M.Tech. Degree

MATERIALS SCIENCE AND ENGINEERING

SYLLABUS
FOR
CREDIT BASED CURRICULUM
(2011-2013 Batch)

Department of Metallurgical and Materials Engineering
National Institute of Technology
Tiruchirappalli - 620 015

July 2011

M.Tech. MATERIALS SCIENCE AND ENGINEERING

The total minimum credits required for completing the M.Tech. Programme in Materials Science & Engineering is **64.**

SEMESTER – I

CODE	COURSE OF STUDY	L	T	P	C
MA 613	Engineering Mathematics	3	0	0	3
MT 601	Physical Metallurgy	4	0	0	4
PH 610*	Electrical, Magnetic and Optoelectronic Materials	3	0	0	3
MT 655	Thermodynamics and Kinetics	3	0	0	3
MT 657	Metallography, Materials Testing and Characterization Laboratory	0	0	3	2
	Elective - I	3	0	0	3
	Elective – II	3	0	0	3
					21

SEMESTER – II

MT 659	Manufacturing Processes	3	0	0	3
MT 654	Ceramics, Polymers and Composites	4	0	0	4
MT 656	Nanomaterials and Technology	3	0	0	3
	Elective – III	3	0	0	3
	Elective – IV	3	0	0	3
	Elective – V	3	0	0	3
					19

SEMESTER – III

MT 697	Project Work Phase -I	0	0	30	12
					12

SEMESTER – IV

MT 698	Project Work Phase -II	0	0	30	12
					12
				Total Credits	**64**

* Code number is prone for change

ELECTIVES

MT 613	Mechanical Behaviors of Materials
MT 615	Selections of Materials
MT 617	Computational Techniques
MT 619*	Surface Engineering
MT 621	Testing, Inspection and Characterization
MT 623	Ceramic Science and Technology
MT 614	Corrosion Engineering
MT 618	Metallurgical Failure Analyses
MT 660	Biomaterials
MT 662	High Temperature Materials
MT 674	Developments in Iron Making and Steel Making
MT 665	Particulate Technology
MT 666	Statistical Quality Control and Management
MT 670	Polymer Processing
MT 671	Nuclear Materials
MT 673	Severe Plastic Deformations

* Code number is prone for change

MA 613 ENGINEERING MATHEMATICS

L	T	P	C
3	0	0	3

Partial Differential equations – basic concepts – One dimensional heat flow equation - Two dimensional heat flow equation in steady flow in Cartesian and Polar coordinates.

Calculus of variations - Euler's equation - Variational problems in parametric form - Natural boundary condition – Conditional Extremum - Isoperimetric problems.

Numerical Solution of ODE's – Euler's, Taylor's and Runge Kutta methods – Milne's and Adams' predictor-corrector methods.

Finite difference scheme for elliptic, parabolic, and hyperbolic partial differential equations.

Introduction to Finite Element Method - Rules for forming interpolation functions - Shape functions - Application to fluid flow and heat transfer problems.

TEXT BOOKS

1. *Desai, C.S. and Abel, J. P., Introduction to Finite Element Method, Van Nostrand Reinhold.*
2. *Elsegolts, L., Differential Equations and the Calculus of Variations, Mir Publishers.*
3. *Grewal, B.S., Higher Engineering Mathematics, Khanna Publishers.*
4. *Reddy, J.N., Introduction to Finite Element Method, Mcgraw Hill.*

MT 601 PHYSICAL METALLURGY

L	T	P	C
4	0	0	4

(*This is a core course for both WE and MS specializations in MME*)

Introduction to engineering materials. Atomic structure and inter atomic bondings, theoretical concept of crystalline materials – types of packing, voids and packing factors for each of the packings, concept of alloy design using lattice positions and intristitial voids. Planes and directions and imperfections in solids. Polymorphism and allotropy.

Basic concept of dislocations their types and its interactions. Concept of alloying steels and non-ferrous metals such as aluminum, magnesium, titanium zinc and copper, Diffusion, energetic of solidification Nucleation and growth-dealing homogeneous and heterogeneous nucleations and growth of solids, dendritic growth in pure metals, constitutional super cooling and dendritic growth in alloys. Phase diagrams dealing unary, binary, ternary and quaternary phase diagrams. Understanding of isotherms and isopleths.

