M.Tech. Degree

IN

MATERIALS SCIENCE AND ENGINEERING

SYLLABUS
FOR
CREDIT BASED CURRICULUM
(From academic year 2015-2016 onwards)

Department of Metallurgical and Materials Engineering
NATIONAL INSTITUTE OF TECHNOLOGY
Tiruchirappalli - 620 015
TAMIL NADU, INDIA

CURRICULUM

The total minimum credits required for completing the M.Tech. Programme in Materials Science and Engineering is **65.**

SEMESTER – I

CODE	COURSE OF STUDY	L	T	P	C
MA 613	Engineering Mathematics	3	0	0	3
MT 651	Electrical, Magnetic and Optical Materials	3	0	0	3
MT 653	Thermodynamics and Kinetics	3	1	0	4
	Elective - I	3	0	0	3
	Elective – II	3	0	0	3
	Elective – III	3	0	0	3
MT 659	Metallography, Materials Testing and Characterization Laboratory	0	0	3	2
					21

SEMESTER – II

MT 652	Ceramic Science and Technology	3	0	0	3
MT 654	Polymers and Composites	3	0	0	3
MT 656	Metallic Materials	3	0	0	3
	Elective – IV	3	0	0	3
	Elective – V	3	0	0	3
	Elective – VI	3	0	0	3
MT 660	Advanced Materials Processing Laboratory	0	0	3	2
					20

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			**65**

ELECTIVES

MT 611	Physical Metallurgy (compulsory for non metallurgy students)
MT 612	Mechanical Behaviour of Materials
MT 613	Corrosion Engineering
MT 614	Design and Selection of Materials
MT 615	Computational Techniques
MT 616	Metallurgical Failure Analyses
MT 617	Surface Engineering
MT 618	Testing, Inspection and Characterization
MT 619	Process Modeling
MT 620	Statistical Quality Control and Management
MT 621	Particulate Technology
MT 622	Developments in Iron Making and Steel Making
MT 623	Intellectual Property Rights
MT 624	Non Destructive Testing

MT 661	High Temperature Materials
MT 662	Polymer Processing
MT 663	Biomaterials
MT 664	Nuclear Materials
MT 665	Manufacturing Processes
MT 667	Severe Plastic Deformation
MT 668	Nanomaterials and Technology
MT 669	Automotive Materials
MT 670	Advanced Bioceramics
MT 671	Processing of Aluminium alloys

Programme Educational Objectives (PEO) of M.Tech. (Materials Science and Engineering)
I. Selecting their career in core and emerging areas of Materials Engineering and allied industries.
II. Make them achieve timely progress towards higher degree in Materials, Engineering and related fields.
III. To solve challenging industrial problems and serve effectively in globally competitive industrial environments with leadership skills.

Programme Outcomes (PO)

1	Materials Science and Engineering post graduates are attaining knowledge of materials and their science & Engineering
2	Materials Science and Engineering post graduates are talented to formulate and analyse the engineering data.
3	Materials Science and Engineering post graduates can recognize classify and solve engineering problem.
4	Materials Science and Engineering post graduates are capable of exploring the resources to collect the required data, analyse and solve critical problems.
5	Materials Science and Engineering post graduates have skills in locating and applying modern tools to resolve the complex engineering problems
6	Materials Science and Engineering post graduates are competent to work in research, industrial sectors and with multi-faceted team
7	Materials Science and Engineering post graduates have the capacity to design, plan and execute complex processes adhering to environmental considerations and cost effectiveness.
8	Materials Science and Engineering post graduates are capable to communicate effectively to engineering community and explain well to the society.
9	Materials Science and Engineering post graduates have motivation for enduring education to maintain competency.
10	Materials Science and Engineering post graduates have gained knowledge to adhere to the ethical considerations and play a key role in sustainable development.
11	Materials Science and Engineering post graduates are capable to asses both persons and problems & take decisions independently.

MA 613 ENGINEERING MATHEMATICS

L	T	P	C
3	0	0	3

COURSE OBJECTIVE:

1.To make the students mathematically strong for solving engineering and scientific problems.
2. To train students with mathematical aspects so as to comprehend, analyse, design and create novel products and solution for the real life problems.

COURSE CONTENT

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.*

COURSE OUTCOME: Upon completion of this class, the students will be able to:
1. To identify, formulate and solve metallurgical engineering problems in terms of Mathematical concepts.
2. To be knowledgeable about partial differential equations (PDEs) and how they serve as mathematical models for physical processes such as vibrations and heat transfer problems.
3. To be familiar with the mathematical ability to design and conduct experiments, interpret and analyse data, and generating correlation of obtained results.

MT 651 ELECTRICAL, MAGNETIC AND OPTICAL MATERIALS

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: The objective of this course is to provide students a fundamental understanding of electrical, magnetic and optical properties of materials and to apply those fundamentals for selecting and developing materials for different engineering applications.

