

The selection of foreign candidates for a Master of Engineering at one of the graduate schools of engineering composing Institut Mines-Télécom is based on a written examination followed by an interview, provided the students have obtained good results at their written examination.

ORGANIZATION OF THE WRITTEN TESTS

The written examination consists of a test in Mathematics and a test in various specialty areas. Both tests are Multiple Choice Questionnaires in which, by definition, candidates are asked to select the correct answer out of the choices from a list:

- A correct answer earns 1 point toward the total mark
- An unanswered question earns nothing
- A quarter of a point is removed from the test score for every incorrect answer

The test in mathematics is:

- 90 minutes long
- Composed of 35 questions
- Designed to be treated entirely throughout the examination

The second test is:

- 120 minutes long
- Composed of 65 questions
- Not designed to be answered totally, however candidates should try to answer (correctly) as many questions as possible during the 2 hours of examination. The test consists of 2 parts:
 - A set of 15 questions in General Physics
 - A set of 50 questions in 5 categories corresponding to different specialties (10 questions/specialty). Candidates can choose to answer the questions they want within the 5 categories.

WHAT CANDIDATES SHOULD BE ACQUAINTED WITH IN MATHEMATICS

Elementary logic and Algebra

- Quantifiers, propositional calculus (sentential logic)
- Argumentum ab absurdum (argument to absurdity), recursion
- Set and function terminology 集合和函数术语
- Sets N (natural integers), Z (all integers), Q (rational numbers): arithmetic and combinatorics 集合: N 自然数, Z 整数, Q 有理数, : 算数和组合数学
- Polynomials: arithmetic, Euclidian division, functions, roots 多项式: 算数, 欧几里得除法, 函数, 根

Probability and statistics

- Basic probability models 基本概率模型
- Independent and dependent events 独立与从属事件
- Combinatorics (permutations and combinations) 组合 (排列和组合)
- Random variables 随机变量
- Standard discrete and continuous probability distributions (binomial, Normal, Poisson...) 标准离散、连续概率分布 (二项分布, 正态分布, 泊松分布...)
- Descriptive statistics: measures of central tendency and dispersion, mean, median, mode, variance and standard deviation, skewness, flatness
- Central limit theorem 中心极限定理 描述性统计: 中心趋势和离散度的测量, 平均值, 中位数。众数, 方差和标准差, 偏斜度, 平坦度
- Statistical estimation and testing 统计参数估计
- Confidence intervals 置信区间
- Basics of linear regression 线性回归

Properties of the set R (Real numbers)

- Interval, neighbourhood, lower/upper bound 区间、领域、上下界
- Sequences: limit (Cauchy criterion), convergence, rate of convergence, recursion ($u_{n+1}=f(u_n)$) 数列: 极限 (柯西标准)、收敛性、收敛率、递归
- Numerical function of the real variable: continuity, differentiability, monotony and variations, limits, inverse functions, Taylor formulas and inequality, finite increments formula, finite expansions, integrability, integral calculus (Riemann), definite and indefinite integrals 实数数值函数: 连续、可微、单调、变换、极限、反函数、Taylor展开式和不等式、有限增量公式、有限展开、可整定行、黎曼积分计算、定积分和不定积分
- Usual functions

Complex numbers

- Properties of the set C (complex numbers) 复数集合 C 的性质
- Arithmetic of complex numbers 复数的计算
- Complex numbers and trigonometric functions 复数和三角函数
- Usual complex functions (exponentials, hyperbolic functions...)