Phases and micro constituents in steels and cast irons- equilibrium and non-equilibrium cooling of different Fe-C alloys. Effect of alloying elements and cooling rate on structure and properties of steels and cast irons.TTT and CCT diagrams – hardenability measurements,

annealing, normalizing and tempering. Heat treatment furnaces – atmospheres – quenching media – case hardening techniques.

Introduction to specifications – types of steels, alloy steels, tool steels; stainless steels. Types of cast irons – compositions, properties and applications, specific heat treatment.

Dislocations and strengthening mechanisms strengthening by grain-size reduction, solid solution strengthening, strain hardening, Recovery, recrystallization and grain growth, dispersion hardening and other recent modes of hardening.

Fundamentals of fracture – ductile and brittle fracture, principles of fracture mechanics, impact fracture testing, crack initiation and propagation, crack propagation rate, factors affecting fatigue life – Environmental effects. Assessment of fractography.

Text Books

1. *Avner, S. H., "Introduction to Physical Metallurgy", second edition, McGraw Hill, 1985.*
2. *William F. Hosford, Physical Metallurgy, Taylor & Francis Group, 2008*
3. *Raghavan, V., "Physical Metallurgy", Prentice Hall of India, 1985*
4. *Donald R Askland and Pradeep P Phule "Essentials of Materials Science and Engineering, Baba Barkha NathPrinters, Delhi.*
5. *Willam D. Callister, Jr. Materials Science and Engineering, Wiley India Pvt. Ltd.*
6. *Vijendra Singh, Physical Metallurgy, Standard Publishers.*

PH 610 - ELECTRICAL, MAGNETIC AND OPTOELECTRONIC MATERIALS

Electrical and Dielectric Materials: Review of electrical conduction - resistivity and dielectric phenomena - concept of polarization - effects of composition, frequency and temperature on these properties - discussion on specific materials used as conductors (OFHC Copper, Al alloys, Fe-Si alloys, amorphous metals) - discussion on specific materials used as dielectrics (ceramics and polymers) - dielectric loss, dielectric breakdown - ferro electricitypiezo and pyro electricity.

Magnetic Materials: Introduction to dia, para, ferri and ferro magnetism - hard and soft magnetic materials - iron- silicon alloys – iron, nickel alloys - ferrites and garnets - (Ag - Mn - Al) alloys - (Cu - Ni- Co) alloy - fine particle magnets - applications of hard and soft magnetic materials - Giant magneto resistance- Nanomaterials.

Semiconducting and Superconducting Materials: Review of semiconducting materials - concept of doping - simple and compound semi conductors - amorphous silicon, oxide semiconductors; amorphous semiconductors - FER, MOSFET and CMOS - Concept of super

Production of Electronic Materials: Review of electronic materials - methods of crystal growth for bulk single crystals - zone melting-refining, leveling - synthesis of epitaxial films by VPE, PVD, MBE and MOCVD techniques - lithography; production of silicon - starting applications.

Optical and Optoelectronic Materials: Principles of photoconductivity - simple models - effect of impurities - Principles of luminescence - types, Laser Principles - ruby, He-Ne, injection, Nd-Yag and Dye lasers; LED materials - binary, ternary photo electronic materials - effect of composition on band gap, crystal structure, phase equilibria and properties - LCD materials - photo detectors - applications of optoelectronic materials - introduction to optical

fibers - light propagation - electro optic effect - electro optic modulators - Kerr effect - Pockel's effect.

References

1. Raghavan V, Materials Science and Engineering, 4th Edition, Prentice Hall of India, 1998.
2. Kittel C, Introduction to Solid State Physics, 6th Edition, Wiley Eastern, New International Publishers, 1997.
3. Dekker A.J, Solid State Physics, MacMillan India, 1995.

MT 655 THERMODYNAMICS AND KINETICS

L	T	P	C
3	0	0	3

Introduction to thermodynamics and kinetics – different approaches – emphasis on metallurgical thermodynamics, transport phenomena and applications

Laws of thermodynamics and related applications – concepts of free energy and entropy – criteria for spontaneity

Introduction to solutions – partial molar entities – Gibbs Duhem relations - thermodynamic aspects of metallic solutions and salt melts – Raoult's Law and Henry's Law - regular and quasi chemical models

Thermodynamic aspects of phase diagrams – similarity in thermodynamic approach towards different classes of materials – thermodynamic aspects of defect formation in metals and ceramics – approaches used in chemical modeling