COURSE CONTENT

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 condcutivity

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 Properties of Materials:Introduction toelectromagnetic radiation, atomic and electronic interactions with electromagnetic radiation, optical propert ies of metals, optical propert ies of nonmetals, opacity and translucency in insulators, color of materials, applications of optical phenomena-luminescence,photoconductivity, lasers, optical fibers in communications

References

1. *Raghavan V, Materials Science and Engineering, 4th Edition, Prentice Hall of India, 1998.*
2. *Pradeep fuley, Electrical, magnetic, and Optical Materials, 1st edition, CRC press, 2010*
3. *Kittel C, Introduction to Solid State Physics, 6th Edition, Wiley Eastern, New International Publishers, 1997.*
4. *Dekker A.J, Solid State Physics, MacMillan India, 1995*

COURSE OUTCOME: After the completion of this course, the student will be able to:

1.Understand the conducting, semiconducting, superconducting, dielectric, ferro-eleletric and piezoelectric behavior of materials

2. Differentiate between diamagnetic, paramagnetic, ferromagnetic, ferromagnetic, and anti-ferromagnetic behavior of materials
3. Synthesis and processing of semi-conducting materials for engineering applications
4. Study the effect of composition,structure and temperature on the properties of the materials.
5. Describe the interactions of light with materials and its effects at the interface
6. Understand the working principles of solid state devices, etc.

MT 653 THERMODYNAMICS AND KINETICS

L	T	P	C
3	1	0	4

COURSE OBJECTIVE:

To introduce the principles of thermodynamics and kinetics and illustrate their applications in the design of alloy systems.

COURSE CONTENT

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*

COURSE OUTCOMES: Upon completion of this class, the students will be able to:

1. Understand the terminology associated with engineering thermodynamics and have knowledge of contemporary issues related to metallurgical thermodynamics.
2. Knowledge of phase equilibria in two-component and multi-component systems Estimate thermodynamic properties of an alloy in solid or liquid state of ideal and real mixture
3. Predict the phase transformations in an alloy system with an understanding of phase diagrams.

MT 659 METALLOGRAPHY, MATERIALS TESTING AND CHARACTERIZATION LABORATORY

L	T	P	C
0	0	3	2

COURSE OBJECTIVE: To learn the principles of material testing and characterization and to apply them for various engineering applications.

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

COURSE OUTCOMES: Upon completion of this class, the students will be able to:

1. Prepare the specimens for metallographic examination with best practice, can operate the optical microscope and understand, interpret, analyze the microstructure of materials
2. Classify the different mechanical testing methods with their inherent merits and limitations
3. Apply various test methods for characterizing physical properties of materials
4. Recommend materials testing techniques based upon desired results, perform basic statistical analysis on data, and summarily present test results in a concise written format

MT 652 CERAMIC SCIENCE AND TECHNOLOGY

L	T	P	C
3	0	0	3

COURSE OBJECTIVES: To understand the fundamentals (structure, properties and processing) of ceramic materials to appreciate its advantages and limitations and to apply those fundamentals for selecting and developing ceramic materials for different engineering applications.

COURSE CONTENT

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*

COURSE OUTCOME: After the completion of this course, the student will be able to:

1. Know the structure and properties of different ceramic materials
2. Understand the phase diagrams and comprehend the phase transformations in ceramic materials

3. Understand the testing methods for evaluating the mechanical properties of ceramic materials
4. Understand the electrical, magnetic and optical properties of important ceramic systems
5. Appreciate the properties of ceramic materials for different engineering applications

MT 654 POLYMERS AND COMPOSITES

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: Understand the basics of polymers and composites- classifications and their properties and applications.

COURSE CONTENT

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*

COURSE OUTCOMES: At the end of this course, the students would be able to:

1. Classify different types of polymers and composites and their structure –property relationships

2. Understanding the properties of different types of polymers and composites
3. Designing and processing new types of polymers and composites.

MT 656 METALLIC MATERIALS

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: Understand the basics of metallic materials- classifications and their properties and applications

COURSE CONTENT

Classification of metallic materials - Ferrous and non ferrous.

Ferrous metals and alloys-Introduction to specifications – types of steels, alloy steels, tool steels; stainless steels, HSLA, TRIP steels, TWIP steels. Types of cast irons – compositions, properties and applications, specific heat treatment.

Aluminium and its alloys; physical chemical and mechanical properties, classifications, heat treatable and non heat treatable types - structural features corrosion behaviour; cladding and other methods of corrosion protection. Copper and its alloys, electrical conductivity as influenced by other elements, alloys for high conductivity.

Titanium and its alloys; physical, chemical and mechanical properties of titanium, effect of other elements on its properties, types of titanium alloys, microstructural features, properties and applications.

