**BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI**

**HYDERABAD CAMPUS**

**SECOND SEMESTER 2023-24**

**Course Handout (Part II)**

Date: 09/01/2024

In addition to part ‑I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course.

*Course No.* : CHE F243

*Course Title* : Materials Science and Engineering

*Instructor‑in‑charge***:** Karthik Chethan V.

# Tutorial Instructors : Karthik Chethan V.

**1.** **Scope and Objective of the Course:**

Materials Science and Engineering is very simply a sequel to Engineering Chemistry, a highly interdisciplinary course that permeates into all branches of materials chemistry, materials physics, materials properties, materials characterization, materials processing and product development. It includes every product that we encounter in our lives, all the way from ourselves (skin, tooth, hair, bone etc.) to defence and aerospace components.

The main advantage about a course such as this is that every student will find something that will suit one’s aptitude and sensibilities (analytics, logical reasoning, hypothesizing, identifying issues and compiling, experimenting, illustrating, modeling and simulating, product development, machine learning, artificial intelligence etc.). The disadvantage would be the breadth and rigor that is required to undertake this learning adventure.

The key is not to be overwhelmed but to maintain continuity and learn in an integrated manner by identifying the points of intersection between topics and the huge number of similarities between concepts and the rules governing the same. This is possible with a commitment to relevant and creative analogies and project based learning. In short, the approach is to reorient a subject such as materials science and engineering into a real-world based problem-solving and product development course.

The objective of the course is to introduce the flavor of materials science and engineering to undergraduate students. It gives a basic understanding of the structure (crystalline and amorphous) and properties (thermal, mechanical and electrical) of different types of materials such as metals, ceramics, polymers and biomaterials. The course also deals how materials processing (thermo-mechanical) affects the type of bonding, crystal structure, formation of microstructure (defects, diffusion, phase diagrams and phase transformation) and molecular dynamics and thus influence the properties of these materials.

For the students, the course should provide a strong holistic base in regards to learning, skill and personal development and should facilitate in making learning easy and meaningful for life.

**Course Outcomes (CO):**

CO1. To learn and gain some insights in real world chemistry and its association in engineering products (familiarity with reactions, processes, problem solving, product development and characterization of materials that are commonly encountered in adhesive, composite, aerospace, defence, soap, food, chemical and biotechnology industries).

CO2. To conduct hypothesis based discussions to solve chemistry and engineering based issues in a confident and feasible manner by combining conceptual, numerical and design based solutions learnt during the course of the semester. The issues can be research, product development, process, quality control and application related.

CO3. To inculcate the skill of coupling micro and macro aspects of chemistry and engineering, and to apply interdisciplinary skills of science and engineering in problem-solving. The course will attempt to cover various case studies in engineering chemistry.

**Student Learning Outcomes (SLO):** SLOs are outcomes (a) through (l) plus any additional outcomes that may be articulated during the course.

(a) an ability to learnt to alleviate and manage fear (fear of failure, embarrassment, grades etc.) which rears its ugly head in learning and learn to connect and collaborate with peers and faculty in and out of classrooms. To develop into thinking (how and why) and collaborative individuals.

(b) an ability to apply knowledge of science and engineering.

(c) an ability to design and conduct characterization experiments, as well as to analyze and interpret results.

(d) an ability to select and apply relevant characterization techniques to meet specific desired needs within realistic constraints such as availability, expertise and economics.

(e) an ability to function on teams.

(f) an ability to identify, formulate, and solve engineering problems.

(g) an understanding of professional and ethical responsibility.

(h) an ability to communicate effectively.

(i) the broad education necessary to understand the impact of engineering solutions in a

global, economic, environmental, and societal context

(j) a recognition of the need for, and an ability to engage in life-long learning

(k) a knowledge of contemporary issues

(l) an ability to use the techniques, skills, and modern engineering tools necessary for

engineering practice.

**2.** **Text Book:**

**T1.** MATERIALS SCIENCE AND ENGINEERING-AN INTRODUCTION by WILLIAM D.CALLISTER, JR. Seventh Edition, John Wiley (2007)

**2.** **Reference Books:**

R1. MATERIAL SCIENCE AND ENGINEERING by V. RAGHAVAN, Fifth Edition, Prentice-Hall of India private Limited (2004)

