UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2017/2018
MASTER'S DEGREE (MSC)	MATERIALS SCIENCE AND ENGINEERING
SUBJECT	DEGRADATION AND PROTECTION OF METALLIC MATERIALS
TYPE OF EDUCATIONAL ACTIVITY	C
AMBIT	20973-Attività formative affini o integrative
CODE	17370
SCIENTIFIC SECTOR(S)	ING-IND/23
HEAD PROFESSOR(S)	SANTAMARIA MONICA Professore Ordinario Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	1
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**SANTAMARIA MONICA** Monday 13:00 14:00 Studio personale Edificio 6 secondo piano previa conferma per e-mail Wednesday 12:30 14:00 Studio personale Edificio 6 secondo piano previa conferma per e-mail Friday 12:30 14:00 Studio personale Edificio 6 secondo piano previa conferma per e-mail

DOCENTE: Prof.ssa MONICA SANTAMARIA

PREREQUISITES	General Chemistry, basic electricity with an emphasis on Ohm's Law.
LEARNING OUTCOMES	Knowledge and understanding At the end of the course student is expected to have a deep understanding of the mechanism of corrosion processes and on their nature as a function of the environmental physico-chemical conditions. Student will be aware on the synergistic effect of stress and corrosion in materials degradation and failure. He/ she is expected to know the corrosion protection methods and strategies and to isolate the critical issues responsible of material degradation. Student will learn about corrosion protection and prevention in chemical, pharmaceutical and aerospace industry, and in the field of building engineering. Applying knowledge and understanding Student is expected to know corrosion mechanism and morphology of the metallic material indifferent environments. Thanks to this fundamental knowledge he/she will be able to understand causes of the corrosion processes with a special focus on the phenomena involving metals and alloys usually employed in the chemical, pharmaceutical and aerospace industry, and in the field of building engineering, being able to select the most appropriate material according to the environmental conditions. Making judgments Starting from knowledge of the theoretical aspects of the corrosion processes as well as from the laboratory experiences the student is expected to be able to match the right material with the environment where the latter is supposed to work, and he/she will regulate the material life cycle, in order to ensure safe and correct functioning during operating conditions. Communication Student is expected to be able to work autonomously and collaborate with other team members involved in the same project (design and/or maintenance). Learning skills Following a deep understanding of the theoretical aspects and after laboratory experience, student is expected to be able to seek advice from technical regulations, technical manuals, scientific literature updating frequently his/her knowledge.
ASSESSMENT METHODS	The assessment will be performed through an oral exam with questions focused on three main subjects: thermodynamic aspects of corrosion processes, kinetic aspects of corrosion processes and possible problems/warning using metals and/or alloys typical of chemical and pharmaceutical industry, aerospace industry and building engineering as a function of the hosting environment conditions. The student must support the answers qualitatively and quantitatively taking advantage of the technical tools provided by the evaluation committee (Pourbaix Diagram, national and international prescriptions, etc.). The student will also discuss a case study (selected among three options) of practical relevance in the field of building engineering. The interview is aimed at determining the student abilities to process the knowledge gained by using them to solve problems and the ability to express the teaching content using a technically correct language. Special attention will be paid to the correct use of physical dimensions (current, current density, corrosion rate, etc.). The vote is expressed in thirtieths with possible praise. A maximum of 24/30 will be attributed according to the student reply on the proposed questions, while the remaining 6/30 will be attributed according to the discussion on the case study. In order to get the minimum score for a positive evaluation (18/30), the student must know the general aspects of the course content, and must identify the main factors affecting the behaviour of metals and/or alloys as a function of the environmental conditions. His/her command of technical language must be sufficient to clearly discuss with the evaluation committee about corrosion issues in chemical and pharmaceutical industry, aerospace industry and building engineering. Higher score will be attributed according to their ability in applying knowledge and skills learned in this course to practical and technical problems, according to what extent students are aware of the steps they go through in solving problems and how well can they explain their problem-solving steps.
EDUCATIONAL OBJECTIVES	The aim of the course is to provide basic concepts of corrosion processes and the tools for a correct selection of the materials, of the protection and prevention methods to control and limit the damages and failure in chemical, pharmaceutical and aerospace industry, and in the field of building engineering.
TEACHING METHODS	Frontal lectures, Laboratory and Demonstration Sessions, Laboratory Practice Sessions
SUGGESTED BIBLIOGRAPHY	Pietro Pedeferri, Corrosione e protezione dei materiali metallici. Vol. I e Vol. II, polipress, 2007, Milano Italia. L. Lazzari, P. Pedeferri, Protezione catodica, McGraw-Hill, 2000, Milano, Italia. Lectures notes and powerpoint presentations.

