UNIVERSITÀ
DI TRENTO
Department of
Industrial Engineering

Materials Engineering

Enrollment Prerequisites

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The course

The Master’s degree course in Materials Engineering trains engineers skilled to produce and manage technology innovation and work as high-level technicians and managers, in areas requiring a deep knowledge of base sciences and engineering, with particular attention paid to the design, customization, processing, development, use, sustainable management of materials, and other related topics.
The graduates in the Master’s degree course in Materials Engineering will master technologies, devices, systems and infrastructures for the production, customization and design of traditional and innovative materials, their use in specific applications of the industries in the field of chemistry, mechanics, textiles, optics-electronics, biotechnologies and, more in general, for the development and the production and use of goods and services.

Study plan

The first year of the Master’s degree course in Materials Engineering provides fundamentals of materials chemistry and physics as well as topics of particular current interest in the industry, such as material selection, processing, environmental degradation, failure mechanisms and materials innovation processes. Courses cover engineering aspects of metals, ceramics, polymers and composites. From the second year, MSc Students of Materials and Engineering can choose one of the following curricula, which are closely linked to the industry as well as contemporary research.

Manufacturing and Product Development

Aims at training experts in Materials Engineering, with deep knowledge of production and processing technologies, on the mechanisms of damages during while operating and on the planning tools and methods used in the manufacturing industry for the optimizations of current processes and products, and for the development of the innovative products.

Energy, Environment and Sustainable Development

Aims at training experts in Materials Engineering highly skilled in materials and processes for production and transformation of energy, the reduction of energy consumption through innovative materials and technologies, the reuse and recycling to reduce the environmental impacts of the processes of material production and transformation.

Engineered Materials and Biomedical Applications

Focus on the engineering and use of materials for biomedical and functional applications, also with reference to “bioinspired” and “biomimetic” materials. The basic subjects of the master’s course are completed with specific courses on materials applications which have increasingly acquired scientific and applicative importance.

Whatever the Bachelor’s degree program you attended, we expect you to meet the entry requirements before you join the courses.

You can check the entry requirements for your chosen curriculum in the following section. Our entry requirements usually include basic concepts of solids mechanics, physics, chemistry and materials science.

First year prerequisites

Ceramic materials engineering	• Chemistry: periodic table, chemical bonds, orbitals, energy levels, solutions, acids and bases, pH, chemical reactions, stoichiometry; • Physics and thermodynamics: phase transition, latent heat, surface tension/energy, viscosity, free energy (enthalpy & entropy), thermodynamic stability, specific heat, Arrhenius law and activation energy, diffusion in solids, phase transitions, equilibrium phase diagrams, conduction, convection, radiation; • Solid mechanics: force and deformation, stress/ strain, pressure, elastic moduli, Poisson's ratio, tension, bending, compression, shear; • Materials science: crystals, defects, grain boundary, basic materials sample preparation, basic characterization techniques (OM, SEM, TEM, XRD).
Corrosion and degradation control of materials	• Chemistry: periodic table, chemical bonds, orbitals, solutions, acids and bases, free energy (enthalpy & entropy), chemical reactions; RedOx reactions; • Materials science: lattice structures, defects, grain boundary, phase transitions/phase diagrams.
Engineering properties of materials	• Mathematics: derivatives and integrals, differential equations; • Chemistry: atomic structure, chemical bonding (ionic and covalent bonds, Valence Bond theory, Molecular Orbitals), weak interactions; nomenclature of inorganic compounds, basic concepts of organic chemistry (classes of organic compounds); • Physics: rigid body dynamics, waves and electromagnetism; • Materials science: crystalline solids, basic knowledge of structure and main properties of materials (glasses, ceramics, metals, polymers); • Basic concepts of statistics; • Solid mechanics concepts of stress and strain, constitutive equation, structural analysis.
Metallic materials engineering	• Chemistry: periodic table, chemical bonds, orbitals, energy levels, solutions, acids and bases, pH, chemical reactions, stoichiometry; • Physics: phase transition, latent heat, surface tension/energy, viscosity, free energy (enthalpy & entropy), thermodynamic stability, specific heat, Arrhenius law and activation energy, diffusion in solids, phase transitions, equilibrium phase diagrams, conduction, convection, radiation; • Solid mechanics: force and deformation, stress/ strain, pressure, elastic moduli, Poisson's ratio, tension, bending, compression, shear, fracture strength and toughness; • Materials science: crystals, defects, grain boundary, basic materials sample preparation, basic characterization techniques (OM, SEM, TEM, XRD); • Metallurgy: Fe-C diagram, steel, cast iron, heat treatment of steel, metallurgical constituents, strengthening mechanisms.

