राष्ट्रीय प्रौद्योगिकी संस्थान रायपुर
NATIONAL INSITUTE OF TECHNOLOGY RAIPUR
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Courses for Semester VII (Year 4)

National Institute of Technology, Raipur (C. G.)													
Course of Study and Scheme of Examination (NEW)							**B. Tech. VII 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**	MT20711(MT)	Corrosion Engineering	4	1	-	20	15	15	50	70	120	5
2		MT 20712(MT)	Phase Transformation and Phase Equilibrium	3	1	-	20	15	15	50	70	120	4
3		MT 2073X(MT)	***Optional III***	3	1	-	20	15	15	50	70	120	4
4		MT 2074X (MT)	***Optional IV***	3	1	-	20	15	15	50	70	120	4
5		MT 20721(MT)	Corrosion Engineering lab	-	-	3	30	-	-	30	20	50	2
6		MT 20722(MT)	Phase Transformation Lab	-	-	3	30	-	-	30	20	50	2
7		MT 20723(MT)	Practical training	-	-	-	50	-	-	50	-	50	2
8		MT 20724(MT)	Minor Project	-	-	12	100	-	-	100	50	150	6
9		MT 20725(MT)	Seminar And Report writing	-	-	2	50	-	-	50	-	50	1
TOTAL				**13**	**4**	**20**	**340**	**60**	**60**	**460**	**370**	**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 **VII (Year 3)**

Optional	Subject Code	Course
Optional III	1020731(MT)	Ceramics Engineering
	1020732(MT)	Polymers Engineering
	1020733(MT)	Composite Materials
Optional IV	1020741(MT)	Light metals and alloys
	1020742(MT)	Advanced Engineering Materials
	1020743(MT)	Introduction to Nanoscience and Nanotechnology

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Name of the Subject	Corrosion Engineering	Subject Code	MT20711(MT)
Semester	VII	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
4	1	-	5 (Th)

CORROSION ENGINEERING

Introduction to corrosion; Examples of corrosion, Economic and Technical significance of Corrosion, Chemical and Electrochemical reactions, Electro motive force, Electrode potential, Galvanic Series, Electrochemical Equilibrium, Potential - pH diagram (Examples H_2O, Zn-H_2O and Fe - H_2O system) Electrode kinetics, Evans diagram, Polarization and types of polarization. Mixed potential theory. Passivity; Effect of oxiders, solution velocity and galvanic coupling.

Classification of various forms of corrosion and their mechanisms; Details of General pitting, crevice, intergranular, selective leaching, stress corrosion cracking, Hydrogen embrittlement, high temperature oxidation, Hot corrosion, etc. Wagner Electrochemical oxidation theory, Hauffe's valency affects, Weld-decay and knife line attack,

Methods of testing in corrosion, high temperature oxidation and hot corrosion. Methods like Gravimetric, Potential-time, Potentio dynamic polarization, Linear polarization, Electrochemical Impedance, Spectroscopy, Electrochemical noise, etc. with case studies.

Taffel□s equation , Butler Volmer equation, Stern Geary equation Corrosion Measurement Techniques - linear polarisation, Tafel extrapolation, EIS, electrochemical noise, harmonic analysis, Mott Schottky technique, Kinetics of oxidation, Pilling-Bed worth ratio,

Corrosion behaviour of industrial metals and alloys like steels, stainless steels, copper and copper alloys, nickel and nickel alloy, aluminium and aluminium alloys, titanium and titanium alloys etc. Application of these metals and alloys. Effect of environment on their corrosion behaviour.

Methods of corrosion control (practical and fundamental approach) like selection of material, inhibition, coatings, alloying, heat treatment, change in design, change in corrosive environment, etc. Types of inhibitors, types of coatings. Cathodic and anodic protection. Instruments and accessories for cathodic and anodic protection; Wear resistant coating. Environmental degradation of composite

Essential Reading:

1. M.G. Fontana& N.D Greens, Corrosion Engineering, Mc Graw Hill publishing company (2006).
2. H.H. Uhlig, Corrosion & Corrosion control- John Wiley & Sons, (2000).
3. Daniels and Alberty, Physical Chemistry;
4. Raj Narayan; 'An Introduction to Metallic Corrosion & its Prevention'; Oxford & IBH Publishing Co. Pvt. Ltd., 1988.

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Supplementary Reading:

1. S.N. Banerjee, An introduction to science of corrosion & its inhibition- Oxonian Press Pvt. Ltd., India, (1985).

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Name of the Subject	Phase Transformation and Phase Equilibrium	Subject Code	MT20712(MT)
Semester	VII	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	-	4 (Th)

PHASE TRANSFORMATION AND PHASE EQUILIBRIUM

Introduction to phase transformation: Definition of phase changes, long rage and short range diffusion, diffusion-less changes, classification phase transformations.