SYLLABUS

Hrs	Frontal teaching
2	Brief overview on fundamentals of inorganic chemistry and electrochemistry
3	Introduction. General aspects of corrosion processes. Mechanical and physico-chemical properties of materials. Direct and indirect corrosion damages.
6	Wet and dry corrosion. Electrochemical mechanism of corrosion. Corrosion reactions: anodic and cathodic half cell reactions. Faraday's law. Thermodynamics of corrosion. Standard potential, Nernst Equation and Pourbaix diagrams.
6	Kinetic of corrosion. Cathodic and anodic overvoltage.Charge transfer and mass transfer control. Passivation conditions. Evans diagrams. Influence of metal on corrosion processes.
4	Corrosion attack morphology: generalized corrosion, galvanic coupling, pitting corrosion, crevice corrosion, interference corrosion, selective dissolution, intergranular corrosion, turbulence corrosion, erosion corrosion, impingement corrosion, stress corrosion cracking, fatigue corrosion, hydrogen embrittlement, microbial corrosion. CO2 and H2S induced corrosion.
3	Degradation of reinforced concrete structures, Corrosion induced by carbonatation and/or chloride ions., corrosion of pre-stressed concrete. Corrosion phenomena involving metals used for construction directly exposed to natural environment (atmosphere, soil, water). Durability of reinforced concrete and of pre-stressed reinforced concrete structures. Protections methods (coating, surface treatments, cathodic protection and prevention).
3	Steel construction. Atmospheric corrosion of carbon steel structure. Protection criteria. Patinable steel. Under ground constructions, offshore constructions. Stainless steel. Stainless steel sensitization. Intergranular corrosion. Non ferrous metallic material for building engineering.
3	Al alloys and Mg alloys. Effects of corrosion on the integrity of light alloys structures for automotive or aerospace applications. Surface treatment: conversion coatings and anodic films.
2	Dry corrosion. Kinetic aspects. Protective and non protective oxides. Wagner theory. Scale morphology. Dry corrosion of alloys. Dry corrosion environments. High temperature materials.
2	Corrosion in oil industry (up stream and down stream), Corrosion in pharmaceutical industry. Monitoring, inspection and maintenance.
2	Monitoring, evaluation and prevention of corrosion processes: non destructive techniques for corrosion evaluation. Modelling of corrosion processes, Chemical and microstructural analyses for corrosion monitoring and control.
2	Corrosion tests: corrosion rate estimate in laboratory and in real systems (Salt Spray Test, Adhesion test coatings etc).
2	Design and selection of material: data base consulting, smart systems and regulations. Economic evaluation and reliability assessment (Life Cycle Cost, Decision analysis)
1	Corrosion of metallic biomaterials.

Hrs	Practice
2	Pourbaix diagrams from thermodynamics data and their use in corrosion studies.
3	Experimental determination of corrosion potential and corrosion rate. Polarization curve recording in different environments. Corrosion potential measurements and polarization resistance estimate with dc and ac methods. Test on the corrosion resistance of passive films on steel and on non ferrous metallic materials for building engineering.
2	Corrosion protection and prevention: noble materials, passive films, coating, anodic films. Anodizing of Al alloys for building engineering.
2	Inspection techniques on structure and non destructive techniques. Analysis of corrosion damaged materials. Monitoring of on going corrosion processes.
2	Cathodic protection: potential and current density for cathodic protection. Selection of sacrificial anodes.
2	Corrosion products identification by X-ray diffraction and Raman Spectroscopy. Analysis of the attack morphology by scanning electron microscopy.