Physics and thermodynamics of materials	• Chemistry: periodic table, chemical bonds, orbitals, solutions, acids and bases, free energy (enthalpy & entropy), chemical reactions; • Physics: phase transition, latent heat, surface tension/energy, viscosity; • Solid mechanics: stress/ strain, elastic constant, tension, bending, compression, shear, fracture strength and toughness); • Materials science: lattice structures, defects, grain boundary, phase transitions/phase diagrams, basic materials sample preparation, basic characterization techniques (OM, SEM, TEM, XRD); • Metallurgy: Fe-C diagram, steel, cast iron, heat treatment of steel, metallurgical constituents, strengthening mechanism.
Polymeric and composite materials engineering	• Chemistry: chemical bonds, basic chemical reactions, stoichiometry, orbitals - transition elements; • Organic chemistry: carbon bonds, functional groups groups (alcohol, ether, ester, amide), organic reactions (oxidation); • Basics of statistics: average values and standard deviation; distribution; • Physics : definition of calorie; heat transport; melting and crystallization; heat capacity; density; electrical insulator and conductors; • Solid mechanics: stress/strain definition, tensors and matrices, elastic constants in tension, bending, compression, shear, rheological behaviour, fracture strength and toughness.

Second year: Manufacturing and Product Development curriculum

Design methods for industrial engineering	• Applied geometry - geometric constructions and mechanical curves. Orthogonal projections - meaning and use of European and American systems for representation - definition of axonometries and perspectives - intersection solids/planes; • Representation of mechanical parts and related standards - meaning and use of line types - representation and use of sections in mechanical drawing; • Dimensioning systems and their criteria - functional dimensioning, technological aspects and verification - particular conventions of dimensioning; • Designation, representation and dimensioning of joints- welded joints - shafts and hubs - threaded parts; • Dimensional tolerances (definition, representation and indication on drawings - general tolerances - connections based on the shaft or on the hub and related tolerances).
Finite elements modeling	• Calculus: derivatives and integrals, differential equations, linear algebra; • Physics: vectors and vector calculus, forces and moments, static equilibrium of rigid bodies, support reactions; • Mechanics of materials: stresses and strains, elastic constitutive law, internal loading, beam theory, energy methods; • Machine design: product design specification, strength and stiffness constraints, technical drawing, machine elements, joining techniques.

Mechanics and materials for engineering design	• Calculus: derivatives and integrals, differential equations; • Physics: vectors and vector calculus, forces and moments, static equilibrium of rigid bodies, support reactions; • Materials science: stress-strain curve of a metallic material; • Solid mechanics: internal loading diagrams, stresses and displacements of beams; • Industrial drawing: mechanical drawing, possibly CAD software.
Product design	• Knowledge of the Italian industrial system and of the most famous Italian design-oriented world leader factory; • Attitude to break stereotypes and to lateral thinking; • Knowledge of materials science; metallurgy; polymeric materials and production processes.
Steelmaking and foundry technology	• Physics and thermodynamics of materials.