Principles of metallurgical kinetics – reaction rates and reaction mechanisms – overview of mass transfer, heat transfer and fluid flow – related applications in metallurgical processes – role of transport phenomena in mathematical and physical modeling

TEXT BOOKS

1. *Gaskell, David R., 'Introduction to Metallurgical Thermodynamics', McGraw Hill, 1973*
2. *Mohanty, A. K., "Rate Processes in Metallurgy", Prentice Hall of India (EEE), 2000*

MT 657 METALLOGRAPHY, MATERIALS TESTING AND CHARACTERIZATION LABORATORY

L	T	P	C
0	0	3	2

List of experiments:

1. Study of metallurgical microscope and sample preparation
2. Microscopic examination of ferrous alloys (plain carbon steels, stainless steels, maraging steels and tool steels and cast irons).
3. Microscopic examination of non-ferrous materials (Magnesium alloys, Aluminium alloys, Titanium alloys, Copper alloys, Super alloys).
4. Tensile Testing using Hounsfield and UTM
5. Hardness Measurements (Rockwell, Vickers and Brinell)
6. Impact Testing (Izod and Charpy)
7. Determination of crystal structure and lattice parameters from XRD data
8. Crystallite size determination of materials using XRD
9. Fractography using scanning electron microscope

MT 659 MANUFACTURING PROCESSES

L	T	P	C
3	0	0	3

Introduction to manufacturing processes – different approaches – technical and economic considerations – significance of material properties with respect to selection of manufacturing process

Conventional casting processes – advantages and limitations – melting practices – design of castings – special casting processes

Conventional material joining processes – concept of weldability – need for dissimilar joints - machining processes – concept of machinability – material examples – developments in machining processes

Rolling – forging – extrusion – drawing - sheet metal forming – classification, advantages and limitations

Introduction to powder metallurgy – recent developments esp. in forging and mechanical alloying - concept of near net shape processing - concept and applications of rapid prototyping – emerging technologies for nano – processing

TEXT BOOKS

1. *Rao, P.N, 'Manufacturing Technology', Tata McGraw Hill, 1996.*
2. *Kalpakjian, S, 'Manufacturing Engineering and Technology', 3rd Edition, Addison-Wesly, 1995.*

MT 654 CERAMICS, POLYMERS AND COMPOSITE

L	T	P	C
4	0	0	4

Types of ceramic materials, structural and functional applications of ceramics, physical properties of ceramics, structure – property correlation and introduction to ceramic processing.

Structure of polymers, characterization and applications of polymers: mechanical behavior of polymers, strengthening of polymers, crystallization and glass transition phenomenon and types of polymers.

Design and selection of plastics, structure property correlation, mechanical properties, degradation, wear and friction, thermal, electrical and optical properties, flammability of plastics and processing of plastics and FRP

Composites: Particle reinforced composites, fiber reinforced composites – influence of fiber length, orientation and concentration. Fiber phase, matrix phase, metal matrix composites, polymer matrix composites, ceramic matrix composites, carbon – carbon composites, hybrid composites and structural composites.

Processing of composites: Processing of MMC, liquid metal infiltration, squeeze casting, stir casting, compo casting, solid state route and diffusion bonding, powder metallurgy route slip casting. in-situ composites, eutectic alloy composites and directional solidification, constitutional super cooling and deviation from eutectic with variation in volume fraction of hard face, co extrusion of Cu-Nb composites and manufacturing of superconductors, self propagating high temperature synthesis, melt oxidation, precipitation reactions.

TEXT BOOKS

1. *W.D Callister. Jr, Materials Science and Engineering, Wiley India Pvt. Ltd, 2007*
2. *R.J. Crawford, plastics engineering, Pergamon Presss, II edition, 1987*
3. *K.K.Chawala, Cermic Matrix composite Materials, Kluwer Academic Publishers, 2002*
4. *R.J.Young, Introduction to Polymers, Chapman and Hall,,London, 1981*
5. *F.W.Billmeyer, Text book of polymer science, John Wiley &Sons, Newyork,1984*

MT 656 NANO MATERIALS AND TECHNOLOGY

L	T	P	C
3	0	0	3

Pre-requisite: At least one 600 level course related to materials

Concept of nano materials – scale / dimensional aspects, Top-down and bottom-up approaches for preparing nano materials

Advantages and limitations at the nano level – thermodynamic aspects at the nano level, health and environmental issues.

Characterization of nano materials and nano structures, important characterization techniques for nano size measurement.

