Semester - 03

MATERIAL SCIENCE AND ENGINEERING (IPCC)			
Course Code	**21ME33**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2*:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 12 Lab slots	Total Marks	100
Credits	04	Exam Hours	03
* One additional hour may be considered wherever required			

Course objectives:

- Provide basic background to systematically approach for selection of materials for a wide range of products in engineering applications.
- Introduce the concept of crystal structure, atomic planes and directions.
- Introduce the concept of atomic packing, coordination, and symmetry elements.
- Introduce imperfections in solids.
- Introduce phase stabilities and phase diagrams.
- Teach mechanism of phase transformations.
- Introduce various heat treatment methods.

Teaching-Learning Process (General Instructions)

Teacher can use to accelerate the attainment of the various course outcomes.

- Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
- Chalk and Talk method for Problem Solving.
- Adopt flipped classroom teaching method.
- Adopt collaborative (Group Learning) learning in the class.
- Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

MODULE-1 **8 HOURS**

Structure of Materials

Introduction: Classification of materials, crystalline and non-crystalline solids, atomic bonding

Geometrical Crystallography: Symmetry elements: the operation of rotation, Proper and Improper rotation axes, Screw axes, Glide planes

Crystal Structure: Crystal Lattice, Unit Cell, Planes and directions in a lattice, Planar Atomic Density, packing of atoms and packing fraction, Classification and Coordination of voids, Bragg's Law

Imperfections in Solids: Types of imperfections, Point defects: vacancies, interstitials, line defects, 2-D and 3D-defects, Concept of free volume in amorphous solids.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk. 4. Laboratory Demonstrations and Practical Experiments.

MODULE-2 **8 HOURS**

Physical Metallurgy

Alloy Systems: Classification of Solid solutions, Hume- Rothery Rules

Phase Diagrams: Gibbs Phase Rule, Solubility limit, phase equilibria and Phase Diagrams: Isomorphous systems, Invariant Binary Reactions, Lever Rule; important phase- diagrams , Iron-Carbon Diagram.

Diffusion: Diffusion-Fick's Laws, Role of imperfections in diffusion.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk. 4. Laboratory Demonstrations and Practical Experiments.

MODULE-3 **8 HOURS**

Nucleation and growth: Introduction to homogeneous and heterogeneous nucleation, critical radius for nucleation.
Plastic Deformation: Slip, Twinning; Recovery- Recrystallization-Grain Growth, Introduction to Strengthening mechanisms. Lever rule and phase diagram.
Heat treatment: Annealing, Normalizing, hardening, Tempering, Nitriding, Cyaniding, Induction Hardening and Flame Hardening, Recent advances in heat treat technology. TTT diagram, microstructural effects brought about by these processes and their influence on mechanical properties.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk. 4. Laboratory Demonstrations and Practical Experiments.

MODULE-4 **8 HOURS**

Surface coating technologies: Introduction, coating materials, coating technologies, types of coating, advantages and disadvantages of surface coating.
Powder metallurgy: Introduction, Powder Production Techniques: Different Mechanical and Chemical methods, Characterization of powders (Particle Size & Shape Distribution), Powder Shaping: Particle Packing Modifications, Lubricants & Binders, Powder Compaction & Process, Sintering and Application of Powder Metallurgy.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, 3. Chalk and Talk. 4. Laboratory Demonstrations and Practical Experiments.

MODULE 5 **8 HOURS**

Materials Selection
The need for material selection in design, the evolution of Engineering materials.
The Design Process and Materials Data: Types of design, design tools and materials data, processes of obtaining materials data, materials databases
Engineering Materials and Their Properties: The classes of engineering materials and their structure, material properties: mechanical properties, functional properties.
Material Selection Charts: Selection criteria for materials, material property Charts, deriving property limits and material indices, materials indices which include shape.

Teaching-Learning Process	1. Power-point Presentation, 2. Video demonstration or Simulations, **3.** Chalk and Talk.

PRACTICAL COMPONENT OF IPCC

Sl.NO	Experiments
1	Specimen preparation for macro and micro structural examinations and study the macrostructure and microstructure of a sample metal/ alloys-
2	To study the crystal structure of a given Cast Iron, Mild steel, Aluminium and Copper/Brass specimens and study the crystal imperfections in a given Cast Iron, Mild steel and Aluminium specimens.
3	Study the heat treatment processes (Hardening and tempering) of steel/Aluminium specimens.

