LEBANESE UNIVERSITY
FACULTY OF ENGINEERING
Department of Mechanical Engineering

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| **Course code and name:** | MECA306 Science des Matériaux | | | **Section:** | 1 |
| **Credits:** | - | | | | |
| **Semester:** | Semester 5 / Fall 2021 | | | | |
| **Coordinator:** | Dr. Hassan Shraim | **Email:** | hassan.shraim@ul.edu.lb | | |
| **Instructor:** | Ali Harkous | **Email:** | ali.harkous.1@ul.edu.lb | | |
| **Office Hours:** | - | **Room:** | - | **Phone:** | - |

**Textbook**

- [T1] Materials Science and Engineering: An Introduction, 9th edition, William D. Callister and David G. Rethwisch, Wiley, 2014.
- [T2] Fundamentals of Modern Manufacturing, 6th edition, M. P. Groover, John Wiley & Sons, 2016.

**Additional Material**

- External resources.

**References**

- [R1] Materials Science and Engineering: A First Course, 5th edition, V. Raghavan, PHI Learning Private Limited, 2011.
- [R2] Essentials of Modern Materials Science and Engineering, J. Newell, Wiley, 2009.

**Course Description**

The course introduces the fundamental concepts in science of materials as applied to engineering: atomic structure, crystalline structures, imperfections, mechanical behavior and failure.

In the first chapter, this course presents a state of art describing briefly the different types of classical (metal, ceramic, glass, polymer and composite) and modern materials (electronic materials, optical materials, smart materials …).
Having several types of classical materials with different structures and behaviors, the second and third chapters focus on the crystal structure of metallic materials as a basic example.

Then, an important part is dedicated to explain the different types of imperfections (for all classical materials), the Stress–Strain diagram (mechanical behavior, types of deformation…), the mechanism of failure and the thermal treatment processes. Finally, the different types of materials (Metals, Ceramics, Polymers and Composites) are elaborated with presentation of their structure, classification and applications.

Therefore, engineering materials course allows the students to have the basic skills to distinguish materials, understand their behaviors, choose the corresponding material for each application, evaluate the quality of a material and realize new designs.

**Project**

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| Course Assessment | | | | | |
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| **Number** | **Assessment type and description** | **Session #** | **Duration** | **Weight** | **Link to CLO** |
| 1 | Attendance | - | - | - | - |
| 2 | Midterm Exam | - | - | - | LO 1-4 |
| 3 | Final Exam | - | - | - | LO 5-8 |
| 4 | Assignments | - | - | - | - |

| **Course Learning Outcomes (CLO)**<br>**Students who successfully completes this course will able to:** | |
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| LO 1: | Select appropriate materials for various engineering applications. |
| LO 2: | Predict basic physical properties of materials based on the knowledge of their atomic structure. |
| LO 3: | Recognize the crystal structure systems of metals. |
| LO 4: | Discuss the mechanisms of defect, dislocation and imperfection. |
| LO 5: | Analyze the mechanical behavior of materials and Identify the different types of deformation. |
| LO 6: | Distinguish the different types of failure and describe their principles and related tests. |
| LO 7: | Recognize the different types of materials (Metals, Ceramics, Polymers and Composites), their properties and applications. |
| LO 8: | Discuss the different methods of thermal treatment. |

**Detailed List of Covered Topics**

| Session Number | Topic | Book Chapter | Comment |
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| **Lecture 1** | **Syllabus overview**<br>–Grade distribution<br>–Course outline and Goals<br>–Topics<br><br>**Chap 1: Introduction to Materials Science and Engineering**<br>–Historical Perspective<br>–Materials Science and Engineering<br>–Why to study Materials Science and Engineering?<br>–Classification of Materials<br>–Advanced Materials<br>–Modern Materials' Needs | [T1] Chap 1 | |
| **Lecture 2** | **Chap 2: Atomic Structure & Bonding**<br>–Atomic Structure | [T1] Chap 2 | |
| **Lecture 3** | **Chap 2: Atomic Structure & Bonding**<br>–The Ionic Bond | [T1] Chap 2 | |