Overview of properties of nano materials, Introduction to nano composites, processing of nanocomposites.

Applications in different areas such as semi conductors, sensors, nanostructured bioceramics and nanomaterials for drug delivery applications.

TEXT BOOKS

1. *Pradeep T "Nano: The Essentials", Mc Graw Hill Publishing Co. Ltd., 2007*
2. *Mick Wilson et al, "Nanotechnology", Overseas Press (India) Pvt. Ltd., 2005.*
3. *Charles P. Poole, Jr., Frank J. Owens, "Introduction to nano technology", Wiley, 2003.*
4. *Gunter Schmid, "Nanoparticles: From Theory to Applications", Wiley-VCH Verlag GmbH & Co., 2004.*

ELECTIVES

MT 613 MECHANICAL BEHAVIOUR OF MATERIALS

L	T	P	C
3	0	0	3

Strength of materials- basic assumptions, elastic and plastic behaviour, stress–strain relationship for elastic behaviour, elements of plastic deformation of metallic materials. Mohr's circle, yielding theories

Elements of theory of plasticity, dislocation theory properties of dislocation, stress fields around dislocations, application of dislocation theory to work hardening, solid solution strengthening, grain boundary strengthening, dispersion hardening

Ductile and brittle fracture, Charpy and Izod testing, significance of DBTT, ECT, NDT and FATT; elements of fractography - Griffith's theory, LEFM– COD and J integral – determination of K_{IC}, COD and J integral

Characteristics of fatigue failure, initiation and propagation of fatigue cracks, factors affecting fatigue strength and methods of improving fatigue behaviour – testing analysis of fatigue data, mechanics of fatigue crack propagation, corrosion fatigue

Introduction to creep - creep mechanisms, creep curve, variables affecting creep, accelerated creep testing, development of creep resistant alloys, Larsen Miller parameter - Manson Hafred parameter

TEXT BOOKS

1. *Dieter G. E., 'Mechanical Metallurgy', 3rd Edition, McGraw Hill, 1988*
2. *Suryanarayana, 'Testing of Metallic Materials', Prentice Hall India, 1979.*
3. *Rose R. M., Shepard L. A., Wulff J., 'Structure and Properties of Materials', Volume III, 4th Edition, John Wiley, 1984*

MT 615 SELECTIONS OF MATERIALS

L	T	P	C
3	0	0	3

Technologically important properties of materials, Physical, Chemical, Mechanical and Electrical properties of metals, Criteria of selection of materials like properties, cost, manufacturing process, availability, legal and safety factors.

Materials for atmospheric, soil, water, acid and alkaline resistance, Corrosion prevention coatings, material for Chemical and Petroleum industries, materials and coatings for wear resistance.

High temperature strength and stability, Hot hardness requirements, High temperature steels and super alloys, ductile to brittle transition-HSLA steel, low temperature materials.

Materials for engine components, cylinder block, head, liner, piston, ring, pin, connecting rod, crank shaft, exhaust, cam shaft, rocker arm and tappet, etc. Materials for chasis, Materials for aero structure, wings, landing gears, turbine blades, shafts, compressor blades, etc.

Nuclear fuels, control rods, coolants, clad materials etc. - Wear resistant materials - Impact resistant materials - Friction materials - Anti-friction materials - Bearing materials. Electrical & Magnetic materials, Power plant requirement, Materials with special thermal properties, Thermal expansion.

TEXT BOOKS

1. *Gladius Lewis, "Selection of Engineering Materials", Prentice Hall Inc. New Jersey USA, 1995.*
2. *Charles J A and Crane. F A.A., "Selection and Use of Engineering Materials", 3rd Edition, Butterworths, London UK, 1996.*

MT 617 COMPUTATIONAL TECHNIQUES

L	T	P	C
3	0	0	3

Design of Experiments: Factorial Design, Taguchi Techniques, ANOVA

Artificial Intelligence: ANN, fuzzy Logic, Genetic Alogorithm, Applications in Materials Engg.,

Numerical Fluid Flow and Heat Transfer: Classification of PDE, Finite differences, Steady and unsteady conduction, explicit and implict method

Finite element Methods: Introduction to I-D FEM; Problems in structural Mechanics using 2D elements, Plane stress, plain strain, axisymmetric analysis; three dimensional analysis.