Linear algebra / finite dimensional vector spaces

- Vector spaces, linear maps, vector basis and space dimensions, 向量空间、线性映射、向量基和维度
- Matrices, determinant, rank, cofactors, trace, operations on matrices 矩阵、det、rank、分解、trace
- Linear systems of equations 线性方程组
- Endomorphisms 同态
- Eigenvalues, Eigenvectors, characteristic polynomial of a system, Cayley-Hamilton theorem, diagonalization 特征值、特征向量、特征多项式、Cayley-Hamilton定理、对角化

Finite dimensional Euclidean spaces (mainly \mathbb{R}^2 and \mathbb{R}^3)

- Scalar products, norms, distance, Cauchy-Schwarz inequality, orthonormal basis and orthonormalization, cross product 标量积、度量、距离、柯西不等式、正交基、正交化、矢量积
- Orthogonal matrices, diagonalization of symmetric real matrices 正交矩阵、实对称矩阵的对角化
- Definition of the space L^2 (space of square-integrable functions): orthonormal basis in L^2 , Legendre polynomials, basis of trigonometric functions
- Notions about Fourier series and Fourier transformation 傅里叶级数、傅里叶变化

Analysis

- Rational functions and their decomposition, calculus of primitives, integral defined on a closed bounded interval, numerical methods, Taylor's formula with integral remainder, multiple integrals (functions of 2 or 3 variables), computation via successive integrations and change of variables formula
- Vector valued function of the real variable in \mathbb{R}^2 and \mathbb{R}^3 : partial derivatives, differential, chain rule, and linear tangent application
- Taylor formula of order 2: application to local extrema
- Parametric curves in \mathbb{R}^2 and \mathbb{R}^3
- First and second order linear differential equations
- Path, surface and volume integral

Numerical series

- Series of real or complex numbers, simple and absolute convergence 实数和复数的级数、收敛和绝对收敛
- Power series, radius of convergence 幂级数、收敛半径
- Functions expandable in a power series on an interval 函数区间幂级数展开式
- Taylor series expansion of usual functions Taylor级数
- Sequences and series of functions of the real variable, entire series, application to Fourier series
- Simple, absolute, uniform and normal convergence
- Integrals over a real interval, integrals depending on a parameter
- Cauchy-Schwarz inequality
- Fourier, Laplace

WHAT CANDIDATES SHOULD BE ACQUAINTED WITH IN PHYSICS, CHEMISTRY AND OTHER SPECIALTIES

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

牛顿力学：
牛顿定律、惯性和非
惯性参考系、力和
势、重力场、向心
力、微小震动、平动
和转动、运动的合
成、加速度、角动
量、动能K、势能、机
械能、功、功率、保
守力、守恒定律（动
量守恒、角动量守
恒）、能量守恒理论
刚体静态与动态：
质心、绕轴转动的
定义与计算、惯性
矩的定义与计
算、惠更斯理论、
力、扭矩、力的分
布、摩擦力、库仑
定律、平衡态、加
速度、动量、角动
量、动能、守恒理
论、Koenig理论

- Kinematics: position, trajectories, velocity, acceleration 运动学：位置、轨迹、速度、加速度
- 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 谐运动
- 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 热力学

做工、热、内
能、焓、熵、热
平衡

- Work, heat, internal energy, enthalpy, entropy, free energy, free enthalpy, relevant differentials, thermodynamic equilibrium
- Ideal gas: concept, model, limits of the model 理想气体: 概念、模型、不足
- Real gas: Van der Waals' model 实际气体: 范德华模型
- Reversible and irreversible processes, first and second laws of thermodynamics (closed systems) 热力学第一、第二定律
- Heat machines, Carnot cycle 热机、卡诺循环

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 alkenes, 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 算法: 结构、排序、图论
- 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, Kirchhoff's junction and loop laws, Ohm's law, superposition theorem
- Physical basis of operation of resistors, capacitors (condensers), induction coils (inductance) 电阻、电容、电感
- Impedances in series or in parallel, impedance in variable (sinusoidal) regime, complex impedance 阻抗串并联、正弦
- Free and forced oscillations, resonant circuits (analogy with mechanical resonance) 自由、受迫振动
- 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 and 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, Péro-Fabry's cavity
- Basics of lasers
- Light propagation in optical fibers