Universidad Carlos III de Madrid
Escuela Politécnica Superior
Dpto. de Ciencia e Ingeniería de los Materiales e Ingeniería Química.
Avd. Universidad,30, 28911-Leganés
Madrid – Spain

Materials Science and Engineering

Department of Materials Science and Chemical Engineering

Lecturer: Sophia Tsipas

Area: Materials Science and Engineering and Metallurgy

Bachelor of Mechanical Engineering, Bachelor in Electrical Engineering, Bachelor in Electronic Engineering and Automation

OBLIGATORY / YEAR: 2nd / CREDITS: 6 / SEMESTER: 1st

3h class per week
4 laboratory sessions (1,5 h each)
Recommended personal studying time: 73 h

PRERREQUISITES AND RECOMMENDED PREVIOUS KNOWLEDGE

No previous knowledge is required, although some previous knowledge of general chemistry is recommended. Moreover, as a 2nd year course, students will have completed basic subjects such as Chemistry of Materials which provide the basic skills necessary for a better understanding of the subject.

General Description of the Subject

In this subject, it is intended that students learn the basics of materials science, the classification of the various families of materials, their properties and applications, and the technology available for the improvement of their properties

Course Aims and Objectives:

To understand the structure, composition, processing, properties and performance of different families of materials and relationship among them.
To be able to select materials for applications in different engineering fields.
To know the more adequate standardized tests to evaluate properties and performance of materials, and to analyze the results.

Regarding general capabilities or skills, during the year, students will acquire the following abilities:
- Ability to solve complex problems.

- Ability to look for, to understand and to differentiate the relevant information to be able to take a decision.
- Ability to use multi-disciplinary knowledge to solve a problem.
- Ability to work in groups and distribute work to face up to complex problems.

Individuals who successfully complete this course will be able :
- A collaborative attitude that will enable them to get from other people information, skills and knowledge necessary to manufacture components for specific applications.

Teaching Material

- The course will consist of Master Classes where the theory of the topics will be presented and Tutorial Classes where applications and examples will be emphasized and problems exercises will be solved.
- The course is planned in nine blocks/teaching units.
- The teaching materials include presentations, reading the chapters of the recommended books and self-assessment exercises.
- There will be 4 laboratory sessions (1,5 h each) which will result in the acquisition of practical abilities related to the content of the course.

ASSESSMENT ACTIVITIES OR PRACTICAL ASSIGNMENTS

Continuous evaluation will consist of three parts:

(i) exercises to be solved in groups or individually, during classes, or other activities (at least 3 activities) that will count 15% of the total mark

(ii) three individual tests, during classes, that will count 15% of the total mark

(iii) laboratory practices, that will be assessed with a questionnaire that will be handed in at the end of each laboratory session, and that will count 10% of the total mark.

Percentage of continuous evaluation assessment (exercises, tests, laboratory): 40

The **final examination** is will count for 60% of the total mark of the lecture course. Help sessions and tutorial classes will be held prior to the final exam.

Percentage of end-of-term-examination: 60

In order to pass, **the final mark must be at least 5**.

The final mark is obtained in the following way:

Percentage of final mark	Activity	Description
LABORATORY SESSIONS (10%)		
10%	Laboratory Reports	Assessment of the methodology and realization of the laboratory session as well as the written report
CONTINIOUS EVALUATION (30%)		
15%	Exercises and problems handed in during the course.	3 exercises and problems will be performed in groups during class and will be marked
15%	3 assessment test (5% each)	3 tests (one for each module) will take place and be assesed
FINAL EXAM (60%)		
60%	Final Exam	final exam for the lecture course. It will contain problems and question (approximately 50% of each) from the whole lecture course
In order to pass the lecture course the total mark must be at least 5		

IMPORTANT: MINIMUM MARKS

- The assessment tests, the exercises and problems handed in do not have a minimum mark in order to pass the lecture course.
- Attendance to the laboratory sessions is mandatory.
- Attendance to assessment tests or submission of the exercises is not compulsory. However, failure to attend the test or submit the exercises will result in a mark of 0 in the corresponding exercise or test.
- The attendance to practical laboratory sessions is mandatory Failure to hand in the laboratory reports and unjustified lack of attendance will result in no marking for the laboratory session.

