Courses for Semester VIII (Year 4)

National Institute of Technology, Raipur (C. G.)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Board of Studies</th>
<th>Sub. Code</th>
<th>Name of Subject</th>
<th>Period/Week</th>
<th>Examination Scheme</th>
<th>METALLURGICAL ENGG.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>L</td>
<td>T</td>
<td>P</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>MT 20811(MT)</td>
<td>Fracture and Failure Analysis</td>
<td>3</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>MT 20812(MT)</td>
<td>Alloy Design and Application</td>
<td>4</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>MT 2083X(MT)</td>
<td>Optional V</td>
<td>3</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>MT 2084X(MT)</td>
<td>Optional VI</td>
<td>3</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>MT 20821(MT)</td>
<td>Fracture and Failure Analysis Lab</td>
<td>-</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>MT 20822(MT)</td>
<td>Alloy Design and Application Lab</td>
<td>-</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>MT 20823(MT)</td>
<td>Major Project</td>
<td>-</td>
<td>-</td>
<td>16</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>MT 20824(MT)</td>
<td>Seminar and Report Writing</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>13</td>
<td>4</td>
<td>22</td>
</tr>
</tbody>
</table>


Choices for optional courses in Semester in VIII (Year 4)

<table>
<thead>
<tr>
<th>Optional</th>
<th>Subject Code</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optional V</td>
<td>MT 20831(MT)</td>
<td>X-ray Diffraction and electron microscopy</td>
</tr>
<tr>
<td></td>
<td>MT 20832(MT)</td>
<td>Application of soft computing in Materials Engineering</td>
</tr>
<tr>
<td></td>
<td>MT 20833(MT)</td>
<td>Hydro and Electro Metallurgy</td>
</tr>
<tr>
<td>Optional VI</td>
<td>MT 20841(MT)</td>
<td>Surface Engineering</td>
</tr>
<tr>
<td></td>
<td>MT 20842(MT)</td>
<td>Nuclear Materials</td>
</tr>
<tr>
<td></td>
<td>MT 20843(MT)</td>
<td>Solar Energy Materials</td>
</tr>
</tbody>
</table>
FRACTURE MECHANICS AND FAILURE ANALYSIS

Stress intensity factor, Stress analysis of cracks, Strain energy release rate, Derivation of relationship between strain energy release rate and stress intensity factor, Crack-tip plastic zone, Dugdale's plastic strip model.; Fracture mode transition: Plane stress versus plane strain, Crack opening displacement, Plane strain fracture toughness (KIC) testing, Fracture toughness determination with elastic plastic analysis (JIC), Concept of R-curve and fracture toughness measurement using it, Microstructural aspect of fracture toughness, Optimizing microstructure and alloy cleanliness to enhance fracture toughness.; Fatigue stress life approach, Basquin's equation, Fatigue strain life approach, Low cycle fatigue, Cofin-Manson's equation, Fatigue total strain life relation, Fatigue life calculation using this approach, Neuber's analysis for notched specimens.; Fatigue crack growth rate, Paris law, Fatigue life calculation using this approach, Mechanism of fatigue crack nucleation and propagation, Factors affecting fatigue crack growth rate, Influence of load interaction, Short fatigue crack.; Stress corrosion cracking and KISCC determination, Corrosion fatigue, Temper embrittlement, Hydrogen embrittlement, Liquid metal embrittlement, Neutron embrittlement.; Fractographic analysis of ductile, brittle, fatigue and high temperature fractured surfaces.; Failure Analysis: Steps involved in it. Case studies of some engineering failures.

Essential Reading:
2. Metal Hand Book, Failure Analysis & Prevention (Vol. - X) - ASM Publication

Supplementary Reading:
Name of the Subject | Alloy Design and Application | Subject Code | MT 20812(MT)
---|---|---|---
Semester | VIII | Board of Studies | Metallurgy
Maximum Marks | 70 | Minimum Marks | 25
Lecture Periods/Week | Tutorial Periods/Week | Practical Periods/Week | Credits
4 | 1 | - | 5 (Th)

ALLOYS DESIGN AND APPLICATION

Function of Alloying elements in steel, Limitations of plain carbon steel, General effect of alloying elements, mode of combination of alloying elements, Effect of alloy elements on transformation temperature, effect of alloying elements on critical cooling rate.

