NATIONAL INSTITUTE OF TECHNOLOGY JAMSHEDPUR

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

COURSE STRUCTURE OF M.TECH

in

Materials Technology

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY, JAMSHEDPUR

M. Tech (Materials Technology)

CREDIT STRUCTURE

Course Work	**1st Sem**	**2nd Sem**	**3rd Sem**	**4th Sem**	**Total Credits**
Core Course	9	9	-	-	18
Electives	6	6	-	-	12
Lab Course	4	4	-	-	8
Seminar	1	1	-	-	2
Course Total	20	20	-	-	40
Project	5	5	20	20	50
Total	25	25	20	20	90

NATIONAL INSTITUTE OF TECHNOLOGY
JAMSHEDPUR – 831014

M.Tech. Curriculum in Materials Technology

in Department of Metallurgical & Materials Engineering

(Semester I to IV)

I-SEMESTER				
Sl. No.	Course Code	Subject	L-T-P	Credits
1.	MT 41101	Thermodynamics and Phase Diagrams	3-0-2	4
2.	MT 41102	Principles and Techniques of Materials Characterization	3-0-2	4
3.	MT 41103	Mechanical Behaviour of Materials	3-0-2	4
4.		Elective-I	3-0-2	4
5		Elective-II	3-0-2	4
6	MT 41201	Materials Characterization Laboratory	0-0-3	2
7	MT 41202	Physical Metallurgy Lab	0-0-3	2
8	MT 41301	Seminar	0-0-2	1
		TOTAL	15-0-18	25

II-SEMESTER				
Sl. No.	Course Code	Subject	L-T-P	Credits
1.	MT 42101	Mathematical Modeling and Computer application in Metallurgy	3-0-2	4
2.	MT 42102	Physical Metallurgy of Advanced Materials	3-0-2	4
3.	MT 42103	Phase Transformation of Materials	3-0-2	4
4.		Elective-III	3-0-2	4
5		Elective-IV	3-0-2	4
6	MT 42201	Computational Lab	0-0-3	2
7	MT 42202	Phase Transformation (Heat treatment) Lab.	0-0-3	2
8	MT 42301	Seminar	0-0-2	1
		TOTAL	15-0-18	25

III-SEMESTER				
Sl. No.	Sub. Code	Subject	L-T-P	Credits
1.	MT 43401	Research Project Work – I		20
			TOTAL	20

IV- SEMESTER				
Sl. No.	Sub. Code	Subject	L-T-P	Credits
1	MT 44401	Dissertation		20
			TOTAL	20

Elective – I & II

MT41104 Principles of Materials Engineering (for non metallurgy background)*
MT41105 Dislocation Theory and plastic flow
MT41106 Structure & Properties of Metals and alloys
MT41107 Mechanical Working of Materials
MT41108 Advanced Processing Of Materials

Elective – III & IV

MT42104 Surface Engineering
MT42105 Environmental degradation of material
MT42106 Fracture Mechanics and Analysis of Engineering Failures
MT42107 Advance Ceramic and Glasses
MT42108 Manufacturing Processes
MT42109 Advanced Foundry Technology
MT42110 X ray studies of deformed crystals
MT42111 Advance Composite Materials
MT42112 MEMS and NEMS
MT42113 Solidification Technology
MT42114 Joining of Materials
MT42115 Deformation Behaviour of Materials
MT42116 Heat Treatment Technology
MT42117 Nano Structured Materials
MT42118 Powder materials and processing
MT42119 Materials design
MT42120 Advance Materials Science and Engineering

DETAILED SYLLABI OF COURSES

MT 41101 Thermodynamics and Phase Diagrams: 4 Credits [3-0-2]

Thermodynamics basic concepts (state variables, the first law, the enthalpy concept, heat capacity) The second law (reversible and irreversible processes, entropy, Gibbs energy, Hemholtz energy, Gibbs-Duhem equation, Maxwell's relationships) Equilibrium conditions (chemical potential, driving force, the third law, Clausius-Clapeyron equations, Thermodynamic application to materials: Ellingham diagrams; Electrochemistry: Porbaix diagrams; thermodynamics of solutions, construction and interpretation of 2 component phase diagrams.
Phase Diagram – Gibbs's Phase rule – Interpretation of mass fractions using Lever's rule – Hume Rothery rules-Binary Iso-morphous system- Binary Eutectic alloy system (Lead-Tin System) – Binary Peritectic alloy system (Iron-Nickel System) – Invariant reactions – Iron-Iron carbide phase diagram- Slow cooling of Hypo and hyper eutectoid steels – Temperature-Time-Transformation (TTT) and Continuous Cooling Transformation (CCT) Diagrams, Phase equilbria in ceramics

Text Book:

1. Introduction to the Thermodynamics of Materials, David R. Gaskell, 5th ed., CRC Press, 2008.
2. Phase Transformations in Metals and Alloys, Porter, Easterling; 3ed ed, CRC Press, 1991.
3. Thermodynamics in Materials Science, Robert De Hoff; 2nd ed, 2006.

Reference Book:

1. Ceramic Materials: Science and Engineering, C. Barry Carter, M. Grant Norton; Springer, 2007

MT 41102 Principles and techniques of materials characterization: 4 Credits [3-0-2]

Optical Metallography techniques like polarized light microscopy, DIC, fluorescence, etc.; Diffraction Methods like texture measurement, residual stress analysis, EXAFS, neutron diffraction, etc.; Electron Optical and related techniques like TEM, SEM, EDS, WDS/EPMA, CBED, HREM, EELS, etc.; Surface Analysis and related techniques like Auger, XPS, SIMS, RBS, STM, AFM, etc.; Thermal Analysis like DTA, DSC, TGA, TMA, etc.; Spectroscopy Techniques like optical emission spectroscopy, atomic absorption spectrometry, x-ray spectrometry, infrared spectroscopy, Raman spectroscopy, electron spin resonance, nuclear magnetic resonance, Mossbauer spectroscopy, etc.; Electrical Resistivity measurement.