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| | –The Covalent Bond<br>–The Metallic Bond | | |
| **Lecture 4** | **Chap 2: Atomic Structure & Bonding**<br>–The Secondary, or Van der Waals, Bond<br>–Materials: The Bonding Classification<br>–Exercises | [T1] Chap 2 | |
| **Lecture 5** | **Chap 3: Crystalline Structure— Perfection**<br>–Crystal Structures Fundamentals<br>–Metallic Structures<br>–Crystal Systems, Positions, Directions, and Planes | [T1] Chap 3<br>3.1 – 3.15 | |
| **Lecture 6** | **Chap 3: Crystalline Structure— Perfection**<br>–Linear and planar densities<br>–Close-packed crystal structures<br>–Crystalline and Non-crystalline Materials<br>–Exercises | [T1] Chap 3<br>3.1 – 3.15 | |
| **Lecture 7** | **Chap 3: Crystalline Structure— Perfection**<br>–Exercises | [T1] Chap 3<br>3.1 – 3.15 | |
| **Lecture 8** | **Chap 3: Crystalline Structure— Perfection**<br>–Exercises | [T1] Chap 3<br>3.1 – 3.15 | |
| **Lecture 9** | **Chap 4: Imperfections in Solids**<br>–Introduction<br>–Point Defects<br>▪ Vacancies and Self-interstitials<br>▪ Impurities in Solids<br>–Specification of Composition | [T1] Chap 4 | |
| **Lecture 10** | **Chap 4: Imperfections in Solids**<br>–Linear Defects or Dislocations<br>–Planar Defects<br>–3D Imperfections: Bulk or Volume Defects<br>–Examples | [T1] Chap 4 | |
| **Lecture 11** | **Chap 4: Imperfections in Solids**<br>–Exercises | [T1] Chap 4 | |
| **Lecture 12** | **Chap 5: Mechanical Behavior**<br>–Introduction<br>–Concepts of stress and strain<br>–Elastic deformation<br>▪ Stress–Strain behavior<br>▪ Anelasticity<br>–Elastic properties of materials | [T1] Chap 6 | |
| **Lecture 13** | **Chap 5: Mechanical Behavior** | [T1] Chap 6 | |

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| | –Plastic deformation<br>▪ Tensile properties<br>▪ True stress and Strain<br>▪ Elastic recovery after plastic deformation<br>▪ Compressive, shear, and torsional deformations<br>▪ Hardness | | |
| **Lecture 14** | **Chap 5: Mechanical Behavior**<br>–Property variability and design/safety factors<br>–Exercises | [T1] Chap 6 | |
| **Lecture 15** | **Chap 5: Mechanical Behavior**<br>–Exercises | [T1] Chap 6 | |
| **Lecture 16** | **Chap 6: Failure**<br>–Fracture<br>▪ Fundamentals of Fracture<br>▪ Ductile fracture<br>▪ Brittle fracture<br>▪ Principles of fracture mechanics<br>▪ Fracture toughness testing | [T1] Chap 8 | |
| **Lecture 17** | **Chap 6: Failure**<br>–Fatigue<br>▪ Cyclic stresses<br>▪ The S–N curve<br>▪ Crack initiation and propagation<br>▪ Factors that affect fatigue life<br>▪ Environmental effects | [T1] Chap 8 | |
| **Lecture 18** | **Chap 6: Failure**<br>–Creep<br>▪ Generalized creep behavior<br>▪ Stress and temperature effects<br>▪ Data extrapolation methods<br>▪ Alloys for high-temperature use | [T1] Chap 8 | |
| **Lecture 19** | **Chap 6: Failure**<br>–Exercises | [T1] Chap 8 | |
| **Lecture 20** | **Chap 6: Failure**<br>–Exercises | [T1] Chap 8 | |
| **Lecture 21** | **Chap 7: Metals and Phase diagrams**<br>–Alloys and Phase Diagrams<br>–Triple point<br>–Ferrous Metals | [T1] Chap 9<br>[T2] Chap 6 | |
| **Lecture 22** | **Chap 7: Metals and Phase diagrams**<br>–Nonferrous Metals | [T1] Chap 9 | |

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| | –Superalloys | | |
| **Lecture 23** | **Chap 8: Thermal Processing of Metals**<br>–Annealing processes<br>▪ Process Annealing<br>▪ Stress Relief<br>▪ Annealing of Ferrous Alloys<br>–Heat treatment of steels<br>▪ Hardenability<br>▪ Influence of Quenching Medium, Specimen Size, and Geometry | [T1] Chap 11<br>11.7 – 11.9 | |
| **Lecture 24** | **Chap 8: Thermal Processing of Metals**<br>–Precipitation hardening<br>▪ Heat Treatments<br>▪ Mechanism of Hardening | [T1] Chap 11<br>11.7 – 11.9 | |
| **Lecture 25** | **Chap 9: Ceramics**<br>–Structure and Properties of Ceramics<br>–Traditional Ceramics<br>–New Ceramics<br>–Glass | [T2] Chap 7 | |
| **Lecture 26** | **Chap 10: Polymers**<br>–Fundamentals of Polymer Science and Technology<br>–Thermoplastic Polymers<br>–Thermosetting Polymers | [T2] Chap 8 | |
| **Lecture 27** | **Chap 10: Polymers**<br>–Elastomers<br>–Polymer Recycling and Biodegradability | [T2] Chap 8 | |
| **Lecture 28** | **Chap 11: Composites**<br>–Technology and Classification of Composite Materials<br>–Metal Matrix Composites<br>–Ceramic Matrix Composites<br>–Polymer Matrix Composites | [T2] Chap 9 | |

➢ Edited by Dr. Ali HARKOUS, on October 07, 2021.