Low alloy steels (HSLA/ Micro alloyed steel ) , high tensile structural steel, ball bearing steels, spring steels, low alloy high strength structural steels, Study of high Ni steels, high speed steel, die steel, Hadfield steel and maraging steel.

Cast irons, Structure and properties of white cast irons, gray cast iron, malleable cast iron, nodular cast iron and alloy cast irons. Study of Stainless steels, heat resistant high strength steels and ausformed steels.

Non ferrous alloys: Structure and properties of Brasses, bronzes, babbits. Structure and properties of titanium alloys, Aluminium alloys, Magnesium alloy, Monels, brazing and soldering alloys.


Text Books
1. Physical metallurgy for engineers- by D.S. Clark and Warne.
3. Introduction to Physical metallurgy- by Sidney H. Avner.
Name of the Subject | X-ray Diffraction and electron microscopy | Subject Code | MT 20831(MT)
--- | --- | --- | ---
Semester | VIII | Board of Studies | Metallurgy
Maximum Marks | 70 | Minimum Marks | 25
Lecture Periods/Week | 3 | Tutorial Periods/Week | -
| 1 | Practical Periods/Week | Credits | 4 (Th)

**X-ray DIFFRACTION AND ELECTRON MICROSCOPY**


Chemical Analysis by X-ray techniques, X-ray fluorescence. X-ray specto meters, qualitative and quantitative analysis, micro analysis of metals and alloys, LDX, WDX. Effect of texture, particle size, micro strain on diffraction lines. Indexing of powder photographs. EELS, GIXRD, microstructural analysis using XRD, basics of texture/orientation, bulk texture analysis using XRD,

TEM: Principle and operation. Electrons as source, properties of electron beam, elastic and inelastic scattering of electrons, importance in electron microscopy, resolution, principles of transmission electron microscopy, construction, ray-diagram, working, sample preparation, contrast mechanisms, ring and spot diffraction patterns, detectors and imaging modes, kikuchi lines, measurement of lattice parameter, orientation relationship determination, Introduction to HRTEM.Bright field and dark field images, Sample preparation techniques. Selected area diffraction, Reciprocal lattice and Ewald sphere construction, Indexing of selected area diffraction patterns. Microanalysis (EDX, WDS, EBSD etc.)

**Essential Readings:**

**Supplementary Readings:**
APPLICATION OF SOFT COMPUTING IN MATERIALS ENGINEERING

Introduction to soft computing, concept of hard computing and soft computing, computer application and advancement of science in the perspective of theory and experimentation. Role of computation in materials science and engineering.


Concept classical and non classical optimization techniques, Genetic algorithms as optimizer, theory and basic principle, application of genetic algorithm, evolutionary algorithms, simulated annealing, ant-colony optimisation, multi-objective optimisation and multi criteria decision making, cases study focusing on application in materials research and industrial application of these techniques.

Books

HYDRO AND ELECTRO METALLURGY

Introduction: Justification of Hydrometallurgical selection of solvent processing, Eh-Ptt diagrams Principles underlying hydrometallurgical processes, various commercial hydrometallurgical processes. Criteria for selection of solvents, Types of Solvents.

- Thermodynamics & kinetics of hydrometallurgical processes.
- Unit operations in hydrometallurgical processing, Thickness & filters, counter current decantation.
- Applications of hydrometallurgy to Copper, Zinc, Precious metals etc.
- Solvent Extraction & Ion Exchange.
- Purification methods of leach solutions.
- Recovery of metal values from solution.
- Precipitation methods Thermodynamics & Kinetics of concentration.
- Electrolytic Recovery- Electrowinning of methods from Aq. Solutions Electro Refining.
- Fused Salt Electrolysis – Extraction of Aluminium & Magnesium from their ores.
- Mass balance calculations.

