NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF MECHANICAL ENGINEERING
MECHANICAL ENGINEERING PROGRAM

MC114 – SCIENCE OF MATERIALS I

I. GENERAL INFORMATION

CODE	: MC114 Science of Materials I
SEMESTER	: 2
ACADEMIC CREDITS	: 1
HOURS PER WEEK	: 5 (Theory - Laboratories)
REQUIREMENT	: MB844
CONDITION	: Mandatory

II. COURSE DESCRIPTION

The course of Science of Materials I includes the study of: Types of materials used in engineering. Properties and characteristics of materials. Mechanical tests. Structure of solids. Structural fails. Solidification since the liquid state. Metallographic study of the alloys. Production and manufacture of ferrous alloys. Isothermal transformation of austenite. Heat treatment of ferrous alloys. Steel hardenability. Thermochemical treatments. Special thermal treatments. Laboratory´s tests to determine properties and characteristics of materials.

III. COURSE OUTCOMES

The student:

1. Knows and classifies materials applied in engineering and knows its general properties.
2. Performs the tests, take the data, calculate and analyze test data, to determine the mechanical properties of the materials.
3. Explains how could influence the crystal structure and crystalline defects of metallic materials in their mechanical properties.
4. Understands how binary metal alloys are formed, and determine which are the mass percentages of the elements that compose them.
5. Knows and identifies steel products, knows how they are classified the steels and how they can change the properties of these with the thermal treatments.
6. Is able to identify, characterize and apply a ferrous alloy.

IV. LEARNING UNITS

1. MATERIAL'S PROPERTIES / 4 HOURS

Introduction / Types of materials / Properties: Mechanics: cohesion, hardness, elasticity, plasticity, ductility, malleability / thermal, magnetic, electrical, chemical and optical properties.

2. MATERIAL TESTS / 6 HOURS

Destructive and non-destructive tests. Definition of microhardness Test Vickers, Knoop / TRACTION TEST: General, Diagrams Strength (Kgf) vs. Elongation (Δl, mm), Stress diagram (σ) vs. unitary deformation (ξ). Parameters that study the traction test curve / Study of the engineering curve and the real curve / Determination of the creep limit, linear deformation, Poison's coefficient, tenacity / Application problems.

3. INTERATOMIC AND INTERMOLECULAR FORCES / 2 HOURS

Atoms and Molecules - Molar fraction / Interatomic forces, atomic bonds: Primary bonds types: Ionic, Covalent, Metallic / Secondary bonds: Vander Waals.

4. SOLID STATE AND CRISTALINE STRUCTURE / 6 HOURS

Types of molecular structures of solids: Crystalline and amorphous / Crystalline structure / Types of crystalline systems. Space network / Crystalline cells: BCC, FCC and HCP. Application problems / Atomic positions, direction index and Miller's index of crystallographic plans, Allotropy / Atomic Density: Volumetric, planar and linear / X Ray Diffraction. Law of Bragg / Problems of application.

5. STRUCTUARL FAILS / 6 HOURS

Introduction. Classification of fails. Punctiform fails. Linear fails. Grain border or planar fails / Monocrystalline and polycrystalline material / Plastic deformation. Mechanisms of plastic deformation:

Sliding and crystal twinning / sliding systems. Application problems / Nuclear and grain growth / Atomic diffusion: Molecular atomic movement in solids / Diffusion mechanisms.

Diffusion in permanent state, first law of Fick. Diffusion in a non-permanent state, Fick's second law. Application problems.

6. METALLOGRAFIC STUDY OF ALLOYS / 6 HOURS

Preliminary definitions / Alloys constitution. Classification of alloys. Formation of solid solutions and classification / Factors that control the range of solubility in alloy systems. Gibbs's rule / Thermal diagrams (TT) / Phase transformation or phase equilibrium and equilibrium phase stability.

7. EQUILIBRIUM DIAGRAMS / 4 HOURS

Construction of equilibrium diagrams / Rules to determinate phase composition and to determinate the relative quantities of each phase, "Lever Rule" / Study of Alloy diagrams: binary isomorphic, binary with eutectic and partial solubility, Binary with eutectoid, binary with peritectic, binary with peritectoid, binary with monotectic / Notions of diagrams of ternary alloys / Problems of application.