Optimization Methods: Classical optimization methods, unconstrained minimization . Unvariate, conjugate direction, gradient and variable metric methods, constrained minimization, feasible direction and projections. Integer and geometric programming

TEXT BOOKS:

1. *Design and analysis of experiments - Douglas C. Montgomery, 5th ed., John Wiley and Sons, 2001*
2. *Introduction to Finite Elements in Engineering - Tirupathi R. Chandrupatla and Ashok D. Belegundu, 2nd Ed., Prentice-Hall, 1997*
3. *Artificial Neural Networks - B. Yegnanarayana, Prentice-Hall of India, 1999*

MT 619 SURFACE ENGINEERING

L	T	P	C
3	0	0	3

Introduction tribology, surface degradation, wear and corrosion, types of wear, roles of friction and lubrication- overview of different forms of corrosion, introduction to surface engineering, importance of substrate

Chemical and electrochemical polishing, significance, specific examples, chemical conversion coatings, phosphating, chromating, chemical colouring, anodizing of aluminium alloys, thermochemical processes -industrial practices

Surface pre-treatment, deposition of copper, zinc, nickel and chromium - principles and practices, alloy plating, electrocomposite plating, electroless plating of copper, nickel-phosphorous, nickel-boron; electroless composite plating; application areas, properties, test standards (ASTM) for assessment of quality deposits.

Definitions and concepts, physical vapour deposition (PVD), evaporation, sputtering, ion plating, plasma nitriding, process capabilities, chemical vapour deposition (CVD), metal organic CVD, plasma assisted CVD, specific industrial applications

Thermal spraying, techniques, advanced spraying techniques - plasma surfacing, D-Gun and high velocity oxy-fuel processes, laser surface alloying and cladding, specific industrial applications, tests for assessment of wear and corrosion behaviour.

TEXT BOOKS

1. *Sudarshan T S, 'Surface modification technologies - An Engineer's guide', Marcel Dekker, Newyork, 1989*
2. *Varghese C.D, 'Electroplating and Other Surface Treatments - A Practical Guide', TMH, 1993*

MT 621 TESTING, INSPECTION AND CHARACTERIZATION

L	T	P	C
3	0	0	3

Purpose and importance of destructive tests – Concepts, and method of Tensile, hardness, bend, torsion, fatigue and creep testing.

Purpose and limitations of NDT, Concepts, operating principles, advantages, limitations, of liquid penetrant and magnetic particle testing, eddy current testing, ultrasonic testing radiography, acoustic emission, thermal imaging method. Comparison of NDT methods and selection of NDT methods.

Tools of characterization - Light microscopy, basic principles and special techniques. X-ray diffraction and its applications in materials characterization.

Electron microscopy, Construction, operation and applications of scanning electron microscope (SEM), transmission electron microscope (TEM), Thermal analysis: Thermo gravimetric analysis, differential thermal analysis, differential scanning calorimetry & dilatrometry.

TEXT BOOKS:

1. *Non-destructive testing*, B.Hull And V.John, Macmillan, 1988.
2. *Modern Physical Metallurgy and Materials Engineering*, R. E. Smallman, R. J. Bishop, sixth edition, Butterworth-Heinemann, 1999.

MT 623 CERAMIC SCIENCE AND TECHNOLOGY

L	T	P	C
3	0	0	3

Ceramics as a class of material, classification of ceramics, bonding and structure of various ceramic materials; crystal structure and defects; chronological developments, structure of silicates; polymorphic transformations, raw materials.

Non crystalline materials - structure, requirement for glass formation, Zachariasen rules, viscosity based transition points, devitrification; glass forming methods; important ceramic systems: one component system- silica; binary and ternary systems. Silicate glasses and glass ceramics.

Powder processing, pre-consolidation - shape forming processes; Fundamental Sintering mechanisms, various advanced sintering techniques; Mechnacial behaviour of structural ceramics-Brittleness of ceramics, Concept of fracture toughness and different toughness and strength measurement techniques; Concept of various toughening mechanisms. Thermal properties of ceramics

Electrical, magnetic and optical properties of ceramic materials - emphasis on the effects of composition, microstructure, processing, temperature and atmosphere on these properties, Thin film techniques for electronic applications, growth of single crystals.

Introduction to specific ceramic materials – structure property correlation, processing and applications – Bioceramics and bio-glass, ceramic sensors, cermets, superconducting ceramics, cements, refractories, thermal barrier coatings and other functional coatings.