4	To determine the hardness values of Mild Steel/ Aluminium by Rockwell hardness/Vickers Hardness.
5	To determine the hardness values of Copper/ Brass by Brinell's Hardness testing machine.
6	To study the creep behaviour of a given Cast Iron or Aluminium specimen.
7	To study of microstructure of welding Mild Steel components and Heat affected zone (HAZ) macro and micro examinations
8	To determine the tensile strength, modulus of elasticity, yield stress, % of elongation and % of reduction in area of Cast Iron, Mild Steel/Brass/ Aluminium and to observe the necking.
9	To conduct a wear test on Mild steel/ Cast Iron/Aluminium/ Copper to find the volumetric wear rate and coefficient of friction.
10	Study the chemical corrosion and its protection. ***Demonstration***
11	Study the properties of various types of plastics. ***Demonstration***
12	Computer Aided Selection of Materials: Application of GRANTA Edupack for material selection: Case studies based on material properties. ***Demonstration***

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

1. Understand the atomic arrangement in crystalline materials and describe the periodic arrangement of atoms in terms of unit cell parameters.
2. Understand the importance of phase diagrams and the phase transformations.
3. Know various heat treatment methods for controlling the microstructure..
4. Correlate between material properties with component design and identify various kinds of defects.
5. Apply the method of materials selection, material data and knowledge sources for computer-aided selection of materials.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

Two Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Scaled-down marks of two tests and two assignments added will be CIE marks for the theory component of IPCC for **30 marks**.

CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The**15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.

- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to 15 marks.
- The laboratory test **(duration 03 hours)** at the end of the 15th week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and scaled down to 05 marks**.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

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SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally reduced to 50 marks
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
- The students have to answer 5 full questions, selecting one full question from each module.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper shall include questions from the practical component).

- The minimum marks to be secured in CIE to appear for SEE shall be the 12 (40% of maximum marks-30) in the theory component and 08 (40% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.
- SEE will be conducted for 100 marks and students shall secure 35% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50.

Suggested Learning Resources:

Text Books:

1. Ashby, M.F. (2010), *Materials Selection in Mechanical Design*, 4th Edition, Butterworth- Heinemann.
2. Azaroff, L.V., (2001) *Introduction to solids*, 1st Edition, McGraw Hill Book Company.
3. Avner, S.H., (2017), *Introduction to Physical Metallurgy*, 2nd Edition, McGraw Hill Education.
4. Powder Metallurgy Technology, Cambridge International Science Publishing,2002.

Reference Books

1. Jones, D.R.H., and Ashby,M.F., (2011), *Engineering Materials 1:* An Introduction to Properties, Application and Design, 4th Edition, Butterworth-Heinemann.
2. Jones, D.R.H., and Ashby,M.F., (2012), *Engineering Materials 2:* An Introduction to Microstructure and Processing, 4th Edition, Butterworth-Heinemann.
3. Callister Jr, W.D., Rethwisch, D.G., (2018), *Materials Science and Engineering: An Introduction*, 10th Edition, Hoboken, NJ: Wiley.
4. Abbaschian, R., Abbaschian, L., Reed-Hill, R. E., (2009), *Physical Metallurgy Principles*, 4th Edition, Cengate Learning.
5. P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, PHI, New Delhi,2008.

Web links and Video Lectures (e-Resources):

1. Bhattacharya,B., *Materials Selection and Design,* NPTEL Course Material, Department of Mechanical Engineering, Indian Institute of Technology Kanpur, http://nptel.ac.in/courses/112104122/
2. Prasad, R., Introduction to Materials Science and Engineering, NPTEL Course Material, Department of Materials

Science and Engineering, Indian Institute of Technology Delhi, http://nptel.ac.in/courses/113102080/

3. Subramaniam, A., Structure of Materials, NPTEL Course Material, Department of Material Science and Engineering, Indian Institute of Technology Kanpur,https://nptel.ac.in/courses/113104014/
4. Schuh, C., 3.40J Physical Metallurgy. Fall 2009. Massachusetts Institute of Technology: MIT Open Course Ware, https://ocw.mit.edu. License: Creative Commons BY-NC-SA.
5. Ghosh, R.N., Principles of Physical Metallurgy, IIT Kharagpur, http://nptel.ac.in/syllabus/113105024/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- **Course seminar**
- **Industrial tour**