition in statistical physics; non-equilibrium phenomena.
27) Phase transitions: continuous and discontinuous transitions, critical point, latent heat.
28) Canonical and grand canonical ensembles.
29) Direct and indirect measurements; mean values and measurement uncertainties of simple and composite quantities.
30) Thermal radiation of bodies.
31) Wave–particle duality of light. Examples of phenomena demonstrating the wave–particle duality.
32) Matter waves: de Broglie hypothesis and phenomena demonstrating the wave nature of matter.
33) Heisenberg’s uncertainty principle.
34) Postulates of quantum mechanics.
35) Schrödinger equation. The wave function: properties and physical interpretation.

36) Quantum energy levels: the particle in a potential well, the harmonic oscillator, and the hydrogen atom.
37) Pauli exclusion principle and its consequences.
38) The periodic table of chemical elements.
39) The Jablonski diagram, absorption, and photoemission.
40) Influence of external fields on the energy levels of quantum systems: Zeeman and Stark effects.
41) Lasers: physical principles of operation and applications.
42) Quantum distribution functions: Fermi–Dirac and Bose–Einstein statistics.
43) Electrical conductivity of metals. The Hall effect.
44) Pure (intrinsic) and doped semiconductor materials. The diode and the transistor.