Requirements Check List

The master course in Materials Science and Engineering requires a bachelor degree in a field of natural sciences or techniques. The following keywords must be known in basics for theory and practice.

Materials Science	
models of atoms, Schrödinger equation and principles of quantum theory, bonding, concept of potential wells	
perfect crystals: formal description, important lattices	
real crystals: defects in crystals, types of defects, interaction of defects	
thermodynamic equilibrium: types of equilibrium, 1st and 2nd law of thermodynamics, statistical interpretation of the entropy, applications to point defects	
kinetics: reaction rates and Boltzmann factor, phenomenological diffusion and atomic mechanisms	
mechanical properties I: stress and strain, phenomenological description of deformation, brittle behavior and fracture	
mechanical properties II: mechanisms of plastic deformation, dislocation movement and multiplication, theory of yield strength	
structural and mechanical properties of amorphous materials and polymers	
general structural properties, modulus of elasticity, viscose and inelastic behavior, deformation and fracture	
aging and failure of materials: mechanisms in general, fatigue and creep, corrosion, electromigration and special mechanisms	
electronic properties in general, electronic properties and materials science.	
electrons in crystals: classical theory, Hall effect, quantum description, free electron gas model, density of states, Fermi distribution and Fermi energy, properties of the free electron gas	
diffraction in crystals: basic consideration of diffraction in crystals, Bragg law, reciprocal lattice and Ewald construction, intensity of the diffracted waves	
electrons in a periodic potential: free electron gas plus Bragg law, Brillouin construction of diffraction, band structures and electronic properties, band-band transitions and standard representation of semiconductor band structures	
semiconductors: intrinsic conductivity, conductivity as a function of temperature, the concept of holes, doping and extrinsic conductivity	
semiconductor contacts: surface states, space charge region, p-n-junction, currents and current-voltage characteristics, recombination and diffusion currents	

Mathematics	
Calculus	
real and complex numbers, complete induction, sets, functions. Series of real numbers, convergence, Cauchy series. Steadiness, theorems on continuous functions, polynoms, nulls, rational functions	
inverse functions: exponential functions and logarithms, trigonometric functions, hyperbola functions	
differential calculus: characteristics of differentiable functions and differentiation rules, derivatives of basic functions, median theorem, extrema, Taylor's and L 'Hospital's rules	
integral calculus: antiderivative, indefinite integrals, substitutional rules, partial integration, factoring of polynomials, Riemann integrals, examples of continuous and monoton functions, main clause of differential and integral calculus.	
indefinite integrals: gamma function, Stirling's formula	
infinite series: criterions on convergence, power series, monotonous convergence, differentiation and integration of individual terms, examples on Taylor series, criteria of convergence with respect to Fourier series	
arc length, curvature, convergence criteria; power series, uniform convergence, differentiation and integration by segments, examples for Taylor series	
Fourier series: questions of convergence, Bessel's inequality	
Taylor's formula	
extrema of functions in several variables, least squares method, Lagrange multipliers	
Integration in R_n: integral over domains, iterated integrals (Fubini), volume, substitution rule: polar and spherical coordinates	
Algebra	
Euclidean vector spaces in R2, R3: vectors, scalar product, matrices, linear maps in R2, vector product in R3	
analytic geometry in R2, R3 vector spaces: linear independence, basis, dimension, linear maps and matrices, rank	
linear systems of equations: solvability, Gauss' algorithm, L-R-factorization, inverse matrix, Cramer's rule, determinants; eigenvalues and eigenvectors, characteristic polynomial, scalar product and norm, Schwarz inequality, orthonormalization, Legendre polynomials, orthogonal and unitary maps	
linear transformations: eigenvalues and eigenvectors of symmetric and orthogonal matrices, quadratic forms	
some topology in R_n: open, closed, tangent plane, directional derivative, special partial derivatives, gradient, direction of maximum slope	

Chemistry	
Inorganic Chemistry	
periodic system of elements, names, periodic properties, electron configuration	
usage of the elements and their compounds	
atomic structure, crystals, amorphous materials	
chemical bond types, covalent, ionic, metallic, van-der-Waals	
reactivity of the chemical elements, redox potential, oxidation, reduction	
simple inorganic synthesis	
acids and bases, strength, order	
pH value, titration, neutralization	
chemical equilibrium	
Indicators	
basic chemical analysis	
Organic Chemistry	
alkane, alkene, alkyne	
alcohols, ketones, aldehydes, acids	
cyclic molecules, hetero structures, aromatics	
nucleophile, electrophile substitution and addition	
common reactions	
polymerisation, reactions, kinds, usage	
nomenclature	
basics of stereo chemistry, chirality, stereo selectivity	
basics of chemistry of natural products	
Physical Chemistry	
ideal and real gases	
fundamentals of the kinetic theory of gases	
thermodynamic state variables	
laws of thermodynamics	
chemical transformations	
thermochemistry	
phase transition and equilibrium	
multicomponent systems	
phase diagrams	
chemical equilibrium	
fundamentals of equilibrium electrochemistry	

Physics	
fundamentals of physics with a special emphasis on.	
classical mechanics	
electricity	
optics	
acoustics	
introduction into physics of atoms, molecules, nuclei and elementary particles	
basics of solid state physics	