Students must be familiar with:

- International Unit System
- Main physical constants: Planck, Boltzmann, Avogadro, Von Karman, charge and mass of elementary particles, speed of light in vacuum, etc.
- General behaviour of air and water, order of magnitude of relevant physical properties
- Dimensional analysis: it is essential to be able to check the plausibility of derived equations and computations
- Orders of magnitude: it is also essential to check the meaningfulness of the result of a calculus

The distribution of the questions in “General Physics” and “Areas of specialties” will be as follows:

- **General Physics:** questions relative to areas #1 to #8
- **Areas of specialty:** questions relative to areas #1 to #5

As mentioned above, all the areas of specialty below are addressed in the first part of the test. Relevant questions are made to assess the general knowledge of the candidates in physics and outside their area of specialty. Basic definitions, principles and situations are mostly considered in these questions.

Only the areas of specialty #1 to #5 are addressed in the second part of the test in physics. Relevant questions require more regular practice in the field…

Area #1: mechanics (Newtonian) and materials

- Kinematics: position, trajectories, velocity, acceleration
- Newtonian dynamics: Newton’s laws, inertial and non-inertial reference frames, forces and potentials, gravitational field, central forces, small oscillations, translation and rotation, composition of movements, acceleration, angular momentum, kinetic energy, potential energy, mechanical energy, work, power, conservative forces, conservation laws, energy conservation theorems
- Harmonic oscillators
- Rigid bodies statics and dynamics: centre of mass, definition and calculation of moments of inertia around an axis, definition and calculation of inertia matrix, Huygens’ theorem, forces, torques, distributed forces, friction, Coulomb’s laws, equilibrium, acceleration, momentum, angular momentum, kinetic energy, conservation laws (momentum, angular momentum, energy), Koenig’s theorem,
- Kepler’s laws
- Fluids: continuum mechanics, pressure, density, hydrostatics, Archimede’s principle, Euler and Lagrange variables, continuity equation, Euler equation of motion (ideal fluid), mass and volume flow rate, conservation laws, pipe flows (ideal and viscous fluids), regular and singular pressure drop, head loss, Bernoulli equations (incompressible and homogeneous flows of ideal or viscous fluids)
- General classification and mechanical properties of materials
- Mechanical behaviour of materials: normal and shear stress, normal and shear strain, strain-stress curve
- Hooke’s law, Young’s modulus, Poisson’s ratio, shear modulus, bulk modulus, Lamé constants, elastic strain energy
- Principle strains and directions (calculation), Mohr’s circle for plane stress
- Beam deflection and bending

Area #2: thermodynamics

- Work, heat, internal energy, enthalpy, entropy, free energy, free enthalpy, relevant differentials, thermodynamic equilibrium
- Ideal gas: concept, model, limits of the model
- Real gas: Van der Waals' model
- Reversible and irreversible processes, first and second laws of thermodynamics (closed systems)
- Heat machines, Carnot cycle

Area #3: chemistry, chemical/process engineering

- Organic chemistry: structure and bonding in organic chemistry
- Reactions of alkanes, cyclic alkanes, stereoisomerism
- Formation of the hydroxyl functional group
- Reactions of alcohols and the chemistry of ethers
- Reactors of alkens, aldehydes and ketones
- Functional groups containing nitrogen
- Chemical equilibrium, chemical kinetics
- Change of phase, triple and critical points, Clapeyron's formula, chemical reactions, Gibbs' phase rules, phase equilibrium
- Chemical potentials, affinity
- Basic thermochemistry: enthalpy of reaction, endothermic and exothermic reactions
- Electrochemistry, electrochemical batteries, Nernst's law
- Heat and mass transfer, diffusion, flux, Fick's law, conduction, convection, Fourier's law, integral and local balance equations (mass, species, energy, momentum), field operators (grad, div, curl)
- Unitary operations

Area #4: computer science and automatics

- Algorithmics: tests, loops, conditional choices
- Algorithms: structure, sorting techniques, graphs
- Programming, functions, recursion, C language, Unix
- Object-oriented programming
- Computer architecture, computer operation
- Database Management Systems
- Basics of networks
- Automata theory, graphcet
- Automated reasoning

Area #5: electrical circuits and information sciences

- Electric currents: voltage, current, AC/DC
- Thevenin's and Norton's theorems, Kirchoff's junction and loop laws, Ohm's law, superposition theorem
- Physical basis of operation of resistors, capacitors (condensers), induction coils (inductance)
- Impedances in series or in parallel, impedance in variable (sinusoidal) regime, complex impedance
- Free and forced oscillations, resonant circuits (analogy with mechanical resonance)
- Transient regimes in circuits with resistors, capacitors and coils
- Bipolar transistor, MOS transistors
- Operational amplifiers
- Transfer functions of elementary circuits
- Analog filters and amplifiers
- Digital to analog conversion, analog to digital conversion

- Nature of signals
- Sampling (Shannon's theorem)
- Fourier, Laplace and Z transforms
- Nyquist's and Bode's diagrams
- Boolean algebra
- Binary coding, two's complement method
- Data structure
- Digital gates, combinatorial logic, sequential logic
- Counters, memories, registers
- Concept of performance of digital circuits

Area #6: atomic & molecular physics

- Quantum mechanics: Planck's law, Bohr's atom, de Broglie's relation, uncertainty principle, wave function, Schrödinger's equation, stationary states, quantization of energy
- Structure of matter, hydrogen atom, periodic table of the elements, properties of atoms in periodic table, valence bond theory, molecular orbitals, molecules, solid state, crystallography, chemical bonds (covalent, ionic, hydrogen, etc.), interaction of elements/particles/radiation with matter (excitation, fluorescence, photoelectric, Compton, etc.)
- Elementary statistical physics, radioactivity
- Differences between insulators, semiconductors and conductors

Area #7: electricity & magnetism

- Electrostatics: electric charge, Coulomb's law, electric field, potential, Gauss' law, symmetry of the electrostatic field E, calculation of E for simple charge distributions
- Electric dipole, electrostatic field induced by a capacitor
- Poisson's law
- Conductors in electrical equilibrium
- Coulomb's law between 2 charges in a homogeneous linear and isotropic dielectric medium
- Magnetostatics: magnetic field B, symmetries of B, Ampère's laws, Maxwell's laws, Potential vector
- Magnetic field created by an infinite wire or a circular loop, along the axis of a coil, Biot and Savart's law
- Magnetic dipole and moment
- Faraday's law of induction, induction, Lenz's rule
- Electromagnetism: Maxwell's equations in vacuum, progressive harmonic plane waves an solutions of the relevant equations of propagations, wavelength, wave vector, phase velocity, polarization, Poynting vector
- Lorentz force, plane electromagnetic waves
- Magnetic waves: radiation, spectrum, light waves, reflexion, refraction, Huygens principle, diffraction, interference phenomena, laser

Area #8: optics

- Geometrical optics: light rays, reflection, refraction, diffraction, Snell-Descartes' laws, limit angle, total reflection, mirrors, lenses and their association, focal length
- Wave optics: optical path, coherent light/waves, interference, thin slabs, diffraction, Young's slits experiments, Michelson's interferometer, Pérot-Fabry's cavity
- Basics of lasers
- Light propagation in optical fibers