TEXT BOOKS

1. *Richerson D. W., 'Modern Ceramic Engineering - Properties Processing and Use in Design, 3rd Edition, CRC Press, 2006*
2. *Chiang Y.M., Birnie D. P., Kingery W.D., Physical Ceramics: Principles for Ceramic Science and Engineering, John Wiley, 1997*
3. *Kingery W. D., Bowen, H. K., Uhlhmen D. R., 'Introduction to Ceramics', 2nd Edition, John Wiley, 1976*
4. *James E. Shelby., 'Introduction to Glass Science and Technology' 2nd Edition, The Royal Society of Chemistry Publications, 2005*

MT 614 CORROSION ENGINEERING

L	T	P	C
3	0	0	3

Principles of corrosion phenomenon: Thermodynamics and kinetics: emf/galvanic series, Pourbaix diagram, exchange current density, passivity, Evans diagram, flade potential.

Different forms of corrosion: atmospheric/uniform, pitting crevice, intergranular, stree corrosion, corrosion fatique, dealloying, high temperature oxidation-origin and mechanism with specific examples.

Corrosion testing and monitoring: Non-Elecrochemical and Electrochemical methods: weight loss method, Tafel Linear polarization and Impedance techniques, Lab, semi plant & field tests, susceptibility test.

Corrosion prevention through design, coatings, inhibitors, cathodic, anodic protection, specific applications, economics of corrosion control.

Corrosion & its control in industries: Power, Process, Petrochemical, ship building, marine and fertilizer industries. Some case studies-Corrosion and its control in different engineering materials: concrete structures, duplex, super duplex stainless steels, ceramics, composites and polymers.Corrosion auditing in industries, Corrosion map of India.

TEXT BOOKS.

1. Fontana. M.G., Corrosion Engineering, Tata McGraw Hill, 3rd Edition, 2005.
2. Jones.D.A. Principles and Prevention of Corrosion, 2nd Edition, Prentice Hall, 1996.

MT 618 METALLURGICAL FAILURE ANALYSIS

L	T	P	C
3	0	0	3

Stages of failure analysis, classification and identification of various types of fracture. Overview of fracture mechanics, characteristics of ductile and brittle fracture.

General concepts, fracture characteristics revealed by microscopy, factors affecting fatigue life Creep, stress rupture, elevated temperature fatigue, metallurgical instabilities, environmental induced failure. Some case studies failures.

Types of wear, analyzing wear failure. Corrosion failures- factors influencing corrosion failures, overview of various types of corrosion stress corrosion cracking, sources, characteristics of stress corrosion cracking. Procedure for analyzing stress corrosion cracking, various types of hydrogen damage failures.

Causes of failure in forging, failure of iron and steel castings, improper heat treatment, stress concentration and service conditions. Failure of weldments - reasons for failure procedure for weld failure analysis.

Reliability concept and hazard function, life prediction, condition monitoring, application of Poisson, exponential and Weibull distribution for reliability, bath tub curve, parallel and series system, mean time between failures and life testing.

TEXT BOOKS

1. *ASM Metals Handbook "Failure Analysis and Prevention", ASM Metals Park. Ohio, Vol.10, 10th Edition, 1995.*
2. *Colangelo.V.J. and Heiser.F.A., "Analysis of Metallurgical Failures", John Wiley and Sons Inc. New York, USA, 1974.*

MT 660 BIOMATERIALS

L	T	P	C
3	0	0	3

Introduction to biomaterials; need for biomaterials; Salient properties of important material classes; Property requirement of biomaterials; Metallic implant materials, ceramic implant materials, polymeric implant materials, composites as biomaterials; Orthopedic, dental and other applications.

Biomaterials preparation and characterization; Processing and properties of different bioceramic materials; Mechanical and physical properties evaluation of biomaterials; New and novel materials for biomedical applications. Design concept of developing new materials for bio-implant applications; Nanomaterials and nanocomposites for medical applications;

Concept of biocompatibility; cell-material interactions and foreign body response; assessment of biocompatibility of biomaterials; *In-vitro* and *In-vivo* evaluation; Dissolution study, cytotoxicity test, cell adhesion test; Antibacterial assessment: Kirby–Bauer disc diffusion method or antibiotic sensitivity test and spread plate method.

Biomaterials for drug delivery, timed release materials; biodegradable polymers; Blood compatible materials; Biomimetics; Bone biology: bone architecture, collagen, osteoblasts, osteoclasts, etc; Protein mediated cell adhesion;

Introduction to tissue engineering; Applications of tissue engineering; Biomaterials world wide market, technology transfer and ethical issues; Standards for biomaterials and devices.