Magnesium and its alloys; structure, properties and applications of magnesium and some of its alloys; metallurgy of magnesium castings; Lead, tin, zinc, antimony, silver, gold and platinum alloys, relevant phase diagrams and microstructural features, properties and applications

TEXT BOOKS:

1. Avner S. H., 'Introduction to Physical Metallurgy', 2nd Edition, McGraw Hill, 1974
2. Leslie W. C., 'The Physical Metallurgy of Steels', McGraw Hill, 1982
3. Pickering P. B., 'Physical Metallurgy and the Design of Steels', Applied Science Publishers, 1983
4. Brick R. M., Gorden R. B, Phillips A., 'Structure and Properties of Alloys', McGraw Hill, 1965
5. Polmear I. J., 'Light Alloys -Metallurgy of the Light Metals', 3rd Edition, Arnold, 1995

COURSE OUTCOMES: Upon completion of the course, the student will be able to:
1. Understand major types of special steels such as HSLA, TRIP, Dual and Tool steels and cast-irons
2. Understand the structure and properties of nonferrous metals and alloys

3.Identify the phases present in different alloy systems by analyzing the phase diagrams
4.Apply the basic principles of ferrous and non-ferrous physical metallurgy for selecting materials for specific applications.

MT 660 ADVANCED MATERIALS PROCESSING LABORATORY

L	T	P	C
0	0	3	2

COURSE OBJECTIVE: The objective of this laboratory course is to provide an insight for the latest developments in materials processing.

LIST OF EXPERIMENTS:

1. Fabrication of nanostructured coatings by plasma electrolytic processing
2. Mechanochemical synthesis of nanostructured compounds
3. Microwave synthesis of nanosized ceramic powders
4. Diffusion bonding of Materials
5. Equichannel angular processing of materials
6. Cryorolling of materials
7. Vacuum arc melting of materials
8. Spark plasma sintering of materials
9. Microwave sintering of materials
10. In-situ synthesis of metal matrix composites by casting

COURSE OUTCOMES: After the completion of this course, the student will be able to:

1. Understands the working principles of different advanced processes
2. Synthesize nanostructured materials by advanced processing methods.
3. Perform experiments with best practices and understands the advantages and limitations of different processes
4. Interpret and analyze the data and present the results in a concise written format
5. Recommend a suitable process for modifying the material properties.

MT 697 PROJECT WORK PHASE –I

L	T	P	C
0	0	30	12

COURSE OBJECTIVE:

To know in depth exploration of a topic of special interest and to explain, apply relevant theories and laws in the chosen area.

COURSE OUTCOMES: At the end of this course, the students would be able to:
1. Interpret theories and doctrines, and give recommendations where appropriate
2. Acquire knowledge on the chosen topic and apply the knowledge, experience, and skills learned
3. Produce a thesis of publishable quality
4. Effectively present and defend research orally
5. Serve in any of the academic, Industrial and Research Organisations

MT 698 PROJECT WORK PHASE –II

L	T	P	C
0	0	30	12

COURSE OBJECTIVE:

To know in depth exploration of a topic of special interest and to explain, apply relevant theories and laws in the chosen area.

COURSE OUTCOMES: At the end of this course, the students would be able to:
1. Interpret theories and doctrines, and give recommendations where appropriate
2. Acquire knowledge on the chosen topic and apply the knowledge, experience, and skills learned
3. Produce a thesis of publishable quality
4. Effectively present and defend research orally
5. Serve in any of the academic, Industrial and Research Organisations

MT 611 PHYSICAL METALLURGY

(Compulsory for non metallurgy students)

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To develop an understanding of the basis of physical metallurgy and correlate structure of materials with their properties for engineering applications.

COURSE CONTENT

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.

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 – solid solution –types, Hume –Rothery rule. Phase diagrams – Binary- types – Lever rule. Solidification of different types of solid solutions – Iron-Carbon diagram – Effect of alloying element on Iron-carbon diagram. Ternary phase diagrams- Understanding of isotherms and isopleths.

Het treatment of ferrous alloys; Annealing, Normalising, TTT and CCT diagrams, Hardening – hardenability measurements, tempering. Thermo mechanical treatments. Heat treatment furnaces – atmospheres – quenching media – case hardening techniques.

Basic concept of dislocations their types and its interactions.Dislocations and strengthening mechanisms strengthening by grain-size reduction, solid solution strengthening, strain hardening, dispersion hardening and other recent modes of hardening.

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.*

COURSE OUTCOMES: Upon completion of this class, the students will be able to:

1. Describe the basic crystal structures (BCC, FCC, and HCP), recognize other crystal structures, and their relationship with the properties

2. Define and differentiate engineering materials on the basis of structure and properties for engineering applications

3. Select proper processing technologies for synthesizing and fabricating different materials

4. Analyse the microstructure of metallic materials using phase diagrams and modify the microstructure and properties using different heat treatments.

MT 612 MECHANICAL BEHAVIOUR OF MATERIALS

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To understand the concepts on materials failure and fracture analysis of materials and to design new materials that can with stand catastrophic failures at different environment.