Diffusion in solids: Steady state diffusion, non-steady state diffusion, solution of Fick's second law, Grube solution, Matano-Boltzmann Solution, diffusivity, diffusion in ionic crystal, diffusion along grain boundary.

Thermodynamics and kinetics of phase transformation :Free energy of elemental crystal and solid solutions, Thermodynamic order of transformation, First order and second order transformation, kinetics of nucleation and growth homogeneous and heterogeneous nucleation, strain energy effect, interface control and diffusion control growth. Overall transformation kinetics Empirical equations, The Johnson-Mehl model and Avrami model.

Liquid-solid transformation: Nucleation, homogeneous and heterogeneous, Growth continuous and lateral; Interface stability; Alloy solidification cellular and dendritic, Eutectic, off-eutectic, peritectic solidification; Welding, casting and rapid solidification.

Solid state diffusive transformation: Classification, Nucleation and growth - homogeneous and heterogeneous mechanism, Precipitate growth under different conditions, Age hardening, Spinodal decomposition, Precipitate coarsening, Transformation with start range diffusion, Moving boundary transformations recrystallization, grain growth, eutectoid transformation, discontinuous reactions.

Pearlitic and bainitic transformation: Factors influencing pearlitic transformation, Mechanism of transformation, Nucleation and growth, Orientation relationship, Degenerate pearlite. Bainite mechanism of transformation, Nucleation and growth, Orientation relationships, Surface relief, Classical and non-classical morphology, Effect of alloying elements

Non-diffusive transformation: Characteristics of transformation, Thermodynamics and kinetics, Nucleation and growth, Morphology, Crystallography, Stabilization, Strengthening mechanisms, Nonferrous martensite, Shape memory effect/alloys.

Text Books

1. Physical Metallurgy by Reed Hill
2. Solid State Phase transformation by V Raghavan
3. Phase Transformations in Metals and Alloys by D. A. Porter & K. E. Easterling

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Name of the Subject	Ceramics Engineering	Subject Code	MT 20731(MT)
Semester	VII	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	-	4 (Th)

CERAMICS ENGINEERING

Characteristics of ceramic solids: structure and bonding in ceramics bonding in solids and discussion of potential energy vs separation curve; grouping of ions and pauling rules and how pauling rules determine structure. Critical radius ratio and coordination number. Discussion of structure of Nacl, CsCl, ZnS, diamond and silicates.

Imperfections in ceramics: Point defects, frenkel disorder, schottky disorder, defect association and electronic structure nonstoichiometric solids, line and surface defects eg dislocations and grain boundaries.

Glasses (amorphous ceramics):FORMATION OF GLASSES , Structure of glasses, Properties of glasses

Thermodynamic and kinetic aspects of ceramic materials, free energy considerations and gibb's phase rule, PHASE diagrams of one and two component ceramic systems, introduction to ternary phase diagrams specifically mgo-Al2O3- sio2 and information obtained from it.

Diffusion in ceramics: Diffusion and fick's law, diffusion as a thermally activated process, Temperature and impurity dependence of Diffusion. Diffusion in Crystalline Oxides , Nucleation and Growth

Properties of ceramics: thermal properties: thermal conductivity and thermal expansion, thermal shock and thermal spalling, mechanical properties: strength, elasticity and an elasticity, creep of ceramics, electrical properties: electrical conduction and ionic conduction, electronic conduction: polarisation, dielectric loss and dielectric breakdown of ceramics, magnetic properties: para, ferro, antiferro and ferrimagnetism. Magnetic domain and hysterisis curve, optical properties: refractive index, dispersion, opacity and translucency. Fiber optics

Ceramics for refractories: manufacturing and development of ceramic components

Books:

1. Kingery, Bowen and Uhlmann, Introduction to Ceramics, John Wiley and Sons.

References:

1. F.A. Hummel, Introduction to Phase Equilibria in Ceramic systems, Marcel Dekker, New York, 1984
2. L. Pauling, The nature of Chemical Bond, Cornell University Press, Itacha NY 1960
3. L.L. Hench and J.K. West , Principles of electronic ceramics, Wiley Interscience, New York

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Name of the Subject	Polymers Engineering	Subject Code	MT 20732(MT)
Semester	VII	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	-	4 (Th)

PLOYMER ENGINEERING

Polymers ; Classification of polymerization reaction, semi-crystalline and amorphous polymers, Elastomers, Additives, Fillers, Viscoelasticity, Molecular theory for viscoelasticity,
Glass and rubbery states, Glass transition temperature, Crystallinity, Deformation, Mechanical response, High temperature specialty polymers, Polymer liquid crystals.