Text Book:

1. P. J. Goodhow, J.Humbreys & R.Beanland, Electron Microscopy & Analysis (III Edn.); Taylor & Francis Publ., 2001.
2. D. Brandon & W.D. Kaplan, Microstructural Characterization of Materials; John Wiley & Sons Publ., 1999.

Reference Book:

1. A. Guthrie & R. K. Wakerling: Vaccum Equipments and Techniques; McGraw Hill, New York.
2. B. Chalmers & A. G. Quarell: Physical Examinations of Metals, Edward Arnold, 1960.
3. E.C. Subba Rao; Metal Experiments

MT 41103 Mechanical behavior of Materials: 4 Credits [3-0-2]

Dislocation Theory: Introduction, dislocation reaction, cross slip and climb of dislocations, Dislocation sources and dislocation multiplication, Dislocation pile ups; Tensile Behaviours of Metals: True stress-true strain curve, Strain hardening coefficient, Instability in tension, Effect of strain rate and temperature on flow properties; Fracture: Griffith's theory of brittle fracture, Mechanism of brittle and ductile fracture, Fractographic aspects of fracture, Notch effects; Impact Behaviour: Notch bar impact test, Transition temperature phenomenon, Instrumented Charpy test; Theories of solid solution strengthening, theories of precipitation strengthening, theories of polycrystalline strengthening, theories of deformation in coarse multiphase systems, study of the relation between stress, strain, strain rate and temperature for plastically deformable bodies, deformation mechanism maps, creep and superplasticity in solids, deformation behaviour of irradiated materials, computer modelling of microstructure-deformation behaviour relations in solids.

Text Book:

1. G E Dieter, Mechanical Metallurgy –McGraw – Hill Publication (1988).
2. R W Hertzberg, Deformation and Fracture Mechanics of Engineering Materials – John Wiley & Sons Publication (1995).

Reference Book:

1. R E Reed, Physical Metallurgy Principals, Hill Litton Education Publication (2004).
2. W. Soboyejo, Mechanical Properties of Engineering Materials, Marcel Dekker Publication (2003).

MT 41104 Principles of Materials Engineering: 4 Credits [3-0-2]
(For non metallurgy background)

Crystal Structure: Space lattices, Bravais lattices and Reciprocal lattice concept. Miller Indices of planes and directions; Bonding in Solids: Ionic, Covalent, and Metallic bonding. Theory of alloy formation, Solid solution, Substitutional and interstitial solid solution, Hume Rothery Rules, Intermetallic compounds, Normal valency compounds, Electron compounds, Interstitial compounds; Imperfections: Point defects: vacancies, Interstitialcies, Dislocations: Edge & Screw dislocations, Burgers vector; Binary Phase Diagrams: Isomorphous, Eutectic, Peritectic, Eutectoid, Monotectic & Syntectic systems. Phase rule and Lever rule; Iron-Cementite Equilibrium diagrams and its applications; Diffusion: Fick's First and Second law of diffusion. Atomic model of diffusion. Grain boundary, surface and thermal diffusion. Kirkendall Effect, Grube method, Matano method, Interstitial diffusion; Nucleation: Homogeneous and Heterogeneous nucleation, Kinetics of nucleation. Growth and overall transformation kinetics.

Text Book:

1. V. Raghavan, Materials Science and Engineering, Prentice-Hall of India Private Limited (2003).
2. W.F. Smith, Principles of Materials Science and Engineering, McGraw Hill, New York (1994).

Reference Book:

1. R.E. Reid Hill, Physical Metallurgy Principles- PWS-Kent Publishing (2004).
2. V. Singh, Physical Metallurgy, Standard Publisher (2008).
3. W.D.Callister, An Introduction Materials Science & Engineering, John Wiley & Sons (2007).

4. L.H. Van Vlack, Elements of Materials Science and Engineering, Addison Wisley, New York (1985).

MT 41105 Dislocation Theory and plastic flow: 4 Credits [3-0-2]

General aspects of deformation in crystalline solids, review of elasticity theory and stress field around stationary and moving dislocation, forces on a dislocation including concepts of self-energy, line tension, chemical forces and forces between dislocations for varied configurations of dislocation, kinetics of dislocation flow, dislocations in fcc structures, dislocations in bcc, hcp, ordered and superlattice structures, jogs and intersection of dislocations incorporating concepts of elementary, composite and extended jogs, dislocations dipoles, attractive and repulsive junctions, origin and multiplication of dislocations, dislocation arrays and crystal boundaries; Interpretation of tensile response of crystalline solids including theories related to yielding, flow stress and work-hardnening, dislocations and creations of discontinuities.

Text Book:

1. D. Hull and D. J. Bacon, Introduction to dislocation, Elsevier Ltd (2011).
2. J.P. Hirth and Lothe Theory of Dislocations, John Wiley and Sons (1982).

Reference Book:

1. J. Weertman, Elementary Dislocation Theory- Oxford University Press (1992).
2. V. Singh, Physical Metallurgy, Standard Publisher (2008).

MT 41106 Structure & Properties of Metals and alloys: 4 Credits [3-0-2]

Materials in Engineering Design- Metals, Polymers, Ceramics, Composites, Properties of engineering materials relevant to failure
Atomic Structure of Metals-Crystalline solids, Polycrystalline solids, grains and grain boundaries
Metals and Alloys: microstructures, their effect on mechanical properties and their control - Plastic deformations in metals, Elements of fracture mechanics, High temperature creep, Corrosion
Microstructure control in metal alloys-Solidification, Solid state diffusional transformation, Precipitation, nucleation and growth, dispersion strengthened alloys
Case studies-Light alloys (Al & Ti), Steels and Ni superalloys
Molecular Structure of Polymers-Polymerisation, Molecular architecture, Co-polymerisation Thermoplastics and thermosets
Mechanical Properties and Testing-Elastomers, Brittle Materials, Semicrystalline Polymers Ageing and Failure
Blends and Composites, Case Studies-Thermoplastics, Composites
Material Characterization-Mechanical Properties, Structural Characterization

Text Book:

1. V. Raghavan, Materials Science and Engineering, Prentice-Hall of India Private Limited (2003).
2. W.F. Smith, Principles of Materials Science and Engineering, McGraw Hill, New York (1994).