Syllabus

TOPIC 1: INTRODUCTION. FAMILIES OF MATERIALS, APPLICATIONS AND SELECTION CRITERIA. BONDING IN SOLIDS.

1.1- Concepts of Materials Science and Engineering. Families of Materials. Properties, applications and selection of materials.

1.2- Bonding in solids. Relation between bonding, structure and properties of materials.

TOPIC 2. STRUCTURE OF MATERIALS

2.1- Crystalline Structures (metallic and ceramic). Structures of polymers. Amorphous materials. Concept of glass transition.

2.2- Atomic positions, crystallographic directions and planes. Linear, planar and volumetric densities in crystals.

2.3- Defects in crystals. Concept of solid solution.
2.4- Diffusion in solids.

TOPIC 3 PHASE DIAGRAMS

3.1- Basic concepts. Phase diagram of a single component. Systems of two components with partial solubility. Precipitation in solid state. Invariant Reactions. Intermetallic compounds. Congruent and incongruent melting.
3.2- Application of the lever rule. Calculations in phase diagrams. Formation of the microstructure.
3.3- System Fe-C. Phase diagrams of ceramics.
3.4- Calculations in phase diagrams with invariant reactions in solid state Microstructures in eutectoid reactions.

TOPIC 4 MECHANICAL PROPERTIES

4.1- Definition of mechanical properties. Concepts. Elastic deformation and plastic deformation. Slip systems. Hardening mechanisms.
4.2- Application to ceramics. Application to polymers. Hardness

TOPIC 5 METALLIC MATERIALS

5.1- Solidification. Classification of metal alloys. Steels: Equilibrium phase transformation.
5.2- Steels: Non-equilibrium phase transformations. TTT Diagrams and heat treatments
5.3- Types of steels: stainless, tool. Light alloys. Copper alloys.

TOPIC 6 CERAMIC MATERIALS

6.1- Structure and bonding in ceramic materials. Silicates structure. Glasses.
6.2- Properties of ceramic materials. Processing of ceramic materials. Applications.

TOPIC 7 POLYMERIC MATERIALS

7.1- General concepts. Classification. Properties.
7.2- Types of polymers. Processing.

TOPIC 8 COMPOSITE MATERIALS

8.1- Classification of composite materials. Polymer matrix composite materials.
8.2- Processing of composite materials. Problems related to polymeric and composite materials.

TOPIC 9 FUNCTIONAL PROPERTIES

9.1- Metallic conductors. Non-metallic conductors. Semiconductors.
9.2- Insulating materials and dielectrics. Magnetic materials.

Recommended Reading

ASHBY MF, “Engineering materials: an introduction to their properties and applications” Pergamon Press. 1981.

ASKELAND DR. “Essentials of materials science and engineering ", *2nd ed* Ed. Cengage Learning, 2010 .

CALLISTER WD. “Materials science and engineering: an introduction ". *2nd ed* John Wiley & Sons, 2003.

MANGONON PL. “The principles of materials selection for engineering design”. Ed. Prentice Hall, 1999

SHACKELFORD JF. "Introducción a la Ciencia de Materiales para ingenieros", 4th ed. Pearson Prentice-Hall, 2005

SMITH WF. "Principles of materials science and engineering ", *2nd ed* Ed. McGraw-Hill, 1990.

Van Vlack L.H. “Elements of Materials Science and Engineering”. Ed Addison Wesley Co. 1989.

Study Tips and other issues

Students are highly encouraged to read and to work on the contents of each topic prior to attendance to master classes and tutorial sessions. Moreover, it is very important that students make a great effort to understand the contents and each of the topics that will be treated here.

Understanding chemistry as well as knowledge of chemical operations and processes requires **active studying**. Attendance to lectures and tutorial sessions will help you in this task. Reading the suggested complementary material before each lecture and writing down the main points. After each lecture, complete and supplement your notes with the material learned by reading the textbook. When you think you understand the material, do the suggested problems. If you cannot complete the problems without referencing your notes or the textbook, put them down and study the concepts again.

Remember that in case of any questions or doubts related with this subject you can always ask for assistance to the teachers. They will be pleased to help you during their tuition hours.