Italian code: ING-IND/22 (old) – IMAT-01/A (new) **Credits: 9**
Course: Planning of Transportation Systems
Main language of instruction: Italian
Other language of instruction: English

Head instructor
Professor ILARIA CACCIOTTI - ilaria.cacciotti@unicusano.it

Objectives

The course on Materials Science and Technology has the following educational objectives:
1. We define and classify different types of materials
2. Defining the microstructure of the materials
3. Explain the relationship between the structure and properties of the materials
4. Illustration of thermal and mechanical properties of materials
5. Illustration of the composition, preparation, and properties of cement and concrete
6. Experimental process data with calculation tools.

At the end of the Course in Materials Science and Technology, the student will have demonstrated knowledge of topics related to the structure, properties, and applications of different types of materials and will have acquired critical skills necessary for the selection of the most suitable material for specific applications. Furthermore, through the proposed Etivity, students will acquire the ability to process experimental data using Excel or other calculation tools and prepare a report of the activities carried out.

Course structure

- Introduction
- Solids
- Material properties
- Metals and Ceramics
- Polymers
- Composites

- Cement and Concrete

Competencies

A. Knowledge and understanding:

The course of Materials Science and Technology aims to frame and develop the main aspects concerning the structure, properties, and applications of the main classes of materials, highlighting the relationship between the structure and corresponding properties. The course aims to provide students with appropriate tools for the identification and selection of suitable materials for specific applications and to transfer to them the ability to apply the knowledge acquired to the resolution of practical problems. Furthermore, the Etivity associated with the course develops the skills necessary to process experimental data associated with the properties of materials using calculation systems.

B. Applying knowledge and understanding:

The student will be able to use the knowledge acquired regarding the structure, properties, and applications of the different categories of materials to select the most suitable materials for specific applications. The proposed Etivity foresees the application of the theoretical concepts acquired in practical applications, so that the student is able, at the end of the course, to rework experimental data using appropriate calculation tools.

C. Making judgements:

The student will be able to classify materials according to their origin, nature, and relative properties, to interpret tables provided with the specifications of the materials themselves, and to identify the most appropriate materials for specific applications.

D. Communication skills:

The student will be able to describe and sustain conversations focused on topics related to different types of materials, using appropriate terminology, and prepare a report related to the processing of experimental data thanks to the proposed Etivity.

E. Learning skills:

At the end of the course, the student will acquire fundamental notions regarding the structure, properties, and applications of the main categories of materials, which are essential for continuing engineering studies with greater maturity.

Syllabus

Subject 1 – Introduction (7 video-recorded theory lessons for a commitment of 20.5 hours - week 1) Modules 1-7

Lesson 1. Materials Science and Technology.

Lesson 2. Classification of Materials.
Lesson 3. Recall the aggregation states.
Lesson 4. Atomic structure.
Lesson 5. Periodic table, and periodic properties.
Lesson 6. Atomic models and quantum numbers.
Lesson 7. Primary and secondary chemical bonds.

Subject 2 – Solids (11 video-recorded theory lessons and 2 exercise lessons for a commitment of 30.5 hours – week 2) Modules 8-20
Lesson 1. Ionic, covalent, molecular, and metallic solids.
Lesson 2. Crystalline and amorphous structure.
Lesson 3. Rigid sphere model.
Lesson 4. Packing factor.
Lesson 5. Crystal systems and Bravais lattice.
Lesson 6. CFC, CCC, and EC elementary cells.
Lesson 7. Lattice directions and planes.
Lesson 8. Miller indices.
Lesson 9. Linear, planar, volumetric density.
Lesson 10. Polymorphism and allotropy.
Lesson 11. Solidification mechanism of metals. Nucleation and growth.
Lesson 12. Substitutional and interstitial solid solutions. Defects in crystalline structure: point, line, surface, and volume defects. Diffusion mechanisms (substitutional and interstitial).
Lesson 13. Diffusion under stationary and nonstationary conditions. Phase diagrams: one-, two-, and three-component systems.

Subject 3 - MATERIAL PROPERTIES AND ASSOCIATED TESTS (16 video-recorded theory lessons and three exercise lessons for a commitment of 50 hours, weeks 3 and 4). Modules 21-39.
Lesson 1. Chemical, physical, and Magnetic Properties.
Lesson 2. Mechanical behavior of materials.
Lesson 3. Classification of mechanical tests. Notes on UNI and UNI EN standards.
Lesson 4. Tensile test. Stress-strain curve.
Lesson 5. Modulus of elasticity.
Lesson 6. Hooke's law.
Lesson 7. Yield strength.
Lesson 8. Conventional yield strength.
Lesson 9. Load-unload curves.
Lesson 10. Breaking load.
Lesson 11. Necking.