COURSE CONTENT

Definition of stress, strain, transformation of coordinate systems, tensor notations, relationship between stress and strain in elastic materials, concept of principal stress and principal strain, stress invariants, modulus, Hook's law and understanding of stiffness and compliance tensors, elastic anisotropy,

Yield criteria, equivalent stress and plastic strain, Theoretical shear of perfect crystal, Mohs circle, concept of dislocations and dislocation theory, edge and screw dislocations, dislocation interactions, kink and jog, sessile and glissiles, partial dislocations, dissociation of dislocations, Thomson tetrahedral, Lomer-Cottress barriers.

Strengthening mechanisms, work hardening, solid solution strengthening, grain boundary strengthening, particle hardening, polymer elasticity and viscoelasticity, types of reinforcements and their influence, types of composites, high temperature degradation, creep and stress rupture, deformation mechanism maps, superplasticity and hot working.

Hardness, types of hardness measurements, comparison among hardness methods and scales, nanoindentation, compression testing, comparison between tension and compression studies of materials, shear testing, shear modulus, torsion and twist.

Fatigue of materials, S-N curves, life data presentation, influence of stress, linear elastic fracture mechanics in fatigue, crack growth studies, Paris law, metallurgical aspects of fatigue failures, concepts of remedial measures, creep-fatigue interaction, theoretical strength, Griffith equation, Brittle fracture, ductile fracture, fracture maps.

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*
4. *Thomas H. Courtney, "Mechanical Behavior of Materials", 2nd Edition, 2013, Overseas Press India Private Limited, ISBN : 81-88689-69-6*
5. *Norman E. Dowling, "Mechanical Behavior of Materials", International Editirion (4th), Contributed by K. Sivaprasad and R. Narayanasamy, 2013, Pearson Education Limited. ISBN : 13:978-0-273-76455-7*

COURSE OUTCOMES: At the end of this course, the students would be able to:

1. Understand the relationship between stress and strain
2. Understand the yielding behavior and dislocation influence on plastic deformation

3. Understand the various strengthening mechanisms and high temperature deformation
4. Understand testing methods like hardness, compression, and fatigue.

MT 613 CORROSION ENGINEERING

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To provide a practical knowledge about corrosion and its prevention in engineering field.

COURSE CONTENT

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.

COURSE OUTCOMES: At the end of this course, the student will be able to

1. Do electro and electroless plating of Cu, Al alloys
2. Determine the corrosion rate by weight loss method, electrical resistance method, potentionstatic polarization experiment and atmospheric corrosion using color indicator method
3. Analyze galvanic corrosion, pitting corrosion and stress corrosion cracking
4. Estimate the corrosion resistance by IGC susceptibility test, salt spray test and coating thickness

MT 614 DESIGN AND SELECTION OF MATERIALS

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To know different types of materials and properties and to select better materials for different applications.

COURSE CONTENT

Technologically important properties of materials - Physical, chemical, mechanical, thermal, optical, environmental and electrical properties of materials. Material property charts - Modulus – density, strength-density, fracture toughness-strength,
Types of design, Design tools and materials data – Materials and shape – microscopic and micro structural shape factors – limit to shape efficiency Comparison of structural sections and material indices – case studies

Service, Fabrication and economic requirements for the components – Methodology for selection of materials – Collection of data on availability, requirements and non functional things- its importance to the situations – case studies

Classifying process- -systematic selection of process – Selection charts - Ranking of processes – case studies - Influence of manufacturing aspects and processing route on properties of materials and its influence on selection of materials.

Selection of materials for automobile, nuclear, power generation, aerospace, petrochemical, electronic and mining industries.

TEXT BOOKS

1. M.F. Ashby, "Materials Selection in Mechanical Design' – Third edition, Elsevier publishers, Oxford, 2005.
2. Gladius Lewis, "Selection of Engineering Materials", Prentice Hall Inc, New Jersey, USA, 1995.
3. Charles.J.A. and Crane,F.A.A., "Selection and Use of Engineering Materials", Butterworths, London, UK, 1989.

COURSE OUTCOMES: Upon completion of the course, the student will be able to:

1. Understand types of materials and properties
2. Know different methods for materials selection
3. Know different methods for process selection
4. Selection of materials for Specific engineering applications and processes.

MT 615 COMPUTATIONAL TECHNIQUES

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To introduce the general concepts and methods for computational data analysis and to develop skill and tools for analyzing

COURSE CONTENT

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*

COURSE OUTCOMES: At the end of this course, the students would be able to:

1. understand the capabilities provided by various data
2. analysis methods and apply the appropriate ones to solve real problems
3. gain hands-on experience in using data analysis tools

MT 616 METALLURGICAL FAILURE ANALYSES

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To understand the concepts on materials failure and fracture analysis of materials and to design new materials that can with stand catastrophic failures at different environment.

COURSE CONTENT

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.

Analysis of wear failure. Corrosion failures- factors influencing corrosion and wear failures, Procedure for analyzing wear and corrosion failures, various types of hydrogen damage failures.