Reference Book:

1. R.E. Reid Hill, Physical Metallurgy Principles- PWS-Kent Publishing (2004).
2. V. Singh, Physical Metallurgy, Standard Publisher (2008)

3. W. D. Callister, An Introduction Materials Science & Engineering, John Wiley & Sons (2007)
4. L.H. Van Vlack, Elements of Materials Science and Engineering, Addison Wisley, New York (1985).

MT 41107 Mechanical Working of Materials: 4 Credits [3-0-2]

Fundamentals of Metal working processes: Theory of plasticity and yield criterion, Workability Tests, Hot working, Cold working and warm (semi-hot) working of metals, structure of cold worked and hot worked metals; Rolling of Metals: Various rolling Mills and rolling processes, Theories of Hot and Cold rolling Defects in rolling and their remedial measures. Rolling Mill Control, Concepts of roll-pass-design, Roll pass design of some simple shapes like Flat products, Blooms, rounds, etc; Forging of Metals: Type of forging processes, Die design, Various forging equipments, Forging defects and their remedies, Load and energy requirements in Forging, Forging of Rail wheels and tyres; Extrusion of Metals: Types of Extrusion processes, Metal flow in Extrusion process, Variables in extrusion, Extrusion defects and their remedies, Load and energy requirements, sheathing and cladding by Extrusion; Drawing of Metals: Type of operation, Dies, Load and Energy requirement, Drawing of seamless Tubes; Sheet Metal Forming: Operations, Equipment, Technology, Defects and their remedies; Non conventional Processes: High Energy rate forming processes Explosive forming of Metals, Electromagnetic forming.

Text Book:

1. G.E. Dieter, Mechanical Metallurgy.
2. A.Ghosh& A. Mallick. Manufacturing Sciences.

Reference Book:

1. P. Polukhin, N. Fedosov, A.Korolyov & Y. Matveyer, Rolling Mill Practice, Making Shaping and Treating of Steel.

MT 41108 Advanced Processing of Materials: 4 Credits [3-0-2]

Rapid solidification, Powder processing, Preparation and consolidation of nanopowders, Sintering, Spark Plasma and Microwave sintering, Shock compaction, Severe plastic deformation, Mechanical Alloying, near-net-shape forming, self-sustaining high temperature synthesis, sol-gel processing, zone refining, molecular beam epitaxy, laser processing, EDM, etching, glass-ceramic seals, solid oxide fuel cells, armor ceramics, Processing and manufacturing technologies for non-oxide and oxide based structural ceramics, composites, multifunctional materials; Stereolithography (SLA), selective laser sintering (SLS), direct metal laser sintering; (DMLS) and laser engineered net shaping (LENS), Spray formed tooling for rapid manufacture, Plasma spray coating; Preparation of single crystals, doping, sputter coating, CVD and EVD process.

Text Book:

1. W.F. Smith, Principles of Material Science and Engineering, McGraw Hill, 1990.
2. O. Tatsuki,Advanced processing & manufacturing technologies for structural & multifunctional materials, Lavoisier, 2007.
3. O.Tatsuki, M.Singh, J.Salem, D. Zhu, Advanced Processing and Manufacturing Technologies for Structural and Multifunctional Materials, (eds.), Ceramic Engineering and Science Proceedings. Vol. 28(7).1st Edition 2007. ISBN-10: 0-470-19638-6 - John Wiley & Sons.

Reference Book:

1. R. Hugon, Thin Film Technology, Elsevier Pub., UK, 1978.
2. L. Pawlowski, The Science and Engineering of Thermal Spray Coatings, John Wiley Publications, New York, 1995.
3. F. Kongoli (Editor), R.G. Reddy (Editor) Advanced Processing of Metals and Materials: New, Improved and Existing Technologies: Iron and Steel; Recycling and Waste Treatment Vol.5,Publisher: The Minerals, Metals & Materials Society ISBN-10: 0873396383.
4. G. Goodman, M. Dekkar, Ceramic Materials for Electronics, New York, 1968.
5. S. Kalpakjian, S. Schmid, Manufacturing Engineering and Technology, Prentice Hall; 5th edition, ISBN-10: 0131489658, 2005.

MT 42101 Mathematical Modeling and Computer application in Metallurgy:

4 Credits [3-0-2]

Mathematical modeling: Basic equations of diffusive, convective heat, mass, momentum transfer, turbulent system and concept of friction factor, heat & mass transfer coefficients and correlations. Formulation of mathematical model. Case studies.Numerical solution of partial differential equations.

Physical Simulation: Experimental design based on dimensional analysis, similarity criteria, case studies.

Reactor Design: Ideal reactors (PFR, CSTR), real reactors, characterization of these reactors, chemical performance of reactors, Modeling/design of reactors

Thermodynamic modeling.

Text Book:

1. Applied Numerical Methods with MATLAB for Engineers & Scientist S.C.Chapra

Reference Book:

1. Numerical Methods in Engineering & Science Dr. S.B.Grewal
2. A friendly Introduction to Numerical Analysis by Brian Bradie

MT 42102 Physical Metallurgy of Advanced Materials: 4 Credits [3-0-2]

Ferrous alloys: Alloy Steels - General Introduction, Maraging Steels (Heat-treatment Cycle, Aging behavior), High-Strength Low-Alloy Steels (Role of Microalloying of Steels), Ultra-High Strength Steels (Role of Alloying Elements), Dual-Phase Steels, Stainless Steels (Fe-Cr-Ni System, Schaeffler Diagram, Precipitation of Carbides/Nitrides, Microstructural Aspects of Various Types of SS, Ni-free Duplex SS, Embrittlement Phenomena), Tool Steels (Secondary Hardening, Types of Carbides), TRIP-assisted Steels (Microstructural evolution, Stress induced transformation, Role of alloying elements, Factors affecting performance, Concept of δ-TRIP Steel), Bearing Steels (Metallurgical & Engineering Requirements of Steel, Microstructural Aspects, Microcracking, Spheroidise Annealing, Inclusions, Aerospace Bearings)