BOOKS
2. T. Rosenquist, Principles of Extractive Metallurgy
3. S. Venkatachalam, Hydrometallurgy Narosa Publication Co
4. E. Jackson, Hydrometallurgical Processing & Reclamation, John Wicky & Sons.
SURFACE ENGINEERING


Surface: Substrate and pretreatment, role of surface cleanliness and surface finish. Type of contaminants and their sources. Methods of surface cleaning; abrasive cleaning, chemical cleaning, chemical polishing, electrolytic cleaning, electrolytic polishing, ultrasonic cleaning, etc. Criteria for selection of cleaning process. Cleaning of ferrous and non-ferrous metals and alloys.


Chemical conversion coatings: Phosphatizing, chromatizing, ceramic coatings/linings and anodizing. Baths and role of their constituents.

Vacuum and atmosphere controlled coatings: Principle and equipments for coating methods like, Thermal spray coating, Chemical vapour deposition (CVD), Plasma assisted CVD, Physical vapour deposition (PVD), sputter, arc deposition, diffusion coatings and pulsed laser deposition.

Industrial applications: Surface engineering of polymers, metals and alloys.

Books:
3. ASM Handbook Volume 5- Surface Enginnering, Published by ASM International, 1995
Name of the Subject | Nuclear Materials | Subject Code | MT 20842(MT)
Semester | VIII | Board of Studies | Metallurgy
Maximum Marks | 70 | Minimum Marks | 25
Lecture Periods/Week | Tutorial Periods/Week | Practical Periods/Week | Credits
3 | 1 | - | 4 (Th)

NUCLEAR MATERIALS

Nuclear Structure: Structure of nucleus, binding energy, fission reaction, neutron cross sections, moderation of neutrons, multiplication factor. ; Fusion reaction, Reactors and Materials: Classification of nuclear reactors, Materials for nuclear reactors, Fuels, Moderators, Control rods, Coolant, Reflectors and Structural materials. Fabrication of fuel and cladding materials. ; Radiation Effects: Effect of radiation on reactor materials, Radiation hazards, safety and shielding, disposal of radioactive wastes. ; Production of Nuclear Materials: Atomic minerals, their occurrence in India, General methods of their processing. Production metallurgy of nuclear grade uranium, Thorium beryllium and zirconium, Production of enriched uranium. ; Processing of spent fuel: Indian reactors and atomic energy programme in India. Use of nanomaterials for nuclear application

Essential Reading:
1. R. Stephenson, Introduction to Nuclear Engineering, McGraw-Hill.

Supplementary Reading:
1. S. Glasstone and A. Sesonke: Nuclear Reactor Engineering, Van Nostrand
SOLAR ENERGY MATERIALS

Physics and Properties of Semiconductors materials: crystal structure, energy bands, Fermi level, carrier concentration at thermal equilibrium, carrier transport phenomena, Hall Effect, recombination mechanism, optical and thermal phenomenon.


Metal-Semiconductor Contacts: equilibrium, idealized metal semiconductor junctions, ohmic contacts, Schottky diodes. Solar energy definitions, its intensity distribution, variation and spectrum, thermodynamics of solar energy spectrum, mechanism of heat losses, efficiency, photo thermal conversion materials and their preparation and characterization.

Design of material for solar applications: collectors, selective surface, composite semiconductors, solar reflectors and concentrators, thermoelectric conversion, chalcogenide and alloy semiconductors, criteria for material selection, spectral response, efficiency.

Types of Photovoltaic (PV) cells; p-n homo and hetero junction, First, Second and Third Generation PV devices, PV materials: silicon - single crystalline, polycrystalline, ribbon, amorphous, nanocrystalline; CdS, Cu(In,Ga)Se2, CdTe/Se, GaAs, InP/As, ZnMgO, PbS.

PV Material qualification for terrestrial and space application, radiation damage, arrays and solar cell systems, energy storage-thermal, chemical, electrochemical storage and hydrogen generation; Challenges and Solutions for Manufacturing of PV solar cell, Understanding the defect related issues, Field test of PV Modules with solar spectrum variation.

Text book


Reference

2. Flexible solar cell by Mario Pgliaro, Giovanni Palmisano, Rosaria Ciriminna, John Wiley VCH Verlag GmbH and Company KGAA 2008,