Causes of failure in forming, 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.*

COURSE OUTCOMES: At the end of this course, the students would be able to:
1. Understand the concepts of types of failures and analysis
2. Learn the various factors affecting/causing failures
3. Design new materials that can withstand failures, based on the environmental considerations and applications

MT 617 SURFACE ENGINEERING

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To analyse the various concepts of surface engineering and comprehend the design difficulties.

COURSE CONTENT

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*

COURSE OUTCOMES: Upon completion of the course, the student will be able to:

1. Define different forms of processing techniques of surface engineering materials
2. Know the types of Pre-treatment methods to be given to surface engineering
3. Select the Type of Deposition and Spraying technique with respect to the application
4. Study of surface degradation of materials
5. Asses the surface testing methods and Comprehend the degradation properties

MT 618 TESTING, INSPECTION AND CHARACTERISATION

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To provide an understanding of the basic principles of various testing, Inspection and characterization tools and use those tools to analyze metallurgical components.

COURSE CONTENT

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 characterisation - 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.
3. Materials Characterisation, P.C.Angelo, Elsevier (India) Pvt. Ltd, Haryana, 2013,

COURSE OUTCOMES: By successful completion of this course, the student will be able to

1. Know various destructive and non destructive methods of testing materials
2. Know the principles of metallurgical microscope, X-ray Diffractrometer (XRD), Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Thermal analysis and dilatometer
3. Describe the various sample/specimen preparation techniques for XRD, SEM, TEM and thermal analysis and quantitative metallography
4. Determine crystal structure, lattice parameter, phase identification, solvus line estimation and residual stress analysis using XRD
5. Select the appropriate tool to characterize the material by knowing its merits and demerits. Analyze the material in lattice level by using different modes of TEM like bright and dark field imaging, selected area diffraction and microchemical analyses.
6. Evaluate the specimen by thermal analysis and dilatometry.

MT 619 PROCESS MODELING

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To provide an understanding of the basic principles of modeling and use those methods to analyze and solve metallurgical Processes.

COURSE CONTENT

Mathematical modeling, physical simulation, advantages and limitations; process control, instrumentation and data acquisition systems

Review of transport phenomena, differential equations & numerical methods; concept of physical domain and computational domain, assumptions and limitations in numerical solutions, introduction to FEM & FDM, examples

Introduction to software packages– useful websites and generic information about different products - ANSYS, Thermocalc, CFD; usage of expert systems, artificial intelligence and robotics; demonstration of some software packages

Physical modeling – cold and hot models; case studies of water models, use of computers for the construction of phase diagrams, alloy design, crystallography, phase transformations and thermo chemical calculations.

Case studies from literature – pertaining to modeling of solidification / heat transfer, fluid flow, casting, welding and liquid metal treatment

TEXTBOOKS:

1. Szekely J., Themelis N. J., 'Rate Phenomena in Process Metallurgy', Wiley, 1971
2. P.S. Ghosh Dastidar, "Computer Simulation of Flow and Heat Transfer", Tata McGraw Hill, New Delhi, 1998

COURSE OUTCOMES: At the end of this course, the students would be able to:
1. understand the capabilities provided by various modeling methods
2. analysis methods and apply the appropriate ones to solve real problems
3. gain hands-on experience in using software packages.

MT 620 STATISTICAL QUALITY CONTROL AND MANAGEMENT

L	T	P	C

3	**0**	**0**	**3**

COURSE OBJECTIVE: To learn the concepts of quality control and quality management and their applications related to the manufacture of metallurgical products.

COURSE CONTENT

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*

COURSE OUTCOMES: At the end of this course, the students would be able to:

1. Understand the basic concepts in quality control and management
2. Learn the statistics and probability and distribution functions related to quality management
3. Understand the process of inspection, sampling and their statistical approach in quality management in industry

MT 621 PARTICULATE TECHNOLOGY

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To introduce the importance non-conventional processing routes for different materials and its importance for advanced materials manufacturing.

COURSE CONTENT

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.*

COURSE OUTCOMES: At the end of this course, the students would be able to:

1. Describe the basic mechanism of powder production for variety of materials to meet the demand of the research and industrial needs
2. Characterize the various powders (materials) based on the engineering applications Differentiate the processing routes for various powders (materials) and associated technology
3. Define modern day processing routes and apply them successfully to materials processing
4. Apply the powder metallurgy concepts to design new materials for advanced engineering materials
5. Apply the concepts of particulate processing to produce non-conventional materials which are difficult to produce other techniques

MT 622 DEVELOPMENTS IN IRON MAKING AND STEEL MAKING

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To study the concepts and various processing techniques involved in the field of iron and steel making.

COURSE CONTENT

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.*

COURSE OUTCOMES: At the end of this course, the students would be able to:

1. Understand the basics of metallurgy involved in iron and steel making [1,2]
2. Describe the overview of processing of iron and steel [4,6]
3. Understand the recent developments, modifications, and applications in the iron and steel making process and apply them in real time problems associated with the making of iron and steel industry [1,3,4,6,7]

MT 623 INTELLECTUAL PROPERTY RIGHTS

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To impart the knowledge in IPR and related areas with case studies.