Lesson 12. Percentage elongation at break.
Lesson 13. Ductility.
Lesson 14. Toughness.
Lesson 15. Ductile and brittle behavior.
Lesson 16. Dislocation sliding mechanism in the lattice.
Lesson 17. Role of dislocations and grain boundaries in metal ductility work-hardening.
Lesson 18. Hardness and hardness tests: qualitative and quantitative. Impact strength.
Lesson 19. Charpy pendulum. Notes on fatigue failure.

Etivity 1 – Processing experimental data relating to tensile tests using Excel starting from a txt file (20 h of study load - week 5)

Subject 4 – METALS and CERAMICS (eight video-recorded theory lessons for a commitment of 25 h to week 6) Modules 40-41
Lesson 1. Ferrous and non-ferrous metal alloys. Heat treatment of the metal alloys. Simple crystalline structures.
Lesson 2. Properties of ceramics. Traditional and advanced ceramics. Glasses. Production and applications of ceramics.

Subject 5 – POLYMERS (eight video-recorded theory lessons and two exercise lessons for a commitment of 30 hours to weeks 7 and 8) Modules 42-44
Lesson 1. Polyaddition and polycondensation. Average and ponderal molecular weight.
Lesson 2. Thermoplastic and thermosetting polymers. Production and Application of Polymers. Elastomers and vulcanization.
Lesson 3. Thermal, mechanical, and viscoelastic properties of the polymeric materials.

Etivity 2 – Processing of experimental data relating to differential scanning calorimetry (DSC) measurements using the open-source program TA Universal An (20 h of study load – weeks 8 and 9).

Subject 5 – Composites (seven video-recorded theory lessons and one exercise lesson for a commitment of 25 hours, weeks 9 and 10) Modules 45-53
Lesson 1. Particulate composites.
Lesson 2. Fiber-reinforced composites.
Lesson 3. Laminates.

Subject 6 – CEMENT AND CONCRETE (nine video-recorded theory lessons and two exercise lessons for a commitment of 40 hours–weeks 10, 11, and 12) Modules 54-59

Lesson 1. Aerial binders (gypsum and lime).
Lesson 2. Hydraulic binder (cement). Portland cement (chemical reactions, composition, hydration, and porosity).
Lesson 3. Aggregates (chemical and physical properties, porosity, and grain size).
Lesson 4. Additives (Plasticizers, Plasticizers, Aerating agents, retarders, etc.).
Lesson 5. Properties of fresh concrete. Workability (slump test, Standards, Segregation, Bleeding, Plastic shrinkage).
Lesson 6. Properties of hardened concrete. Mix design. Concrete processing (mixture production, transportation, placement, compaction, and curing).

Evaluation system and criteria

- The exam consists of a 90-minute written test aimed at assessing the ability to analyze and rework the concepts acquired and a series of activities (Etivity) carried out during the course in virtual classes.
- The score assigned to Etivity, from 0 to 3 points, is considered in the overall evaluation only if a pass mark (18/30) is achieved with the profit exam.
- The profit exam is evaluated from 0 to 30 and can be taken in written form both at the Rome office and at the teaching centers upon reservation by the student. The written test included open-ended questions and exercises in a combined format.
- The expected learning outcomes regarding knowledge of the subject and the ability to apply them are assessed by the written test, while communication skills, the ability to draw conclusions, and the ability to self-learn are assessed through the Etivity.
- During the written test, it is NOT permitted to use handouts, notes, periodic tables, texts or forms in paper or digital format. The use of a calculator is permitted only in the case of nonscientific or programmable calculators.

Bibliography and resources

1. TEACHING MATERIALS PROVIDED BY THE TEACHER

The teaching material on the platform covers the entire program and all the elements necessary to study the subject.

2. RECOMMENDED BIBLIOGRAPHY

- W.F. Smith, W.S. Harwood, G. Herring, "*Scienza e Tecnologia dei Materiali*", McGraw-Hill
- W.D. Callister, D.G. Rethwisch, "Scienza e ingegneria dei materiali. Una introduzione", Edises

- V.A. Rossetti, "*Il calcestruzzo - Materiali e tecnologia*", McGraw-Hill