Composites ; Classification of polymer matrix composites, metal matrix composites, ceramic matrix composites. Determination of Engineering Elastic Constants, Stiffness of composites.,

Fabrication of composites: PMC; Injection moulding and Liquid resin impregnation route. MMC; Squeeze infiltration and Physical vapour deposition. CMC; Powder based route and reaction processing. ;

Matrix deformation, Interfacial debonding, Effect of microstructure, Interfacial fracture and crack deflection. Fatigue Failure, Stress Corrosion Cracking, Creep, Selection of Polymers for design applications of mechanical components.

Essential Reading:

1. D.Hull and T.W. Clyne, *An Introduction to composite material,* Cambridge University press.
2. Young and Lovell, *Introduction to Polymers*, Nelson Thomes.

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Name of the Subject	Composite Materials	Subject Code	MT 20733(MT)
Semester	VII	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	-	4 (Th)

COMPOSITE MATERIALS

Introduction to Composites, Matrices, Reinforcements, Classifications, Applications, Advantages, Fundamental concept of reinforcement, review of current developments; design fabrication and economic considerations. ;

Basic mechanics of reinforcement, Stiffness of parallel arrays of fibres in a matrix. Discontinuous and particulate reinforcement. Fibres and resin materials. Rule of Mixtures, Critical Fiber Length, Short and Continuous Fibers, Fiber Orientation; Matrix and Reinforcement Materials, Polymeric Matrices, Metallic Matrices, Ceramic Matrices, Particulates, Flakes, Whiskers, Fibers: C, B, Glass, Aramid, Al2O3, SiC, Nature and manufacture of glass, carbon and aramid fibres.

Review of the principal thermosetting and thermoplastic polymer matrix systems for composites. ; Polymer Matrix Composites (PMCs), Metal Matrix Composites (MMCs), Ceramic Matrix Composites (CMCs), CFRP & Carbon/Carbon Composites (CCCs); Types, Manufacturing, Processing methods, Interfaces, Properties, Applications, Toughening Mechanisms, Fiber Forms, Prepregs, Molding Compounds-Processes, Lay-Ups, Filament Winding, Pultrusion, Recycling. ;

Matrix –Reinforcement Interface, Wettability, Interactions at Interface, Interfacial Bonding Types, Interfacial Strength Tests, The role of the interface. The nature of fiber surfaces, wetting and adhesion. ;

Strength, Stiffness, Fracture, Toughness and toughening mechanisms of composites ; Strengths of unidirectional composites. Multiple fracture in laminates. Macroscopic fracture and energy dissipating processes. Application of fracture mechanics to composite materials. Fracture Mechanics and Fracture Toughness in Composites, Linear Elastic fracture mechanics, Toughness, Fiber matrix debonding, Fiber Pullout Buckling and Post-Buckling ; Failure criteria, Fatigue and Creep in composites, Environmental effects in Composites, Green composites. ; Synthesis and Properties of Nanocomposites.

Essential Reading:

1. Chawla, Composite Materials: Science and Engineering, Springer, 2nd Ed. 1998.

Supplementary Readings:

2. Matthews & Rawlings, Composite Materials: Engineering and Science, Chapman & Hall, 1994.
3. Hull, An Introduction to Composite Materials, Cambridge, 2nd Edt. 1997.

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Name of the Subject	Light metals and alloys	Subject Code	MT 20741(MT)
Semester	VII	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	-	4 (Th)

LIGHT METALS AND ALLOYS

Introduction to Light Metals & Alloys .Importance of Strength to weight Ratio. Classification Of Light metals &alloys .Review of Methods of Extraction of Al, Mg, Ti

Al-alloy, Principles of Age Hardening , trace elements effect ,Hardening Mechanism,Ageing process, Wrought Al-alloy, production, designation of alloy and temper, New alloy development ,Al-Li alloy, Al-Cu-Li alloy, super plastic alloys, SAP alloy, Rapid solidification processing, Joining o wrought Al-alloy ,Application of Wrought Al-alloy.

Cast Al-alloy, Designation temper and Characteristics of cast Al-alloy, Review of Al-Si system, modification, High strength alloy, Al-Mg-alloy, New casting process(rheocasting, squeeze casting, cosworth process), Joining etc.