COURSE CONTENT

Introduction to Intellectual Property Law – The Evolutionary Past - The IPR Tool KitPara -Legal Tasks in Intellectual Property Law – Ethical obligations in Para Legal Tasks in Intellectual Property Law - Introduction to Cyber Law – Innovations and Inventions Trade related Intellectual Property Right.

Introduction to Trade mark – Trade mark Registration Process – Post registration Procedures – Trade mark maintenance - Transfer of Rights - Inter partes Proceeding – Infringement - Dilution Ownership of Trade mark – Likelihood of confusion - Trademarks claims – Trademarks Litigations – International Trade mark Law

Introduction to Copyrights – Principles of Copyright Principles -The subjects Matter of Copy right – The Rights Afforded by Copyright Law – Copy right Ownership, Transfer and duration – Right to prepare Derivative works – Rights of Distribution – Rights of Perform the work Publicity Copyright Formalities and Registrations - Limitions - Copyright disputes and International Copyright Law – Semiconductor Chip Protection Act

Introduction to Trade Secret – Maintaining Trade Secret – Physical Secrurity – Employee Limitation - Employee confidentiality agreement - Trade Secret Law - Unfair Competation – Trade Secret Letigation – Breach of Contract – Applying State Law. Geographic indication

Managing intellectual property in a knowledge-based society. IPR and technology transfer, case studies.

TEXT BOOKS:
1. Debirag E.Bouchoux: “Intellectual Property”. Cengage learning , New Delhi
2. M.Ashok Kumar and Mohd.Iqbal Ali: “Intellectual Property Right” Serials Pub.
3. Cyber Law. Texts & Cases, South-Western’s Special Topics Collections
4. Prabhuddha Ganguli: ‘ Intellectual Property Rights” Tata Mc-Graw –Hill, New Delhi

COURSE OUTCOMES: At the end of this course, the students would be able to:
1. Understand the different types of IPR
2. Study the fundamentals of IPR laws
3. Understand scope of patent, copy right, geographic indication and trade secrete

MT 624 NON-DESTRUCTIVE TESTING

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To impart the knowledge in Non Destructive Testing with case studies.

COURSE CONTENT

Visual Inspection- tools, applications and limitations. Liquid Penetrant Inspection - principles, types and properties of penetrants and developers. Advantages and limitations of various methods of LPI. Magnetic particle inspection- principles, applications, advantages and limitations

Ultra sonic testing(UT) - Nature of sound waves, wave propagation - modes of sound wave generation - Various methods of ultrasonic wave generation, types of UT Principles, applications, advantages, limitations, A, B and C scan - Time of Flight Diffraction (TOFD)

Radiography testing (RT) – Principles, applications, advantages and limitations of RT. Types and characteristics of X ray and gamma radiation sources, Principles and applications of Fluoroscopy/Real-time radioscopy - advantages and limitations - recent advances.

Eddy current testing - Principles, types, applications, advantages and limitations of eddy current testing.

Thermography - Principles, types, applications, advantages and limitations. Optical & Acoustical holography- Principles, types, applications, advantages and limitations. Case studies: weld, cast and formed components.

TEXT BOOKS:

1. Practical Non – Destructive Testing, Baldev raj, Narosa Publishing House(1997).
2. Non-Destructive Testing, B.Hull and V.John, Macmillan (1988)
3. Krautkramer, Josef and Hebert Krautkramer, Ultrasonic Testing of Materials, 3rd edition, New York, Springer-Verlag (1983).

COURSE OUTCOMES: At the end of this course, the students would be able to:

1. Understand the basics of Non destructive testing
2. Describe the overview of Non destructive testing methods
3. Understand the recent developments, modifications, and applications in Non destructive testing and apply them in real time problems associated with failure analysis and regular quality testing for industries

MT 661 HIGH TEMPERATURE MATERIALS

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To study the high temperature sustainability of various materials in critical high temperature applications.

COURSE CONTENT

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*

COURSE OUTCOMES: At the end of this course, the students would be able to:

1. Describe the basic mechanism of high temperature deformation
2. Understand the details of creep deformation mechanisms
3. Analyze the fracture phenomenon in various materials in high temperature failures
4. Apply basic understanding of high temperature phenomenon like oxidation and hot corrosion in identifying suitable materials for specific high temperature applications
5. Study the high temperature behaviour of superalloys
6. Design new materials for high temperature applications

MT 662 POLYMER PROCESSING

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: Understand the basics of polymers and its various processing techniques towards technological applications.

COURSE CONTENT

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*

COURSE OUTCOMES: At the end of this course, the students would be able to:
1. Understand the structure and properties of polymers
2. Learn different types of processing techniques of polymers
3. Choose a processing technique for the given polymer for a particular application

MT 663 BIOMATERIALS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

The objective of this course is to provide students a fundamental understanding of different materials (metallic, ceramic, polymeric, composite, and biological materials) for biomedical-applications and their in-vitro and in-vivo characteristics. This course will also provide students an introduction to bone biology, tissue engineering and ethical issues in biomaterials research.

