Courses for Semester VIII (Year 4)

National Institute of Technology, Raipur (C. G.)												
Course of Study and Scheme of Examination (NEW)											**B. Tech. VIII semester**	**METALLURGICAL ENGG.**
S. No.	**Board of Studies**	**Sub. Code**	**Name of Subject**	Period/Week			Examination Scheme					Total Marks	Credits L+(T+P)/2
				L	T	P	TA	FE	SE	T.C.A.	ESE		
1	**METALLURGY**	MT 20811(MT)	Fracture and Failure Analysis	3	1	-	20	15	15	50	70	120	4
2		MT 20812(MT)	Alloy Design and Application	4	1	-	20	15	15	50	70	120	5
3		MT 2083X(MT)	***Optional V***	3	1	-	20	15	15	50	70	120	4
4		MT 2084X(MT)	***Optional VI***	3	1	-	20	15	15	50	70	120	4
5		MT 20821(MT)	Fracture and Failure Analysis Lab	-	-	3	30	-	-	30	20	50	2
6		MT 20822(MT)	Alloy Design and Application Lab	-	-	3	30	-	-	30	20	50	2
7		MT 20823(MT)	Major Project	-	-	16	100	-	-	100	100	200	8
8		MT 20824(MT)	Seminar and Report Writing	-	-		50	-	-	50	-	50	1
TOTAL				**13**	**4**	**22**	**290**	**60**	**60**	**410**	**420**	**830**	**30**

TA= Teacher Assessment, FE= First Exam. , SE= second Exam., T.C.A.= Total of continuous assessment, ESE=End Sem. Exam.

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

Optional	Subject Code	Course
Optional V	MT 20831(MT)	X-ray Diffraction and electron microscopy
	MT 20832(MT)	Application of soft computing in Materials Engineering
	MT 20833(MT)	Hydro and Electro Metallurgy
Optional VI	MT 20841(MT)	Surface Engineering
	MT 20842(MT)	Nuclear Materials
	MT 20843(MT)	Solar Energy Materials

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Name of the Subject	Fracture and Failure Analysis	Subject Code	MT 20811(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)

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 embrit-tlement. ; 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:

1. R.W. Hertzberg, Deformation and Fracture Mechanics of Engineering Materials - (John Wiley & Sons Pub.).
2. Metal Hand Book, Failure Analysis & Prevention (Vol. - X) - ASM Publication

Supplementary Reading:

1. G.E. Dieter, Mechanical Metallurgy by Mc-Graw Hill (1988).
2. D. Broek, Elementary Fracture Mechanics - Martinus Nijho Publisher.
3. N. Perez, Fracture Mechanics, Klwer Academic Publishers.

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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.

Metals at low temperatures: Effect of low temperature on properties, Effect of low temperature on notched bar test, Metallurgical factors, mechanical factors. Magnetic steels and alloys. Alloys for electrical applications. Zirconium alloys in nuclear technology. Amorphous metals. Specifications of alloys:- I S I, A I S I and En standards (Basic concepts only).

Text Books

1. Physical metallurgy for engineers- by D.S. Clark and Warne.
2. Structures and Properties of alloys- by Robert M. Brick and Phillips.
3. Introduction to Physical metallurgy- by Sidney H. Avner.

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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	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	-	4 (Th)

X-ray DIFFRACTION AND ELECTRON MICROSCOPY

Introduction to crystallography, Symmetry – point group and space group, reading of the space group tables, X-ray diffraction and analysis: Production and properties of X-rays, X-ray diffraction, Structure factor and intensity calculations. Production and properties of X-rays, Electromagnetic radiation, continuous and characteristics spectrum, absorption. Filter and detectors. Bragg's law, scattering by atom, electron, unit cell, structure factor calculation. Diffraction Methods: Laue's method, rotating crystal, Debye scherrer – Specimen preparation, film loading, powder method, Determination of crystal structure, determination of precision lattice parameter, sources of error in measurements. Applications – Effect of plastic deformation. Determination of particle size, grain size, residual stresses, determination of phase diagrams, order-disorder transformation. texture, importance of texture, measurement of texture, pole figures (stereographic projections), orientation distribution function, sample symmetry,

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:

1. B.D. Cullity, Elements of X-ray Diffraction by (II edition), Addison-Wesley Publishing Co Inc., Reading, USA, 1978.
2. P.J. Goodhew and F.J. Humphreys, Electron Microscopy and Analysis by Taylor and Francis, London, 2001(ISBN-0-7484-0968-8).

Supplementary Readings:

1. S.H. Cohen and M.L. Lightbody, Atomic Force Microscopy / Scanning Tunneling
1. Microscopy, (Editors), Plenum Press, New York, 1994.
2. P.J. Haines (Editor), Principles of Thermal Analysis and Calorimetry by Royal Society of Chemistry (RSC), Cambridge, 2002.