**3. Course Plan:**

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| --- | --- | --- | --- |
| **Lect. No.** | **Topics** | **Learning Objectives** | **Ref. Chap./ Sec.Book)** |
| 1 | Introduction and classification of materials | Intro to the course with an objective to review and summarize the variety of materials that are present in us, around us and in the products that we use | Ch. 2 (TB) |
| 2 | Bonding in materials | To learn the concept of bonding in materials, intramolecular and intermolecular | Ch. 2 (TB) |
| 3-4 | Energy diagrams and force-displacement curves | To learn about bonding hands-on by conducting mechanical tests and correlating stiffness, strength etc. with energy diagrams | Project or activity based learning |
| 5-7 | Crystallography | To learn about unit cells, Bravais lattices, crystallographic directions and planes and Millers Indices | Ch. 3 (TB) |
| 8 | Evidence of Bravais lattices in materials | To select various materials and check for evidence of various Bravais Lattice by using optical microscopy | Project or activity based learning |
| 9-11 | Lattice structures | To learn about various lattice systems and to learn to calculate linear and planar densities | Ch. 4 (TB) |
| 12 | Metal and ceramic structures | To learn about various crystal structures of metals and ceramics | Ch. 4 (TB) and microscopy based learning |
| 13-14 | Polymer structures | To learn about molecular weight, molecular structures of polymers, and polymer crystallinity | Ch. 4 and 13 (TB) |
| 15-16 | X-ray diffraction (XRD) | To learn how to determine crystal structure by using Bragg’s Law and the diffraction technique | Ch. 4 (TB) |
| 17 | XRD experiments | To learn to use XRD in determining crystal structures of various materials | Project or activity based learning |
| 18-20 | Defects and Dislocations | To learn about point, line, plane and volume defects and its consequences and to learn how to identify the same | Ch. 5 (TB) |
| 21-23 | Diffusion | To learn about diffusion in relation to internal diffusion (structural rearrangement, phase change, blends) and external diffusion (volatiles, vacancies etc.) | Ch. 6 (TB) |
| 24 | Modeling of diffusion | To learn how to model various diffusion mechanisms and develop plot based illustrations by hand | Project or activity based learning |
| 25-28 | Phase diagrams | To learn to read phase diagrams and correlate them to various microstructures in materials | Ch. 7 (TB) |
| 29-31 | Phase Transformations | To learn about phase transformation kinetics at various temperatures and for various transformations | Ch. 8 (TB) |
| 32-34 | Mechanical properties of materials and characterization | To learn about various mechanical properties of materials and to learn how to characterize materials and obtain quantified mechanical properties | Ch. 9 (TB) |
| 35 | Mechanical characterization of materials | To learn to use various mechanical testing instruments in obtaining quantified properties of materials | Project or activity based learning |
| 36-38 | Thermal properties of materials and characterization | To learn about various thermal properties of materials and to learn how to characterize materials and obtain quantified thermal properties | Ch. 19 (TB) |
| 39 | Thermal characterization of materials | To learn to use various thermal testing instruments in obtaining quantified properties of materials | Project or activity based learning |
| 40-41 | Electrical Properties of Materials and characterization | To learn about various electrical properties of materials and to learn how to characterize materials and obtain quantified electrical properties | Ch. 17 (TB) |
| 42 | Electrical characterization of materials | To learn to use various electrical testing instruments in obtaining quantified properties of materials | Project or activity based learning |

**4. Evaluation Scheme:**

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| --- | --- | --- | --- | --- |
| **Component** | **Duration** | **Weightage** | **Date & Time** | **Remarks** |
| Midterm | 90 mins | 20% | 14/03 - 4.00 - 5.30PM | Open Book |
| Continual Evaluation\* | NA | 45% |  | NA |
| Comprehensive Exam. | 3 hours | 35 % | 14/05 AN | Open book |

\*Continual evaluation will involve the following:

1. Brainstorming and interacting in class (attending classes and maintaining continuity is highly encouraged). For the instructor it will allow for clear assessment of students and provide relevant opportunities for students to continually learn and improve.

2. Lab visits and learning in hands-on manner (attending labs and experimenting is highly encouraged).

3. Each student will work on a group project for the semester (the projects will be part of the project or activity based learning (experiential learning) listed in the table) (the groups will contain a maximum of 3 students and the freedom to choose group members and projects will be provided to the students). More details about the projects will be discussed when we meet in class.

4. Last but not least, for a fair continual evaluation, attending classes and interacting in class and conducting project activities is imperative.

5. 45% of continual evaluation is split into the following: 20% is for project activity, 15% is for involvement and interaction in class, 5% is for industrial trip and other miscellaneous activities and 5% is for student’s abilities of positive attitude, resilience, creativity and ability to learn.

**Chamber Consultation Hour:** To be announced later.

**Notices:** All notices related to the course will be uploaded in CMS.

**Make-up Policy:** Make-up will be granted for genuine cases with prior approval.

**Academic Honesty and Integrity Policy:** Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

**Karthik Chethan V.**

**INSTRUCTOR-IN-CHARGE**