TEXT BOOKS

1. *Hench L. Larry, and Jones J., (Editors), Biomaterials, Artificial organs and Tissue Engineering, Woodhead Publishing Limited, 2005.*
2. *Hench L. Larry, & Wilson J., (Editors), An Introduction to Bioceramics, World Scientific, 1994.*

MT 662 HIGH TEMPERATURE MATERIALS

L	T	P	C
3	0	0	3

Factors influencing functional life of components at elevated temperatures, definition of creep curve, various stages of creep, metallurgical factors influencing various stages, effect of stress, temperature and strain rate

Design of transient creep, time hardening, strain hardening, expressions for rupture life for creep, ductile and brittle materials, Monkman - Grant relationship

Various types of fracture, brittle to ductile from low temperature to high temperature, cleavage, ductile fracture due to microvoid coalescence - diffusion controlled void growth; fracture maps for different alloys and oxides

Oxidation, Pilling-Bedworth ratio, kinetic laws of oxidation - defect structure and control of oxidation by alloy additions - sulphation, hot gas corrosion deposit, modified hot gas corrosion, effect of alloying elements on hot corrosion

Iron base, nickel base and cobalt base superalloys, composition control, solid solution strengthening, precipitation hardening by gamma prime, grain boundary strengthening, TCP phase - embrittlement, solidification of single crystals

TEXT BOOKS

1. *Raj R, 'Flow and Fracture at Elevated Temperatures', American Society for Metals, 1985*
2. *Hertzberg R. W, 'Deformation and Fracture Mechanics of Engineering Materials', 4th Edition, John Wiley, 1996*
3. *Courtney T.H, 'Mechanical Behaviour of Materials', McGraw Hill, 1990*

MT 674 DEVELOPMENTS IN IRON MAKING AND STEEL MAKING

L	T	P	C
3	0	0	3

Principles of ferrous process metallurgy; review of related concepts from metallurgical thermodynamics and kinetics; sequence of operations in steel plants; basic aspects of furnaces, refractories and fuels; differences between the production of carbon steels and highly alloyed steels

Overview of iron making, steel making, refining and continuous casting processes; indicative process calculations; environmental considerations; quality issues in steel plant operations

Modifications of steel making converter operations; developments such as sub lance and dynamic control of steel making, secondary treatment including ladle metallurgy and injection metallurgy; continuous steel making; illustrative numerical problems
Modifications of continuous casting process; developments such as flow control devices in tundish, sequence casting, high speed casting, detection / prevention of caster breakouts, electromagnetic stirring, thin slab casting; strip casting; illustrative numerical problems

Current research on metallurgical slags, measurement of critical properties, use of process modeling; design and selection of slags and refractories; discussion on related binary and ternary phase diagrams

TEXT BOOKS

1. *Current literature on related topics.*
2. *Tupkary R.H., 'Introduction to Modern Steel Making', Khanna Publishers, 2004 (primary text).*
3. *Bashforth G.R, 'Manufacture of Iron and Steel', Volume I - IV, Asia Publications, 1996.*
4. *B. Deo, R. Boom, 'Fundamentals of steel making metallurgy', Prentice Hall International, New York, 1993 (primary reference).*
5. *Continuous casting – Vol. 1, 'Chemical and Physical Interactions during transfer operations', Iron and Steel Society, Warrendale, PA, USA, 198.*

MT 665 PARTICULATE TECHNOLOGY

L	T	P	C
3	0	0	3

Pre-requisite: MT 659 (Manufacturing Processes)

Introduction to particulate processing – advantages, limitations and applications of particulate processing

Science of particulate processing – issues related to particle morphology – differences in mechanical behaviour (with respect to cast and wrought materials) and related mathematical treatment - similarities and differences between metal powder and ceramic powder processing

Production and characterisation of metal and ceramic powders – compaction processes – powder properties and powder compaction – Pressing, Hot Isostatic Processing and extrusion

Sintering – thermodynamic and process aspects – recent developments in mechanical alloying and reaction milling

Production of particulate composites - application of P/M based on case studies - manufacturing of typical products – near net shape processing

TEXT BOOKS

1. *German R.M., 'Powder Metallurgy Science', Metal Powder Industries Federation, New Jersey, 1994*
2. *Kuhn H. A. and Alan Lawley, 'Powder Metallurgy Processing - New Techniques and Analysis', Oxford IBH, Delhi, 1978.*

MT 666 STATISTICAL QUALITY CONTROL AND MANAGEMENT

L	T	P	C
3	0	0	3

Quality – philosophy; cost of quality; overview of the works of Juran, Deming, Crosby, Taguchi; quality loss function; PDCA cycle; quality control; quality assurance; quality audit; vendor quality assurance.