Non-ferrous alloys: Nickel-Based Superalloys (Microstructural features, Role of Alloying Elements, Strengthening Mechanisms, Heat-Treatments, Dispersion-Hardened Superalloys), Titanium Alloys (Deformation Modes, Effect of Alloy Addition on Phase Diagrams, Alloy Classification, Phase Transformations, Microstructures, Hardening Mechanisms of Alfa- & Beta- Phases, Microstructure in Dependent of Processing, Basic Correlation between Microstructure & Mechanical Properties, Ti-based Intermetallic Compounds), Aluminum Alloys (Microstructures of Al-Si Alloys, Modified/Unmodified Al-Si Alloys, Aging Process in Al-4%Cu alloy), Brass, Bronze

Physical metallurgy concepts of special alloys: Bulk Nanostructured Steels – the Latest Development in Steels, Mechanically Alloyed Metals, Shape Memory Alloys, Metallic-glass Forming Alloys, Nuclear Power Plant Alloys (Irradiation Damages in Microstructure, Irradiation Hardening, Concepts of ODS Steels)

Text Book:

1. H.K.D.H. Bhadeshia & R.W.K. Honeycombe: "Steels: Microstructure and Properties", 3rd Edition, Butterworth-Heinemann publications, Elsevier Ltd., 2006.
2. Smallman, R. E.; Ngan, A. H. W.: "Physical Metallurgy and Advanced Materials", 7th Edition, Elsevier Ltd., 2007.
3. A.K. Sinha: "Physical Metallurgy Handbook", McGraw Hill, New York, 2003.
4. D.A. Porter, K.E. Easterling & M.Y. Sherif: "Phase Transformations in Metals and Alloys", CRC Press (Indian Edition), 3rd Edition, 2008.

Reference Book:

1. R.C. Reed, The superalloys: fundamentals and applications, Cambridge University Press, 2006.
2. Sourabh Chatterjee, Transformations in TRIP-assisted Steels: Microstructure and Properties, PhD Thesis, University of Cambridge, U.K., 2006.
3. Inoue, X.M. Wang and W. Zhang, Developments and applications of bulk metallic glasses, Rev. Adv. Mater. Sci. 18, pp. 1-9 (2008).

MT 42103 Phase Transformation of Materials: 4 Credits [3-0-2]

Thermodynamics and Kinetics of solid state Phase transformation, Atomic models of Diffusion, Functions of alloying elements, Allotropy of Iron and Fe – C Phase diagram, Importance of Austenite Grain size; Formation of Austenite, TTT and CCT Diagrams; Homogeneous and Heterogeneous nucleations, Strain energy effects; Pearlitic, Bainitic and Martensitic Transformation (Mechanisms, Kinetics and Morphologies); Pearlitic transformation: Factors influencing pearlitic transformation, Mechanism of transformation, Nucleation of growth, Orientation relationship; Bainite transformation: Mechanism of transformation, Nucleation and growth, Orientation relationship, Surface relief, Classical and non-classical morphology, Effect of alloying elements; Martensitic Transformation: Characteristics of transformation, Thermodynamics and kinetics, Nucleation and growth, Morphology, Crystallography, Stabilization; Annealing (Full, Homogenizing, Spherodization and Stress-relieving annealing), Normalising, Comparison of Annealing and Normalizing, Hardening and Tempering of steel, Aims and stages of tempering, Effect of Carbon and alloying elements, Tempering of alloy steels and Multiple tempering.

Text Book:

1. D. A.Porter& K E Easterling, Phase Transformation in Metals and Alloys, CRC Press.
2. V Raghvan, Solid State Phase Transformation, PHI.

Reference Book:

1. J W Christian, The Theory of Transformations in Metals and Alloys, Pergamon Press.
2. J E Hilliard, Phase Transformations, ASM.

MT 42104 Surface Engineering: 4 Credits [3-0-2]

Introduction to surface Engineering, Differences between surface and bulk, Properties of surfaces, surface energy concepts, degradation of surfaces, wear and its type, Adhesive, Abrasive, Fretting, Erosion wear, Surface fatigue, Different types of Corrosion and its

prevention, Galvanic corrosion, Passivation, Pitting, Crevice, Mircobial, High-temperature corrosion, Corrosion in nonmetals, polymers and glasses, Protection from corrosion through surface modifications
Changing the surface metallurgy: Localized surface hardening (flame, induction, laser, electron-beam hardening, Laser melting, shot peening), Changing the surface chemistry: Phosphating, Chromating, Anodizing (electrochemical conversion coating), Carburizing, Nitriding, Ion implantation, Laser alloying, boriding, Organic coatings (paints and polymeric or elastomeric coatings and linings), Hot-dip galvanizing (zinc coatings), Ceramic coatings (glass linings, cement linings, and porcelain enamels), Advanced surface coating methods: Gaseous State (CVD, PVD etc), Solution State (Chemical solution deposition, Electrochemical deposition, Sol gel, electroplating), Molten or semimolten State (Laser cladding and Thermal spraying)
Characterization of surface and coatings, Surface Characterization (physical and chemical methods, XPS, AES, RAMAN, FTIR etc), Structural Characterization, Mechanical Characterization (Adhesion, Hardness, Elastic Properties, Toughness, Scratch and Indentation etc.), Tribological Characterization, Corrosion tests

Text Book:

1. Introduction to Surface Engineering and Functionally Engineered Materials, Peter Martin; Wiley, 2011.
2. Materials and Surface Engineering: Research and Development, J. Paulo Davim; Woodhead Publishing review, 2012.

Reference Book:

1. Surface Engineering: Processes and Applications, Chinnia Subramanian, K.N. Strafford, R. St. Smart, I.R. Sare; Technomic Publishing Company, 1995.
2. Surface Engineering for Corrosion and Wear Resistance, J. R. Davis; ASM International, 2001.

