Syllabus for Admission to the Master's Degree in Materials Engineering for Industry 4.0

1. Required Knowledge and Skills

In addition to the curricular and language requirements detailed in the academic regulations of the Master's Degree Course in Materials Engineering for Industry 4.0, successful attendance in the program requires possession of the following minimum skills and knowledge in both basic engineering and specialized fields relevant to the course:

1.1 Basic Engineering Training

A solid and applicable understanding of the fundamentals of industrial engineering is required, including:

Applied Mechanics, Structural Mechanics, and Strength of Materials (09/IIND-02, 08/CEAR-06):

Knowledge:

- Stress analysis;
- Strain and deformation;
- Mechanical behavior of materials under load;
- Concepts of elasticity and plasticity;
- Failure criteria.

Skills:

- Calculating support reactions in statically determinate structures;
- Drawing stress diagrams in statically determinate structures;
- Operating with stress and strain components;
- Calculating stresses in beam systems;
- Drawing stress diagrams in statically indeterminate structures;
- Verifying the strength of a structure given geometry, load, and material properties.

Thermodynamics and Transport (09/IIND-07, 09/ICHI-01):

Knowledge:

- Energy balances;
- Thermal conduction and convection;
- Diffusion;
- Thermodynamics of material systems.

Skills:

- Performing calculations of changes in thermodynamic potentials, energy exchanges between system and environment, and thermodynamic equilibria;
- Applying acquired knowledge to industrial thermal processes.

Fundamentals of Fluid Machinery (09/IIND-06):
Knowledge:

- Basic principles of operation of power and operating machines;
- Machines using compressible and incompressible fluids, necessary for performance evaluation under design conditions.

Skills:

- Understanding the differences between various machines and their applications;
- Critically discussing key aspects of machine design and operation;
- Analyzing simple machines or systems;
- Evaluating the most technically appropriate decisions for effective machine or plant design.

This engineering background is essential for understanding the production, design, and management issues associated with the use of materials. If these topics and related skills are not already part of the candidate's background, they must be acquired through personal study.

1.2 Materials Science and Technology

The core area of the bachelor's program, which serves as the main prerequisite for entry into the Master's program, includes:

Materials Science and Technology (09/IMAT-01):
Knowledge:

- Understanding the correlations between structure (atomic and microstructural), transformation processes, and properties (mechanical, optical, thermal, electrical, chemical) of materials across different classes (metals, polymers, ceramics, composites).

Skills:

- Correlating the macroscopic properties of materials with their atomic and microstructural features;
- Awareness of the importance of material selection to meet design requirements;
- Interpreting international standards and understanding scientific literature.

Organic Chemistry (03/CHEM-06):
Knowledge:

- Fundamentals of organic chemistry necessary for studying carbon-based materials such as polymers;

- Knowledge of organic compounds and their reactivity, with rational interpretation of reaction mechanisms.

Skills:

- Recognizing the main classes of organic compounds and their main chemical reactions through reaction mechanisms;
- Applying spectroscopic methods to identify organic products or monitor their chemical transformations;
- Gathering data from scientific literature.

Metallic Materials (09/IIND-03):

Knowledge:

- Knowledge of the main metal alloys for engineering applications, including compositional and microstructural features, and key treatments to improve properties;
- Understanding of how metallurgical features influence failure mechanisms in engineering components.

Skills:

- Selecting metallic materials based on performance under service conditions and specific applications;
- Identifying how the properties of metallic materials can be modified by manufacturing processes and post-treatments;
- Understanding how service conditions affect alloy performance, potential failure modes, and appropriate solutions.

Science and Technology of Polymeric Materials (09/IMAT-01):

Knowledge:

- Polymerization processes and structure of polymeric materials;
- Fundamentals of main production and processing techniques;
- Description of key end products.

Skills:

- Identifying the relationship between structure and macroscopic properties of polymeric materials;
- Acquiring basic elements for the design of polymer-based components.

Science and Technology of Ceramic Materials (09/IMAT-01):

Knowledge:

- Basic engineering knowledge of ceramic materials;
- Process variables and understanding of how they influence material performance;

- Mechanical properties of ceramic materials and their correlation with structure.

Skills:

- Applying knowledge of ceramics and ceramic processes to solve practical problems related to mechanical, thermal, rheological, and chemical-mineralogical properties;
- Applying knowledge of ceramic material properties to understand, select, and interpret main characterization techniques;
- Applying knowledge of materials, their properties, and transformation processes to consciously and sustainably select the most appropriate material and production technology for ceramic products.

Structure of Matter (02/PHYS-03, 09/IMAT-01):
Knowledge:

- Basic concepts and key tools to understand microscopic processes in matter in its various states.

Skills:

- Developing a critical analytical mindset regarding physical phenomena, with a rigorous and formal understanding of concepts such as electrical conductivity and optical response in main material classes.

This specialized background in materials engineering is essential for completing the educational path of a master's-level materials engineer. If the candidate does not already possess the knowledge and skills listed above, these must be acquired through personal study (on line tools).