Giuliana Taglieri

Programme of "Materials Science and Engineering and Applied Chemistry"		
I0625, COMPULSORY **1ST CYCLE IN INDUSTRIAL ENGINEERING, 3RD YEAR , 1ST SEMESTER** TEACHER: **GIULIANA TAGLIERI**		
Number of ECTS credits: 12 (workload is 120 hours)		
Teacher:		
1	**Course objectives and Learning outcomes**	The goal of the course is developed to provide an understanding of the relationship between structure, processing and properties of materials. As concerns the "Applied Chemistry" section, the course is intended to be an introduction to water treatment technologies and to preliminary concepts on inorganic bindings. On successful completion of this module, the student should develop an understanding of how the structure of a material, from the nano- to the macro-scale, governs its behavior and they are introduced to the techniques and methodologies that characterize that structure; the control of that structure through processing is also a key topic; in addition, the role of the engineer in designing with and selection of materials is outlined. The student should also develop a detailed knowledge of urban water, focusing on basic drinking water and wastewater treatment technologies. Unit processes involved in the two treatment chains will be described as well as the physical, chemical and biological processes involved.
2	**Dublin descriptors**	Topics of the two modules include: **Atomic Arrangement and Defects:** The atomic structure and electronic structure; atomic bonding. Short-range order and long-range order; unit cells; allotropic or polymorphic transformations; solid crystals; X-ray diffraction. Point defects. Surface defects (material surface, grain boundaries, twin boundaries). Dislocations. **Atomic movement in materials:** Diffusion mechanism; activation Energy for diffusion; Fick's laws; diffusion and materials processing (grain growth, sintering, diffusion bonding). **Mechanical testing and Properties**: The tensile test, stress-strain curve, properties obtained from the tensile test. The bend test for brittle materials. The hardness tests (Brinell, Rockwell, Vickers, Knoop tests). The impact test; ductile-fragile transition. The importance of fracture mechanics. Fracture toughness. The fatigue test: results and application of fatigue testing. The creep test. **Solid Solution and Phase Equilibrium**. Phases and the unary phase diagram; phase rule. Solubility and solutions: unlimited solubility, limited solubility, conditions for unlimited solubility. Solid solution strengthening. Isomorphous phase diagrams: liquidus and solidus temperatures, composition of each phase, lever law. Solidification of a solid solution alloy; nonequilibrium solidification and segregation. Phase diagrams containing three-phase reactions. The eutectic phase diagram. Eutectic, hypoeutectic and hypereutectic alloys. Strength of eutectic alloys. Nonequilibrium freezing in the eutectic system. **Dispersion strengthening by phase transformation and heat treatments**: Nucleation and growth in solid-state reactions: nucleation, growth and kinetics. Alloy strengthened by exceeding the solubility limit, coherent precipitates. Age hardening or precipitation hardening (solid solution, quench, age). Effect of aging temperature and time. Requirements for age hardening. Fe-Fe3C diagram and the eutectoid reaction: solid solutions, compounds, the eutectoid reaction, perlite, primary constituents. Controlling the eutectoid reaction, time-temperature-transformation (TTT) diagram. Martensitic reaction and tempering: martensite phase in steels, properties of steel martensite, tempering of martensite, martensite in other systems. Continuous cooling transformation (CCT) diagrams **Metals**: - Ferrous alloys: Designations for steels. Simple heat treatments (annealing,

		normalizing, quench and temper heat treatments, isothermal heat treatment); surface treatments. Effect of alloying elements. Special steels. Phase transformations in cast iron; the eutectic and eutectoid reaction in cast irons. - Nonferrous alloys: Aluminum alloys; general properties of aluminum, designation, casting alloys, advanced aluminium alloys. Magnesium alloys; structure and properties. Copper alloys; solid solution strengthened alloys. Nickel and cobalt: nickel and Monel; precipitation hardening. - Processing of metals: Casting processes; cold working; strain hardening; the three stages of annealing; hot working; metals joining; metallurgy of powers. **Ceramic materials.** Structures of materials. Imperfections in crystalline lattice of ceramic materials. The structure of ceramic glasses; silicate glasses; modified silicate glasses. Processing and applications of ceramic glasses. Processing and applications of clay products. Processing and applications of advanced ceramics (pressing and sintering). Refractories **Polymers**. Classification of polymers, representative structures. Polymerization. Temperature glass transition. Deformation and failure of thermoplastic polymers. Elastomers. Thermosettings polymers. Forming of polymers. **Physical properties of Materials**. Electrical behavior (band theory, conductivity in metals and in semiconductors, insulators and dielectric properties). Magnetic properties. Thermal properties of materials (heat capacity and specific heat, thermal expansion, thermal conductivity) **Water**. Chemistry of water. Chemical and physical properties of water. Distribution in nature: water cycle, fresh water storage, sea water, surface water and groundwater. **Water pollution**. Main inorganic and organic contaminants of natural water. Physical testing of water. Chemical testing of water. **Urban water treatment.** Pre-treatments. Coagulation and flocculation. Sedimentation (Sludge storage and removal, Floc blanket clarifiers). Dissolved air flotation. Filtration. Disinfection. **Inorganic bindings.** Lime, gypsum. Ordinary Portland Cement On successful completion of this module, the student should - have a **preliminary understanding** of the chemical, electrical and mechanical properties of materials, and relate that to their microstructure, in a wide range of different systems, including metals and alloys, polymers, engineering ceramics, and semiconductors; knowledge and understanding of the basis of processing, production and selection of materials - have a broad but detailed **appreciation** of **materials** and their **properties** , - have a preliminary **understanding** of the chemical, electrical and mechanical properties of materials, and relate that to their microstructure, in a wide range of different systems, including metals and alloys, polymers, engineering ceramics, and semiconductors - have a **knowledge and understanding** of the basis of processing, production and selection of materials - have a **knowledge** and a preliminary level for the design of wastewater treatment technologies.
3	**Prerequisites and learning activities**	The student must know the basic notions of Mathematics, Chemistry and Fundamentals of Physics.
4	**Teaching methods and language**	Lectures and exercises. Language: Italian / English **Ref. Text books** D.R.Askeland, ***The Science & Engineering of Materials***, Ed. PWS-Kent Publishing Company, Boston S.D. Faust, O.M. Aly, **Chemistry of Water Treatment**, CRC Press Italian translation: Callister, ***Scienza e Ingegneria dei Materiali***, Edises Masotti, ***Depurazione delle acque***, Hoepli
5	**Assessment methods and criteria**	Written and oral exam.