MT 42105 Environmental degradation of material: 4 Credits [3-0-2]

Degradation of materials: Oxidation, corrosion and wear. Basics of thermodynamics and kinetics of oxidation and corrosion. Pourbaix diagram, Polarization, Mixed potential theory. Passivity, Characteristics of passivation, Degradation of composites; Corrosion: Fundamentals of corrosion studies. Different types of corrosion. Atmospheric, galvanic, pitting, crevice corrosion, intergranular and de-alloying. Stress corrosion cracking, season cracking, Hydrogen damage and radiation damage. Hydrogen embrittlement.Corrosion rate measurement. Weld-decay and knife line attack. Tafel's extrapolation. Oxidation and hot corrosion of materials at high temperature. Kinetics of oxidation. Pilling-Bedworth ratio. ; Prevention of degradation: Alloying environment, environmental conditioning, design modification, cathodic and anodic protection, organic and inorganic coating, inhibitors and passivators, Wear resistant coating.

Text Book:

1. M.G. Fontana& N.D Greens, Corrosion Engineering- McGraw Hill publishing company, (2006).
2. H.H. Uhlig, Corrosion & Corrosion Control, John Wiley & Sons, (2000).

Reference Book:

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

MT 42106 Fracture Mechanics and Analysis of Engineering Failures: 4 Credits [3-0-2]

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 (K_{IC}) testing, Fracture toughness determination with elastic plastic analysis (J_{IC}), 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, Coffin-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 K_{ISCC} 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.

Text Book:

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

Reference Book:

1. G.E. Dieter, Mechanical Metallurgy by Mc-Graw Hill (1988).
2. D. Broek, Elementary Fracture Mechanics – Martinus Nijho Publisher

MT 42107 Advance Ceramic and Glasses: 4 Credits [3-0-2]

Processing and evaluation of engineering ceramics. Fracture behavior of ceramic materials, The Weibull distribution, Toughening mechanism. Formation, mechanical properties and uses of fused Alumina, sintered Alumina products, Borides, Carbides, Nitrides, Silicides, Zirconia and partially stabilized Zirconia, Sialons.

Abrasives, abrasive operations, natural abrasives, abrasives like Aluminium oxides, Silicon Carbide, Diamond and Boron nitride, miscellaneous synthetic abrasives, raw materials for abrasives, their proportioning, processing, manufacture of abrasives, grinding wheels, their drying, firing and testing.

Glassy State; Kinetic and thermodynamic criteria for glass formation, use of Na_2O-SiO_2 and Na_2O-CaO- SiO_2 phase diagrams in glass manufacture, types of glasses and their chemical compositions, Physical properties of glasses, density, refractive index, thermal expansion and thermal stresses, thermal endurance of glass, toughening of glasses, strength and fracture behavior of glass and its articles, surface tension, viscosity and its measurement, effect of temperature and composition on the physical properties of glasses

Glass making raw materials, addition of cullet to the batch, reactions amongst the constituents of glass, thermal currents and flow pattern in the glass tank furnace, Defects in glass, bubbles and seeds, cords, stresses and colour inhomogeneity and their remedies, annealing of glasses.

Glass ceramics; Nucleation and crystal growth in glasses, nucleation through micro miscibility, nucleating agents, properties and applications of glass-ceramics

Text Book:

1. Ceramic Materials: Science and Engineering, C. Barry Carter, M. Grant Norton; Springer, 2nd ed. 2013.
2. Glass Science and Technology, D.R. Uhlmann, N. J. Kredl (ed); Vol. 1&2, Academic Press, 1990.
3. Chemistry of Glasses, Amal Paul; Chapman Hall, 1990.

Reference Book:

1. Fundamentals of Ceramics, M.W Barsoum; McGraw Hill, 1997.
2. Introduction to Ceramics, 2nd Ed, W. David Kingery, H. K. Bowen, Donald R. Uhlmann, Wiley, 1976.
3. Hank book of Glass Manufacture, F.V.Tooley; Vol 1&2, Ashlee Pub. Co, 1984.

MT 42108 Manufacturing Processes: 4 Credits [3-0-2]

General structure and properties of engineering materials, classification of common materials, their unique properties and applications; metals and alloys, glass and ceramics, polymeric materials and composites, behavior, testing and manufacturing properties of these materials.
Concepts of manufacturing, basic principles of engineering manufacturing; shaping, joining, removal and regenerative processes, methods of applications of common manufacturing processes; performing by casting, forging, rolling, melting, injection and compression moulding, extrusion and drawing, press tool work, powder processing etc., finishing by machining, grinding and superfinishing, Non-traditional manufacturing by chemical. electrochemical, electrophysical and mechanical processes

Text Book:

1. G.E. Dieter, Mechanical Metallurgy.
2. A.Ghosh& A. Mallick. Manufacturing Sciences.

Reference Book:

1. P.Polukhin, N.Fedosov, A.Korolyov& Y. Matveyer, Rolling Mill Practice, Making Shaping and Treating of Steel.

MT 42109 Advanced Foundry Technology: 4 Credits [3-0-2]

Recent developments in design, materials and methods of manufacture of patterns.Modification in casting design with reference to foundry and metallurgical principles.Principles design and methods involved in Gating and Risers of ferrous and non-ferrous castings.
Recent developments in materials and methods of mould and core making such as high pressure moulding. V- process, magnetic moulding, Sodium silicate based processes, shell process, Hot box, cold box, full moulding etc..
Moulding and sand conditioning equipments. Sand reclamation, principles, technology and scope of sand casting processes, Non-metallic mould etc.
Precision casting processes-Principles.Technology and scope of Die casting. Continuous casting, investment casting. Slush casting.
Casting defects, metal-mould reactions, metal penetration and burn-out etc. general principles and objectives of foundry mechanization and lay out.