Second year: Energy, Environment and Sustainable Development curriculum

Electrochemistry for energy and environment	• Thermodynamics and kinetcs of the electrified interfaces, Nernst equation, stern theory and model, Pourbaix diagrams, Butler-Volmer theory, Tafel equations (From the Corrosion and degradation control of materials course).
Materials for energy	• Ceramic Materials Engineering; • Physics and thermodynamics of materials.
Mechanics and materials for engineering design	• Calculus: derivatives and integrals, differential equations; • Physics: vectors and vector calculus, forces and moments, static equilibrium of rigid bodies, support reactions; • Materials science: stress-strain curve of a metallic material; • Solid Mechanics: internal loading diagrams, stresses and displacements of beams; • Industrial drawing: mechanical drawing, possibly CAD software.
Nanomaterials, nanotechnologies and smart materials	• Basic knowledge of materials classes, materials production and properties (courses content of the first year).
Recycling and sustainable materials	• Chemistry at Master's degree level; • Polymeric Materials Engineering, Composite Materials Engineering, Ceramic Materials Engineering, Metallic Materials Engineering: structure, properties and processing techniques of main engineering materials; • Properties and Characterization of Materials: main techniques for mechanical, thermal and structural characterization of engineering materials.

Second year: Engineered Materials and Biomedical Applications curriculum

Bioinspired and functional materials	• Basic knowledge of materials classes, materials production and properties (courses content of the first year).
Biomaterials and biomedical technologies	• Basic knowledge of materials classes, materials production and properties (courses content of the first year).
Biomedical metallic materials and technologies	• Basic knowledge on metals structure and thermodynamics; • Phase transformations and heat treatment of metals; • Base processing of metals and alloys; • Contents of Metallic Materials Engineering course.
Fundamentals of mechanics and biomechanics	• Physics: vectors and vector calculus, forces and moments, static equilibrium of rigid bodies, support reactions; • Solid Mechanics: Internal loading diagrams, stresses and displacements of beams.
Principles of biomaterials and medical device design	• Basic knowledge of polymers structure, crosslinking, functionalization, degradability; • Basic knowledge of the principal Ti-alloys, ceramics; • Very basic knowledge of cell and tissue structure and principal functions.

Elective courses

Bioinks and 3D printing	• Fundamentals of Engineering properties of materials (Materials Science, Knowledge of Solid mechanics concepts of stress/strain elastic constants in tension, bending, compression, shear, rheological behaviour); • Fundamentals of Biomaterials and biomedical technologies; • Basic knowledge of mechanical drawing in 2D and 3D (CAD).
Bio-signals and transducers	• Fundamentals of Mathematics, geometry and physics; • Differential and integral calculus; • Basic knowledge of electrical network and of analogue electronic circuit.
Circular economy for materials processing	• Basic knowledge of materials classes, materials production and properties (courses content of the first year).

Electronic materials and technologies	• Mathematics: differential and integral calculus. Differential equations; • Physics 2: potentials and electric fields, Maxwell's equations. Electromagnetic waves. Elements of optics; • Basics of chemistry: concept of valence, atomic orbital and chemical bond. Introduction on the crystalline structure of solids; • Electrotechnics: circuit elements: resistors, capacitances, inductances and generators. Electrical networks in DC, AC and transient regime.
Glass engineering	• Chemistry: chemical bonds, orbitals, energy levels, solutions, acids and bases, pH, chemical reactions, stoichiometry; • Physics and thermodynamics: phase transition, latent heat, surface tension/energy, viscosity, free energy (enthalpy & entropy), thermodynamic stability, specific heat, Arrhenius law and activation energy, diffusion in solids, equilibrium phase diagrams; • Solid mechanics: force and deformation, stress/ strain, pressure, elastic moduli, Poisson’s ratio, tension, bending, compression, shear; • Materials science: materials structure, basic materials sample preparation, basic characterization techniques (OM, SEM, TEM, XRD).
Interdisciplinary laboratory	• Basic knowledge of materials classes, materials production and properties (courses content of the first year).
Powder metallurgy	• Metallic materials engineering.
Protection of materials and structures	• Electrochemistry and corrosion and degradation phenomena (from: Corrosion and degradation control of materials); • Basic concept of materials science; • Metallurgy (from: Metallic materials engineering).
Optoelectronics and quantum devices for sensing and automation	• Mathematics: derivatives and integrals, differential equations; • Physics 2: Potentials and electric fields, Maxwell's equations. Electromagnetic waves. Elements of optics; • Electrotechnics: circuit elements: resistors, capacitances, inductances and generators. Electrical networks in DC, AC and transient regime; • Basic concept of materials science.