Introduction and classification of Ti-alloy, Basic Principle of Heat Treatment , Alfa-alloy, near alfa-alloy, fully alfa-alloys and their heat treatment, Ti-Cu age hardenable alloy,alfa/beta Ti-allloy,. Effect of Quenching from Beta-phase field, Tempering of Ti-martensite,decomposition of metastable beta-alloy,beta-alloy, fabrication, recent trends in shape memory alloy, Ti-alloy casting ,application,

Introduction, Melting and casting of Mg-alloy, Grain Refinement , Alloy Designation and temper, Mg-Al- alloy ,Mg-Li alloy system, Mg-Al-Zn alloy, Mg-Zr alloy Mg- rare earth metals , Mg- Y alloy, Wrought alloy, forging alloy, extrusion alloy, Noval alloy(Squeeze alloy),Fabrication & their application

Book:

Light Alloys: Metallurgy of the Light Metals by I. J. Polmear , Hodder Arnold H& S (1981)

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Name of the Subject	Advanced Engineering Materials	Subject Code	MT 20742(MT)
Semester	VII	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	-	4 (Th)

ADVANCED ENGINEERING MATERIALS

Electronic Polymers, Organic electronics, Melanin, Organic semiconductor, Printed electronic Organic LED. ; Nanostructures, Nanomaterials, Nanocomposites. ; Biomaterials: Metabiomaterials like 316L stainless steel, Co-Cr Alloys, Titanium Ti6Al4V, Ceramic biomaterials liAlumina, Zirconia, Carbon Hydroxyapatite, Polymeric biomaterials like Ultra high molecur weight polyethylene, Polyurethane. ; Smart Materials: Piezoelectric materials, Shape memory alloys and shape memory polymers. ; High Performance Alloys: Nickel super alloys, Ti alloy Al-Li alloys, Hastelloy, Inconel, Monel, Nitronic, Cobalt based alloys and commercially available pure nickel alloys. ; Functional and Engineering Ceramics: diverse applications as cutting toomobile phone microwave devices, polycrystalline diamond and fuel cells. ; Hybrid Material Design, Synthesis and Properties of hybrid materials created by blending disparate material such as plastics with metals. ; Processing of Advanced Materials: Superplastic, Mechanical alloying spray forming rapid solidification. Materials selection and design.

Essential Reading:

1. L. V. Interrante, M. J. Hampden, Chemistry of Advanced Materials: An Overview, -Smit Wiley-VCH; 1st edition (1997) ISBN-10: 0471185906 ISBN-13: 978-0471185901.
2. R E Smallman, Physical Metallurgy and Advanced Materials, Seventh Edition, A.H.W. Butterworth-Heinemann, 2007, ISBN: 0750669063.

Supplementary Reading:

1. M. Meyers, M Sarikaya, R. Ritchie, Nano and Microstructural Design of Advanced Materials, Elsevier, 2003, ISBN-13: 978-0-08-044373-7, ISBN-10: 0-08-044373-7.

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Name of the Subject	Introduction to Nano Science and Nanotechnology	Subject Code	MT 20743(MT)
Semester	VII	Board of Studies	Metallurgy
Maximum Marks	70	Minimum Marks	25
Lecture Periods/Week	Tutorial Periods/Week	Practical Periods/Week	Credits
3	1	-	4 (Th)

INTRODUCTION TO NANO SCIENCE AND NANO TECHNOLOGY

Introduction to nanoscience and nanotechnology, Definition and Background of development, of nanotechnology, Basic ideas about Atoms, Molecules and structure. Length scale and properties of matter, band structure and density of states at nanoscle, Introductory quantum mechanics for nano science.

Techniques for Synthesis and preparation of Nanostructured materials, Concept of *Bottom Up and top down approach of nanotechnologies*:, nanolithography, mask and resist technology, electron beam lithography, dip pen lithography, mechanical milling,, Self-assembly, Sol – Gel method, Chemical Vapour deposition (CVD)/PECVD etc

Measurement and Characterization of Nanocrystalline Materials: *Structure* (Atomic structure, Particles size determination, surface structure), Microscopy scanning probe microscopy, principle of working of STM and AFM,, Electron microscopy, resolution vs magnifivation issue, SEM, Field Ion, high resolution TEM, .

Carbon nanostructure: Introduction to Carbon Molecules, Carbon Clusters (C_{60}, Buckyball), Carbon Nanotube – Type of Carbon Nanotube, Formation of Carbon Nanotube and properties and Application of Carbon Nanotube.

Cutting age areas of application of Nanotechnology; state of art of the nano technology, current areas of research, scope and opportunity of the technology., some special topics on application of nanomaterials.

Books

1. Introduction to NanoscaleScience and Technology by Massimiliano Di Ventra
2. Stephane Evoy and James R. Heflin, Jr. KLUWER ACADEMIC PUBLISHERS, NEW YORK, BOSTON, DORDRECHT, LONDON, MOSCOW.
3. Carl C Koch, Nanostructured Materials, Noyes Publication, 2002
4. Introduction to Nanotechnology. Charles P Pool. Frank J Owens, Jhon Wiely and Son Publication, New Jersey, 2003
5. Nanotechnology: Basic Science and Emerging Technology, Mick Wilson, Overseas Press, Indian Edition, New Delhi, 2005
6. Introduction to Nanoscience and Nanotechnology , K K Chattopadhyay and A. N Banerajee, PHI, L earning Privet Limited, New Dehli, 2010