Text Book:

1. P.R. Beeley, Foundry Technology, 2001 edition, Publisher – Butterworth & Co.

Reference Book:

1. P.C. Mukherjee, Fundamentals of Metal Castiang Technology.
2. P.D. Webster, Fundamentals of Foundry Technology.

MT 42110 X ray studies of deformed crystals: 4 Credits [3-0-2]

Reciprocal lattice and its relation with diffraction; factors affecting the intensity of diffracted beam, calculation of integrated intensity; estimation of stress, texture and other defects; interaction between electrons and matter; principles of transmission electron microscopy, elements of electron optics, electron lenses - their aberration,. Resolving power, depth and field of focus; kinematical theory of electron diffraction, geometry of electron diffraction and their applications, microdiffraction, trace analysis, bright-field and dark-field image contrast; principles and applications of SEM, principles of microanalysis.

Text Book:

1. B. D. Cullity, Element of X-ray Diffraction, Addison Wesley.
2. C. S. Barret and T. B. Massalski, Structure of Metals, McGraw Hill.

Reference Book:

1. P. J. Goodhow, J. Humhreys, R. Beanland: Electron microscopy & Analysis (III Edn.); Taylor & Francis (publ.) 2001.

MT 42111 Advance Composite Materials: 4 Credits [3-0-2]

Introduction and Overview of Metal based composites, overviews key technologies and issues in the area, Fabrication of Metal Matrix Composites: Commonly used Matrices, Basic Requirements in Selection of constituents, solidification processing of composites - XD process, Spray processes - Osprey Process, Rapid solidification processing, Dispersion Processes - Stir-casting & Compo casting, Screw extrusion, Liquid-metal impregnation technique - Squeeze casting, Pressure infiltration, Lanxide process), Principle of molten alloy infiltration, rheological behaviour of melt-particle slurry, Synthesis of In situ Composites. Resins- Resins used in polymer composites, Fillers- Fibers, conventional fillers and nanofillers used in polymer composites. Fabrication- Different processing techniques for polymer composites.Testing and characterization, Structure property relationship in conventional polymer composites and polymer nanocomposites, Applications. Ceramic matrix composites, mechanical properties of ceramic matrix composites, different processing techniques for ceramic matrix composites, process capability and applications of various techniques.

Text Book:

1. Composite materials, K.K. Chawala; 2nd ed.,Springer-Verlag, 1987.
2. Nanocomposite Science and Technology, P. M. Ajayan, L. S. Schadler, P. V. Braun; Wiley-VCH Verlag GmbH Co, 2013.
3. Mechanics and Analysis of Composite Materials, V.V. Vasiliev, E.V. Morozov; Elsevier Science Ltd, 2001.
4. Ceramic matrix composites, K.K. Chawala; 1st ed., Chapman & Hall,1993.
5. Advances in composite materials, G. Piatti Applied Science Publishers Ltd., 1978.
6. Composite Materials, Mel. M. Schwartz; Vol 1 & 2, Prentice - Hall PTR, 1997.
7. Advanced Polymer composites, BorZ.Jang; ASM International,1994

8. Experimental Characterization of advanced composite materials, L.A. Carlsson and R.B. Pipes, 2nd ed., CRC Press, 1996.

Reference Book:

1. Handbook of Composites, George Lubin, Stanley T. Peters , Springer, 1998.
2. Mechanics of composite materials, Richard M. Christensen, Dover Publications, 2005

MT 42112 MEMS and NEMS: 4 Credits [3-0-2]

Micro and nano mechanics – principles, methods and strain analysis, an introduction to micro sensors and MEMS, Evolution of Microsensors& MEMS, Microsensors & MEMS applications, Microelectronic technologies for MEMS, Micromachining Technology – Surface and Bulk Micromachining, Micromachined Microsensors, Mechanical, Inertial, Biological, Chemical,Acoustic, Microsystems Technology, Integrated Smart Sensors and MEMS, Interface Electronics for MEMS, MEMS Simulators, MEMS for RF Applications, Bonding & Packaging of MEMS, Conclusions & Future Trends. Nanoelectromechanical systems (NEMS) – a journey from MEMS to NEMS, MEMS vs. NEMS, MEMS based nanotechnology – fabrication, film formation and micromachining, NEMS physics – manifestation of charge discreteness, quantum electrodynamical (QED) forces, quantum entanglement and teleportation, quantum interference, quantum resonant tunneling and quantum transport, Wave phenomena in periodic and aperiodic media – electronic and photonic band gap crystals and their applications, NEMS architecture, Surface Plasmon effects and NEMS fabrication for nanophotonics and nanoelectronics, Surface Plasmon detection – NSOM/SNOM

Text Book:

1. Electromechanical Sensors and Actuators, Ilene J. Busch- Vishniac, Springer, 2008.
2. Introduction to Microelectronics Fabrication, Vol. V, G. W. Neudeck and R. F. Pierret (eds.), Addison – Wesley, 1988.
3. Introduction to Microelectromechanical Microwave Systems, H. J. De Loss Santos, 2nd edition, Norwood, MA: Artech, 2004.
4. Microsystems Design, S. D. Senturia, Kluwer – Academic Publishers, Boston MA, 2001.
5. Principles and Applications of Nano-MEMS Physics, H. J. Delos Santos, Springer, 2008.
6. Materials and Process Integration for MEMS Microsystems, Vol. 9, Francis E. H. Tay, Springer, 2002.

Reference Book:

1. Quantum Mechanical Tunneling and its Applications, D. K. Roy, World Scientific, Singapore, 1986
2. Encyclopedia of Nanoscience and Technology, Vol. 5, H. S. Nalwa (ed.), American scientific Publishers, 2004
3. Carbon Nanotubes and Related Structures, P. J. F. Harris, Cambridge University Press, UK, 1986.
4. Carbon Nanoforms and Applications, M Sharon and M. Sharon, McGraw Hill, 2010
5. VLSI Technology, S. M. Sze (eds.), Mc-Graw Hill, NY, 1983
6. Quantum Phenomena, S. Datta, Addison – Wesley, 1989.