3. G.F.V. Voort, Metallography: Principles and Practice by ASM International, Materials Park, USA, 1984
4. S. Amelinckx, D. V. Dyck, J. V. Landuyt and G. Van Tendeloo (Editors), Electron
5. Microscopy: Principles And Fundamentals, VCH, Weinheim, 1997.
6. C. Suryanarayana and M. Norton, X-ray Diffraction, A Practical Approach, Plenum Press, New York, (1998).
7. Metallography and Microstructures, Metals Handbook, Volume 9, 9th edition, AmericanSociety for Metals, Metals Park, Ohio, 1986.

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Name of the Subject	Application of soft computing in Materials Engineering	Subject Code	MT 20832(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)

APPLICATION OF SOFT COMPUTING IN MATERALS 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

Artificial neural network, classification, theory and practice, case study in materials application. Fuzzy logic, fuzzy inference system, rule base design, significance of FIS modelling in materials Engineering. neuro-fuzzy inference systems case studies, rough sets, probabilistic reasoning, machine learning, expert systems, case studies in materials application

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

1. J. S. R. Jnag, C. T. Sun, and E. Mizutani, *Neuro-Fuzzy and Soft Computing*.Prentice-Hall of India Pvt. Ltd., New Delhi, 2002.
2. K. Deb, *Optimization for Engineering Design: Algorithms and Examples*. Prentice-Hall of India Privet Limited, New Delhi, 1995.
3. D. E. Goldberg, *Genetic Algorithms in Search, Optimization and Machine Learning*. Pearson-Education, New Delhi, 2002.

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Name of the Subject	Hydro and Electro Metallurgy	Subject Code	MT 20833(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)

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-
  Electrowining of methods from Aq. Solutions Electro Refining.
- Fused Salt Electrolysis – Extraction of Aluminium & Magnesium from their ores.
- Mass balance calculations.

BOOKS

1. H. S. Ray, K. P. Abraham and R. Sridhar, Extraction of Non-Ferrous Metals , Affliated East- West Press.
2. T. Rosenquist , Principles of Extractive Metallurgy
3. S. Venkatachalam, Hydrometallurgy Narosa Publication Co
4. E. Jackson, Hydrometallurgical Processing & Reclaimation, John Wicky & Sons.

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Name of the Subject	Surface Engineering	Subject Code	MT 20841(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)

SURFACE ENGINEERING

General: Historical perspective and future trends. Scope and application of surface engineering. Classification of surface engineering methods. Typical thickness and metallurgical structure produced by various surface engineering methods. Difference between surface coating and surface treatment.

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.

Plating: Principles of Electroless and electro-plating. Setup for electro-plating. Baths for electroless plating, Baths for electro-plating. Role of bath constituents. Structure of coating. Plating practices for electroplating of Cu, Ni, Cr, Zn, Sn, Cu-alloy, Sn-alloy, Ni-alloy, Cr-alloy, multi-layer alloy plating etc. Electroless plating of Ni, Cu and Au. Electroless plating of industrial alloys

Hot-dip: Principle of hot- dip method. Structure of hot-dip coating. Batch process, its scope and limitations. Continuous process, its scope and limitations. Coating Zn, Zn-Al and Sn by hot-dip method. Industrial practices. Pre- and post surface treatments.

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:

1. Surface Engineering & Heat Treatment- Past, present and Future, Edited by P. H. Morton, Published by The Institute of Metals, London, 1991
2. Electroplating and other surface treatments- A Practical Guide, CD Veghese, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2003
3. ASM Handbook Volume 5- Surface Enginnering, Published by ASM International, 1995

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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.
1. H.S. Ray, R. Sridhar and K.P. Abraham: Extraction of Non ferrous Metals, Affliated East-West Press Private Limited.

Supplementary Reading:

1. S. Glasstone and A.Sesonke: Nuclear Reactor Engineering, Van Nostrand

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Name of the Subject	Solar Energy Materials	Subject Code	MT 20843(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)

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.
Device Processing Technology: oxidation, diffusion, ion-implantation, deposition, lithography, etching and interconnect. p-n Junction: depletion region, diffusion, generation-recombination, current-voltage characteristics, junction breakdown, charge storage and transient behaviour

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, Cd-Te/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

1. Physics of Semiconductor Devices by S.M. Sze, John Wiley & Sons, 2nd Edition (2001)
2. Handbook of Photovoltaic Science and Engineering, by Antonio Luque and Steven Hegedus, John Wiley & Sons, 1 st Edition (2008)

Reference

1. Title Semiconductor Physics and Devices, S.S. Islam, Oxford University Press, 2nd Edition (2006)
2. Flexible solar cell by Mario Pgliaro, Giovanni Palmisano, Rosaria Ciriminna, John Wiley VCH Verlag GmBH and Company KGAA 2008,