COURSE CONTENT

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.*

COURSE OUTCOMES: At the end of this course, the students would be able to:

1. Understand the properties of different biomaterials
2. Understand the synthesis and processing methods for producing the different biomaterials
3. Know the advantages and disadvantages of different biomaterials and select materials for different applications.
4. Characterize the biomaterials for their physico-chemical properties and analyze the cell-material interactions
5. Design new biomaterials for different biomedical applications

MT 664 NUCLEAR MATERIALS

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: Understand the concepts of nuclear materials and their properties, applications and safety precautions.

COURSE CONTENT

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".*

COURSE OUTCOMES: At the end of this course, the students would be able to:
1. Learn different types of materials used to produce nuclear energy
2. Understand properties of nuclear materials and applications
3. Learn and understand the safety precautions of nuclear radiation and protection.

MT 665 MANUFACTURING PROCESSES

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To know the fundamental concepts of various manufacturing processes and its applications and limitations with respect to industries.

COURSE CONTENT

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.

COURSE OUTCOMES: At the end of this course, the students would be able to:

1. Know the selection of materials for various applications
2. Know the fundamental concepts of metal casting, melting techniques and its limitations
3. Know the weldability concepts with respect to different materials and various welding process such as pressure and non-pressure welding
4. Know the machinability concepts and economics of machining
5. Know the concepts of various metal forming techniques and its applications and limitations regarding the manufacture of various wrought products
6. Know the powder metallurgy concepts of powder production, sintering and nanomaterials processing techniques
7. Develop an overall knowledge of the selection of suitable manufacturing technique to produce a product [3,6]
8. Know the basic concepts of rapid prototyping and near-net-shape processing [1].

MT 667 SEVERE PLASTIC DEFORMATION

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To know the concepts of Severe Plastic Deformation and methods. Applying them to the conventional and advanced materials to achieve nano/ultrafine grain structure for various structural applications.

COURSE CONTENT

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*
4. *Aliofkhazraei (Ed), "Handbook of Mechanical nanostructuring" Contributed by .B.Ravisankar, Wiley-VCH Publishers, Germany, 2015.*

COURSE OUTCOMES: At the end of this course, the students would be able to:

1. Apply the concept of plastic deformation for metals and alloys
2. Differentiate the various methods of severe plastic deformation and choose the appropriate one for required engineering applications
3. Analyze various operational and materials parameters influencing the final structure and properties of the materials

MT 668 NANOMATERIALS AND TECHNOLOGY

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To know the fundamental concepts of nanomaterials, synthesizing methods, their properties at nanosclae and possible technological applications in various fields of science and engineering.

COURSE CONTENT

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.*

COURSE OUTCOMES: At the end of this course, the students would be able to:
1. Understand the concepts of nanomaterials and their properties
2. Learn different routes of synthesizing methods of nanomaterials
3. Know the change in properties at the nanoscale level and their applications
4. Understanding the risks on producing nanomaterials and safety precautions.

MT 669 AUTOMOTIVE MATERIALS

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: To impart the knowledge in auto mobile materials and to equip the students to meet the demands of automobile engineering.

COURSE CONTENT

Otto cycle, diesel cycle, working principle and constructional details of two stroke and four stroke engine, carburetor, fuel feed systems, mechanical and electrical pumps. Petrol injection. Working principle of compression ignition engine, diesel injection systems, recent trends in engine technology

Engine cylinder: Structure and functions, types, cylinder blocks materials and manufacturing processes, improving engine components with surface modifications, Piston: Structures and functions, types, piston materials, piston manufacturing processes

Structure, function and materials for piston rings, camshaft, valves and valve seats, valve springs, connecting rod, crankshaft, turbocharger and exhaust manifold; ULSAB initiative from steel industry; tailor welds.

Types of chassis layout and chassis materials, vehicle frames, materials used for car body, front axle and steering system, drive line, propeller shaft, universal joints, wheels and suspension system.

Environmental impact of emissions from IC engines, Catalyst: catalysts for petrol engines, structures and functions, catalyst to reduce NOx, controlling pollution at cold start, On-board diagnosis. Exhaust gas treatment for diesel engine: particulate filters, regenerative methods, expendable catalyst additive, deNox catalyst.

TEXT BOOKS

1. Ganesan.V, Internal Combustion Engines, Tata-McGraw Hill Publishing Co., New Delhi, 1994.
2. Hiroshi Yamagata, The Science and Technology of Materials in Automotive Engines, Woodhead Publishing in Materials, 2005.
3. Hajra Choudhury, Elements of Workshop Technology, Vol-I and Vol-II Asia Publishing House, 1996.