MT 42113 Solidification Technology: 4 Credits [3-0-2]

Plane front solidification of single phase alloys, interface stability, Czochralski growth, growth of single crystals of high perfection, cellular solidification, cellular-dendritic transition, plane front solidification of polyphase alloys, macro- and micro-morphology of eutectic growth, growth of graphite in cast irons, some problems in solidification of polyphase alloys, inclusions - their formation and distribution; Rheocasting, Thixocasting, Electroslag casting, casting of composites.

Text Book:

1. P.R. Beeley, Foundry Technology, 2001 edition, Publisher – Butterworth & Co.

Reference Book:

1. P.C. Mukherjee, Fundamentals of Metal Casting Technology.
2. P.D. Webster, Fundamentals of Foundry Technology.

MT 42114 Joining of Materials: 4 Credits [3-0-2]

Introduction: Principle, Theory and Classification of welding and other joining processes; Manual metal arc (MMA): Equipment requirement, electrodes for welding of structural steels, coating constituents and their functions, types of coatings, current and voltage selection for electrodes, Arc welding power sources; Conventional welding transformers, rectifiers and current and voltage. The influence of these power sources on welding. Metal transfer; Submerged arc welding (SAW): Process details, consumables such as fluxes and wires for welding mild steel, Variations in submerged arc welding process; Gas metal arc welding (GMAW) or MIG/ MAG welding: Process details, shielding gases, electrode wires, their sizes, and welding current ranges. TIG welding: Process details, power sources requirements, electrode sizes and materials, current carrying capacities of different electrodes, shielding gases, application of process. Resistance welding: General principle of heat generation in resistance welding, application of resistance welding processes; Process details and working principle of spot, seam, and. projection welding, electrode materials, shapes of electrodes, electrode cooling, selection of welding currents, voltages; Welding metallurgy of carbon and alloy steels, Cast irons, Stainless steels, Al- and Cu-based alloys. Weldability and Heat affected zones (HAZ); Welding defects and detection techniques; Soldering and brazing: Difference between the processes, consumables used, methods of brazing, fluxes used, their purposes and flux residue treatment.

Text Book:

1. J F Lancaster, Metallurgy of Welding, Allen and Unwin.

Reference Book:

1. J. Norrish, Advanced Welding Processes, Woodhead.

MT 42115 Deformation Behavior of Materials: 4 Credits [3-0-2]

Dislocation Theory: Introduction, dislocation reaction, cross slip and climb of dislocations, Dislocation sources and dislocation multiplication, Dislocation pile ups; Tensile Behaviours of Metals: True stress-true strain curve, Strain hardening coefficient, Instability in tension, Effect of strain rate and temperature on flow properties; Fracture: Griffith's theory of brittle fracture, Mechanism of brittle and ductile fracture, Fractographic aspects of fracture, Notch effects; Impact Behaviour: Notch bar impact test, Transition temperature phenomenon, Instrumented Charpy test; Fracture Mechanics: Strain energy release rate, Stress intensity factor, Plan strain facture toughness, Fatigue: Micromechanisms of crack initiation and

growth, Stress and strain approaches of fatigue, Fracture mechanics approach, Fatigue crack growth, Life prediction; Creep: Creep curves, Mechanisms of creep, Stress rapture test, Life prediction, High temperature alloys; Environmental Assisted Cracking: Stress corrosion cracking, Hydrogen embrittlement, Corrosion fatigue.

Text Book:

1. G E Dieter, Mechanical Metallurgy –McGraw – Hill Publication (1988).
2. R W Hertzberg, Deformation and Fracture Mechanics of Engineering Materials – John Wiley & Sons Publication (1995).

Reference Book:

1. W. Soboyejo, Mechanical Properties of Engineering Materials, Marcel Dekker Publication (2003).

MT 42116 Heat Treatment Technology: 4 Credits [3-0-2]

Time-temperature parameters of a heat treatment process; classification of heat treatment processes; heat treatment as applied to the products of steel-making industry, machine building and automobile industry, tool making industry, etc.; heat treatment defects and their rectification, modernization of heat treatment processes for near net shape applications and surface treatments; energy efficiency in heat treatments; furnace atmospheres and their production, heating and cooling media and their characteristics; calculations on heating and cooling of charges; equipment of heat treatment shops and their selection; mechanization, automation, design and layout of heat treatment shops.

Text Book:

1. V Raghavan, Solid State Phase Transformation, PHI.
2. V Sing, Heat Treatment of Metals, Standard Publishers.

Reference Book:

1. J W Christian, Theory of Transformations in Metals and Alloys, Pergamon Press.

MT 42117 Nanostructured Materials: 4 Credits [3-0-2]

Nanocrystals, thin films & coatings, definitions, Effect on properties and phase stability in lower dimension compared to the bulk state, Materials at Reduced Dimensions, Two-dimensional nanostructures – surfaces and films, One-dimensional nanostructures –nanotubes and wires, Zero dimensional nanostructures – fullerenes, nanoparticles, nanoporous materials, Nanoclays, Graphene, polyhedral oligomericsilsesquioxane (POSS) nanoparticles, Colloidal Monodispersed Nanocrystals, nanocrystals of ferrites, oxides and chalcogenides, core-shell nanoparticles, micelle assisted nanoparticles, surfactant coated nanoparticles, microemulsion synthesis, self-assembly routes, Inorganic-organic hybrid materials, hydrophobic and hydrophilic nanoparticles, water-dispersable nanoparticles, Synthesis routes, Sol-gel technique, Nonaqueous Sol–gel route for Metal Oxide nanoparticles, hydrothermal synthesis, co-precipitation, preparation of nanocomposites, Properties and applications at nanoscale, Electrical, Mechanical, Magnetic, (Electro)Chemical, Optical, Thermal and thermoelectric properties, Health and regulatory issues with Nanomaterials

Text Book:

1. Nanostructures and Nanomaterials: Synthesis, Properties, and Applications, 2nd ed., Guozhong Cao, Ying Wang; Imperial College Press, 2004.
2. Nanoparticles: From Theory to Application, Günter Schmid, Wiley, 2005.