Actions to bridge the gap

Those not meeting the entry requirements for any of the disciplines described in the previous section are suggested to undertake the proper actions. To bridge the gap between course requirements and your current academic level, the Department of Industrial Engineering has several tools. In particular:

- A list of the essential literature which is useful to meet the minimum entry requirements is provided (references are divided by discipline);
- If you need more detailed literature and/or clarifications on the entry requirements for a specific course, you can contact the lecturer of the course directly;
- The Department arranges tutorial activities during the semester on several disciplines (solid mechanics, metallurgy) that cover the basic academic knowledge to support you to meet the minimum entry requirements.

Discipline	Books	Reference person
Calculus	• W. Briggs, L. Cochran, B. Gillet and E. Schulz: *Calculus, Single Variable,* Pearson; • W. Briggs, L. Cochran, B. Gillett and E. Schulz: *Calculus, Multivariable,* Pearson; • S. Axler: *Linear Algebra Done Right*, Springer.	Prof. M. Brunelli
Chemistry	• D. W. Oxtoby, H. P. Gillis and L. J. Butler: *Principles of modern chemistry*, Cengage Learning; • M. Schiavello e L. Palmisano: *Fondamenti di Chimica*, Edises.	Prof. F. Parrino
Industrial drawing	• C. H. Simmons, D. E. Maguire and N. Phelps: *Manual of Engineering Drawing*, Butterworth-Heinemann.	Prof. I. Cristofolini
Materials science	• W. D. Jr. Callister and D. G. Rethwisch: *Materials Science and Engineering: An Introduction*, Willey; • W. F. Smith and J. Hashemi: *Foundations of Materials Science and Engineering*, McGraw Hill; • L. H. Van Vlack: *Elements of Materials Science and Engineering*.	Prof. M. Fedel

Metallurgy	• R. Abbaschian, L. Abbaschian, R. E. Reed-Hill: *Physical Metallurgy Principles*, Cengage Learning; • G. Krauss: *Steels, Processing, Structure, and Performance*, ASM International.	Prof. M. Pellizzari
Physics	• P. Mazzoldi, M. Nigro, C. Voci: *Elementi di fisica. Vol. 2: Elettromagnetismo e onde*, Edises. • K. Cummings, P. Laws, E. Redish, P. Cooney: *Understanding Physics*, Wiley.	Prof. D. Maniglio
Solid mechanics	• R. C. Hibbeler: *Engineering Mechanics, Statics*, Pearson; • R. C. Hibbeler: *Mechanics of Materials*, Prentice Hall.	Prof. M. Benedetti

Self-evaluation test

You should be aware that not meeting the department minimum academic requirements does not exclude, limit, or affect the possibility of attending the courses and undertaking the exams. Therefore, all entry requirements listed in this prospectus reflect the minimum requirement we consider appropriate to participate in the MSc courses fruitfully.

To check if you meet the entry requirements, you can undertake the self-evaluation test at the link https://bit.ly/3lySkFQ.

The self-assessment tests will help you familiarize yourself with the disciplines you will go through during the MSC courses. Before undertaking the self-evaluation test, please consider the following:

- The test is not mandatory;
- The test reflects the entry requirements listed in the previous table;
- The test is a self-evaluation tool: it aims at helping you to autonomously assess your current academic level on the disciplines of the MSc;
- The results of the test are recorded anonymously and elaborated only for statistical purposes.