COURSE OUTCOMES: Upon completion of this class, students are expected to

1. Understand the fundamentals of automobile engineering and different components in automobile
2. Describe the importance and reasons for using different types of material used in automobiles
3. Understand future challenges and expectations in automobile engineering.

MT 670 ADVANCED BIOCERAMICS

L	T	P	C
3	0	0	3

COURSE OBJECTIVE: The objective of this course is to provide students a fundamental understanding of different ceramic materials for biomedical-applications and their in-vitro and in-vivo characteristics.

COURSE CONTENT

Structure and Properties of Ceramics and Glasses: Atomic bonding and arrangement, determination of microstructure, glass formation, strength of glasses, static fatigue of glasses, formation and properties of glass-ceramics, different types of bioceramics, recent advancements in bioceramics, properties and applications.

Fabrication Processes for Bioceramics: Introduction, conventional processing of ceramics, nanostructured processing of ceramics, conventional and chemical processing of glasses and glass-ceramics, calcium phosphate coating techniques.

Characterization of Bioceramics: Mechanical properties of ceramics and glasses, impact strength, hardness, friction, wear, thermal and surface properties, strengthening methods.

In vitro Evaluation of Bioceramics: Bioactivity of ceramics, in vitro bioactivity test, in-vitro apatite forming ability in SBF, mechanisms of apatite formation, osteoconduction and its evaluation, osteoinduction and its evaluation, anti-bacterial assessment.

Ceramics for hard tissue applications: Hard tissue structure, properties, healing, remodelling and biocompatibility, bioceramics as scaffolds for tissue engineering, clinical application of tissue engineered ceramics, Tissue -ceramics interactions.

REFERENCE BOOKS

1. L. L. Hench and J. R. Jones, Biomaterials, Artificial Organs and Tissue Engineering, Taylor & Francis, 2007
2. B. D. Ratner, A. S. Hoffman, F. J. Schoen and J. E. Lemons, Biomaterials Science, Second Edition: An Introduction to Materials in Medicine, Elsevier Academic Press, London, 2004
3. J. Park, Bioceramics: Properties, Characterizations and Applications, Springer; 1st edition, 2008
4. Tadashi Kokubo , Bioceramics and their clinical applications, Edited by, Woodhead Publishing Limited, 2008

COURSE OUTCOME: At the end of this course, the students would be able to:
1. Understand the properties of different bioceramics
2. Understand the synthesis and processing methods for producing the different bioceramics
3. Know the advantages and disadvantages of different bioceramics and select materials for different applications.
4. Characterize the bioceramics for their physico-chemical properties and analyze the cell-material interactions
5. Design new bioceramics and ceramic based compositesmaterials for different biomedical applications

MT 671 PROCESSING OF ALUMINIUM ALLOYS

L	T	P	C
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COURSE OBJECTIVES: The objective of this course is to provide students a fundamental understanding of the classification and physical metallurgy of aluminium alloys, various processing techniques of aluminium alloys and to suggest a suitable technique for making an engineering component, the microstructural details of aluminium alloys.

COURSE CONTENT

Different Aluminium alloys- Cast and Wrought alloys- Temper designation systems – Physical metallurgy of Aluminium alloys. Direct chill (DC) casting of various aluminium alloys. Control of Hydrogen, Inclusions and grain size during DC casting.

Aluminium alloy castings- Different Forming operations – Forging methods (Open die, closed die and rolled rings) – Cold and Hot Extrusions – Sheet/plate rolling of various aluminium alloys. Welding of Aluminium alloys.

Heat treating of various aluminium alloys (Annealing-Solutionising-Ageing) and the related strengthening mechanisms- Heat treatment furnaces used for Aluminium alloy products. Cleaning finishing and coating

Solidification structures of Aluminium alloy Ingots - Microstructures of aluminium wrought Aluminium alloys - Microstructures of Cast alloys – Microstructures of Aluminium alloy weldments.

Tribological behavior – Microstucture control - Properties of pure, wrought and cast Aluminium alloys.

TEXT BOOKS:

1. *ASM Specialty hand book – "Aluminium and Aluminium alloys" –ASM International; Materials park- OH 44073 – 0002 – June 2010.*
2. *T.Sheppard – "Extrusion of Aluminium alloys" – December 2010.*
3. *ASM – "Aluminium – Volume – I:Properties, Physical Metallurgy and Phase diagrams" - ASM Metals Park, Ohio, USA, 1967.*
4. *ASM – "Aluminium – Volume – II: Design and Applications" - ASM Metals Park, Ohio, USA, 1967.*
5. *ASM – "Aluminium – Volume – III: Fabrication and Finishing" - ASM Metals Park, Ohio, USA, 1967.*

COURSE OUTCOMES: At the end of this course, the students would be able to:

1. To learn the classification and physical metallurgy of aluminium alloys
2. To understand various processing techniques of aluminium alloys and to suggest a suitable technique for making an engineering component
3. To analyse the microstructural details of aluminium alloys
4. To evaluate the properties of aluminium alloys