Quality organization; quality management; quality system; total quality management; quality awards; quality certification; typical procedure for ISO 9000, ISO 14000, QS 9000.

Review of some calculation procedures involving statistics and probability; exposure to some applications of statistics and probability; distribution functions; normal distribution curve.

Variations; analysis of variance – statistical tools – statistical quality control; control charts; process capability analysis; statistical process control; introduction to six sigma

Inspection; inspection by sampling; acceptance sampling; statistical approaches; single, double and multiple sampling plans; statistical design of experiments.

TEXT BOOKS

1. *Hansen B.L., P.M. Ghare, 'Quality Control and Application', PHI – EEE, 1997.*
2. *Juran J.M., and F.M.Gryna, 'Quality Planning and Analysis', McGraw Hill, New York, 2nd Edition, 1980*

MT 670 POLYMER PROCESSING

L	T	P	C
3	0	0	3

General features of single screw extrusion, Feed zone, compression zone and metering zone, Mechanism of flow, Analysis of flow in extruder, Extruder volumetric efficiency, and General features of twin screw extruders

Granule production and compounding, Profile production, Film blowing, Blow moulding, Extrusion blow moulding. Extrusion stretch blow moulding. Extrusion coating processes. Recent developments in extrusion technology

Screws. Nozzles. Moulds- runners, sprues, venting, mould temperature controls. Insulated runner moulds. Structural foam injection moulding. Sandwich moulding. Reaction injection moulding. Injection moulding of thermosetting materials.

Thermoforming, Calendering, Rotational Moulding, Compression Moulding, Vacuum forming, pressure forming, analysis of thermoforming. Calendaring and analysis of calendaring. Rotational moulding. Compression moulding. Transfer moulding.

Filament, Fabric, cloth, Mat, chopped fibres, Manufacturing methods. Semi-Automatic processing methods- cold press moulding, Automatic Process- Filament winding, centrifugal casting, pultursion and injection moulding.

TEXT BOOKS

1. *Crawford R.J., "Plastics Engineering", Pergamon Press, 2nd Edition, 1987.*
2. *Billmeyer, "Text Book Of Polymer Science", John Wiley & Sons(Asia) Pvt Ltd,1994*

MT 671 NUCLEAR MATERIALS

L	T	P	C
3	0	0	3

Introduction to nuclear energy / reactors – comparison of different modes of energy generation – ecological and environmental aspects

Nuclear reactions – concept of half life, nuclear minerals – related exploration and processing

Material requirements – structural materials, coolants, shielding materials and fuel rods – fabrication requirements

Nuclear irradiation effects on structural materials – safe guards, safety and health protection

Strategic issues – current status and major needs, overview of nuclear scenario in India, nuclear scenario at international level.

TEXT BOOKS

1. *Benjamin M. M., Van Nostrand "Nuclear Reactor Materials and Applications", Reinhold Company Inc, 1983*
2. *Henley E.J., & Herbert Kouts, "Advances in Nuclear Science and Technology".*

MT 673 SEVERE PLASTIC DEFORMATIONS

L	T	P	C
3	0	0	3

Basics of plastic deformation – Mohr's circle – yield theories – plastic stress – strain relationship – plastic work – constitute relationships – mechanical working – work hardening.

Analysis – slab analysis – upper and lower bound theorem – exact solutions – slip line field theory and its solution – numerical methods and FEM.

Severe plastic deformation by ECAP – types – microstructural variation with different processing routes – multichannel ECAP – strain distribution and texturing.

SPD by cryo rolling – process – types – microstructural variation with stress – strain distribution.

SPD by mechanical alloying – introduction – types of equipment – compaction – sintering – HIP, SIS – mechanism of sintering.

TEXT BOOKS

1. *Hosford W.F. and Caddell R.M. "Metal forming mechanics and metallurgy", Printice Hall 1983.*
2. *Altan T, Metal forming: Fundamentals and Applications (ASM Series in Metal processing)*
3. *Dieter, "Mechanical Metallurgy", Mc Graw Hill Publishers, NY,2002*