3. Synthesis, Properties, and Applications of Oxide Nanomaterials, José A. Rodriguez, Marcos Fernández-García, Wiley, 2007
4. Monodispersed Particles, T. Sugimoto, Elsevier.
5. Characterization of Nanophase Materials, Zhong Lin Wang, Wiley
6. Nanomaterials, Nanotechnologies and design: an introduction for engineering and architects, Michael Ashby and Paulo J. Ferreira; Elsevier, 2009.

Reference Book:

1. Nanoscale Materials in Chemistry, Kenneth J. Klabunde, Ryan M. Richards, 2nd Edition, Wiley, 2009
2. Nanoparticulate Materials: Synthesis, Characterization, and Processing, Kathy Lu, Wiley.
3. Nanostructured Materials (Processing, Properties and Applications), Carl C. Koch, Elsevier, 2006
4. Nanoparticles and Nanostructured Films: Preparation, Characterization, and Applications, Janos H. Fendler, Wiley, 2008
5. Nanostructured Materials and Nanotechnology, Hari Singh Nalwa (ed.); Elsevier, 2001.

MT 42118 Powder materials and processing: 4 Credits [3-0-2]

Introduction: Development of powder metallurgy, scope of powder metallurgy, characterization of metal powders, physical properties-particle size and shape determination, technological properties-apparent density, flow rate etc. and chemical properties, particle interaction and control. Powder manufacturing: powder mixing and blending, dry and colloidal processing, reduction, electrolysis, and atomization processes, shaping techniques such as compacting, injection molding. Compaction and sintering: Die compaction and other consolidation techniques, sintering, sintering with liquid phase. Powder metallurgy products: Bearing, filters, friction parts, hard metals, refractory metals, contact materials, magnetic materials, structural parts, dispersion strengthened materials.

Text Book:

1. Powder metallurgy science, Technology& Materials by Anish Upadhyay & G.S. Upadhyaya.
2. Powder Metallurgy by B. K. Dutta

Reference Book:

1. TREATISE ON POWDER METALLURGY in three volumes by Glaus G. Goetzel
   Volume 1: Technology of Metal Powders and Their Products
   Volume II: Applied and Physical Powder Metallurgy
   Volume III: Classified and Annotated Bibliography Introduction: Development of powder metallurgy, scope of powder metallurgy

MT 42119 Materials design: 4 Credits [3-0-2]

Physical properties of materials – review; Property measurements techniques and limitations; Ashby diagrams-interpretations; Materials selection for: stiffness-limited design, strength limited design, fracture-limited design; Creep behavior of materials: design of materials for high temperature; Materials processing: classification and choice for design; Phase prediction using first principles and CALPHAD approach; Structure-property relationship using molecular dynamic simulation; Processing – microstructure correlation using finite element and phase field simulation methods.

Text Book:

1. Materials Engineering, Science, Processing and Design/ M. Ashby, H. Shercliff & D. Cebon.

Reference Book:

1. Handbook of Materials Modeling (Vol. 1 & 2) by Sidney Yip
2. ASM Handbooks Vol. 22A

MT 42120 Advance Materials Science and Engineering: 4 Credits [3-1-0]

Introduction: Various classes of advanced materials; Ultra light Materials and Metallic Foams: Material Definition and Processing, Characterization of cellular metals, Material properties and applications; Bio-Materials: Various types of biomaterials, Biopolymer, Bioceramics, Nanostructured bio-materials, Classes of materials used in medicine, Application of materials in medicine and dentistry, Various materials and coatings for implants; Composite Materials: Material definition and classifications, Advanced polymer composite, Ceramic composite, Metal matrix composite, Nanocomposite, Applications; Coatings, surface modification and high temperature materials; Semiconductors: Electronic structure, Macroscopic properties, Applications; Smart materials: Piezoelectric materials, Shape memory alloys, Magnetic shape memory, Thin film shape memory alloys for MEMS application; Super alloys: Types of super alloys, Properties and applications; Structural Ceramics: Crystalline and amorphous ceramics, Bonding in ceramics, Properties, Applications.

Text Book:

1. Jr. W. D. Callister, Materials Science and Engineering, An Introduction, 5th Edition, John Wiley & Sons, Inc., New York, 1999, with CD-ROM.
2. R E Smallman, A.H.W. Ngan, Physical Metallurgy and Advanced Materials, Seventh Edition, Butterworth-Heinemann, 2007, ISBN: 0750669063.
3. Edited by B.D. Ratner, A.S. Hoffman, F.J. Sckoen, and J.E.L Emons, Biomaterials Science, An Introduction to Materials in Medicine, Academic Press, Second edition, 2004.

Reference Book:

2. Edited by H.P. Degischer & B. Kriszt, Handbook of Cellular metals, Production, processing, Application, Wiley - VCH, 2002.
3. Edited by J. R. Davis, Handbook of Materials for Medical Devices, ASM international, 2003.
4. L.J. Gibson, and M.F. Ashby, Cellular Solids, Structure and Properties, 2nd Edition, Cambridge University Press, 1999.
5. Ashby, M. F. Evans, A. Fleck, N. A. Gibson, L. J. Hutchinson, J. W. & Wadley, H. N. G. Metal Foams: A Design Guide, Butterworth-Heinmann, Massachusetts; 2000.
6. Disegi, Kennedy, and Pilliar, Cobalt-Base Alloys for Biomedical Applications, ASTM-STP1365.
7. J.F. Shackelford, Advanced Ceramics, Vol.1- Bioceramics, Gordon and Breach Science Publishers, 1999.
8. M. Ohring, Materials Science of Thin Films, 2ndEdition, Academic Press, 2002.
9. C.T. Herakovich, Mechanics of Fibrous Composites, John Wiley & Sons, Inc., New York, 1998.
10. M.P. Grover, Fundamentals of Modern Manufacturing, Materials, Processing, and Systems, 2ndedition, John Wiley & Sons, Inc.

11. S. Suresh, A. Mortensen and A. Needleman, Fundamentals of metal matrix composites, Butterworth Heinemann, 1993.
12. Henkel and Pense, Structure and properties of engineering materials, fifth edition, McGraw Hill, 2002.