8. OBTAINING AND MANUFACTURING FERROUS ALLOYS / 6 HOURS

Generalities / Raw materials and iron products / Blast furnace characteristics, Blast furnace characteristics, obtaining of pig iron / Obtaining of steel: Oxygen converters (LD), conventional converters (air) / Electric arc and induction furnaces / Direct reduction method HYL) / Steel transformation, ingot steel / Cooling curve of technically pure iron, alotropic states and other characteristics /

Graph of Balance Iron - Carbon or Fe vs. C Fe_3. Invariant reactions that are occur in the diagram. Constituents of ferrous alloys / Classification of steels: Depending on the carbon content. Depending on the eutectoid point. As a function of the alloys / AISI - SAE Nomenclature of steels / Application problems.

9. TRANSFORMATION OF THE AUSTENITE BY VARIATING THE COOLING SPEED / 4 HOURS

Generalities. Isothermal transformation curves (TTT) / Control of reaction's properties / Transformation by diffusion / Application problems.

10. HEAT TREATMENT OF FERROUS ALLOYS / 6 HOURS

Normalizing, annealing and types of annealing / quenching, influencing factors and quenching processes, determining the time required for the entire cross-section of the part to reach the quench temperature / Factors affecting the final quenching result / Quenching types / Tempering, factors influencing the tempering, tempering stages, double tempering.

11. QUENCHING / 2 HOURS

Factors influencing in the quenching process / Tests to determine the hardenability in quenching process / Ideal and real critical diameters, practical determination of critical diameters / Application problems.

12. HEAT-CHEMICAL TREATMENTS / 2 HOURS

Generalities / Heat-chemical treatments classes: Cementation and factors regulating the process, applications / Nitriding and influence of alloying elements, advantages and factors which limiting application / Low temperature and high temperature cyanidation / Carbonitriding / Sulfinization / Silicide / Boring.

13. SPECIAL HEAT TREATMENT / 2 HOURS

Precipitation hardening in special steels / Aging of martensite / Heat-mechanical treatments. Ausforming. Applications.

V. TESTING LABORATORIES.

Laboratory 1: Hardness test.
Laboratory 2: Traction test.
Laboratory 3: Non-destructive testing.
Laboratory 4: Metallography test.
Laboratory 5: Test of heat treatment of steel.

VI. METHODOLOGY

The course will be develop in theory sessions and laboratory practices. In the theory sessions, the teacher, with the help of multimedia, videos, separateness, series of problems proposed and solved, develops the concepts of the content of the syllabus, on: structure, properties, characteristics and applications of materials, as well as in class of calculation of problems of application of each one of the subjects treated. In the laboratory sessions makes tests to check the concepts and properties of the materials developed in the theory sessions in where the students conduct the tests guided by the laboratory teacher. They could observe, take the experimental data, perform the necessary calculations, analyze the results and indicating the comparative conclusions and they could elaborate and sustain a report per test performed.

VII. EVALUATION SYSTEM

The course has the “F” evaluation system.
How to calculate Final average: FA = (1 PE+2FE+1AL)/4
PE: Partial Exam, FE: Final Exam, AL: Average in 5 laboratories’ grades

VIII. BIBLIOGRAPHY

Based text.

1. “FUNDAMENTOS DE LA CIENCIA E INGENIERIA DE LOS MATERIALES”
   William F. Smith – Ed. MC. Graw Hill 2008.
2. “LA CIENCIA DE INGENIERIA DE LOS MATERIALES”
   Ronald Askeland – Ed. International Thomson 2011.

Main references

- “Material science for Engineers”
  James F. Shackelford – Ed. Prentice Hall 1995
- “Metallography”
  A. P. Guliaev – Ed. MIR Moscow1978
- “Industrial materials”
  Jose M. Lasheras Esteban 1981
- “Material science”
  Pedro Coca Revollero – Piramides S. A. Madrid
- “Structures I and II”
  William G. Moffat y Gregore W. Pearsal – Ed. Limusa Wilev S.A.
- “Introduction in material science”