Department of Mechanical Engineering
Curriculum and Syllabi for M. Tech. in Materials and Manufacturing Technology (MMT)

With effect from 2019 entry batch

PO Statements:

1. Graduates will demonstrate sound domain knowledge on wider perspective to become successful professionals.
2. Graduates will demonstrate an ability to identify, formulate and solve manufacturing related problems using engineering materials.
3. Graduates will demonstrate an ability to conceptualise product designs with innovative engineering materials and evaluate them considering durability, safety, and other realistic constraints.
4. Graduates will demonstrate skill of good researcher to work on a problem, starting from scratch, to research into literature, methodologies, techniques, tools, and conduct experiments and interpret data.
5. Graduates will demonstrate research skills to critically analyse complex material characterization problems for synthesizing new and existing information for manufacturing engineering products.
6. Graduates will demonstrate skills to use modern engineering tools, software and equipment to analyze and solve complex engineering problems.
7. Graduates will exhibit the traits of professional integrity and ethics and demonstrate the responsibility to implement the research outcome for sustainable development of the society.
8. Graduates will be able to communicate effectively to comprehend and write effective reports following engineering standards.
9. Graduates will demonstrate skills of presenting their work unequivocally before scientific community, and give and take clear instructions.
10. Graduate will demonstrate traits of manager in handling engineering projects and related finance, and coordinate workforce towards achieving their goals.
11. Graduates will exhibit the traits of good academician and engage in independent and reflective lifelong learning.
12. Graduates will demonstrate an ability to work on laboratory and multidisciplinary tasks.

Course Structure

Semester I

S. N.	Code	Subject	L	T	P	Credits
1.	ME 5301	Advanced Material Science	3	0	0	3
2.	ME 5302	Structural Property Correlation of Engineering Materials	3	0	0	3
3	ME 5303	Composite Materials	3	0	0	3
4.	ME 5304	Mini Project-I	0	0	2	1
5.	ME 5xxx	Elective-I	3	0	0	3
6.	ME 53xx	Elective-II	3	0	0	3
7.	ME 5310	Seminar-I	0	0	3	2
		Total contact hours/credits	**15**	**0**	**5**	**18**

Semester II

S. N.	Code	Subject	L	T	P	Credits
1.	ME 5305	Mechanical Metallurgy	3	0	0	3
2.	ME 5306	Fabrication of Engineering Materials	3	0	0	3
3	ME 5307	Modern Manufacturing Methods	3	0	0	3
4.	ME 5xxx	Elective-III	3	0	0	3
5.	ME xxxx	Elective-IV	3	0	0	3
6.	ME 5308	MMT - Lab	0	0	3	2
7.	ME 5320	Seminar-II	0	0	2	1
		Total contact hours/credits	**15**	**0**	**5**	**18**

Semester: III and IV

S. N.	Code	Subject	L	T	P	Credits	Semester
	ME 6399	Project	-	-	-	14	III and IV
		Total contact hours/Credits	-	-	-	14	---

Elective-I

S. N.	Code	Subject	L	T	P	Credits
1.	ME 5131	Optimization Technique	3	0	0	3
2.	ME 5332	Iron and Steel Manufacturing Process	3	0	0	3
3	ME 5333	Non-Ferrous Metals and Alloys	3	0	0	3
4.	ME 5334	Physical and Chemical Characterization of Materials	3	0	0	3
5.	ME 5335	Statistical Quality Control and Management	3	0	0	3

Elective-II

S. N.	Code	Subject	L	T	P	Credits
1.	ME 5346	Failure Analysis and Prevention	3	0	0	3
2.	ME 5347	Advances in Polymeric Materials	3	0	0	3
3	ME 5348	Advanced Ceramics for Strategic Applications	3	0	0	3
4.	ME 5349	Material Selection and Safety	3	0	0	3

Elective-III

S. N.	Code	Subject	L	T	P	Credits
1.	ME 5336	Powder Metallurgy	3	0	0	3
2.	ME 5337	Biomaterials	3	0	0	3
3	ME 5134	Non Destructive Testing of Materials	3	0	0	3
4.	ME 5339	Nano Structured Materials	3	0	0	3
5.	ME 5340	High Temperature Materials	3	0	0	3

Elective-IV

S. N.	Code	Subject	L	T	P	Credits
1.	ME 5350	Surface Engineering	3	0	0	3
2.	ME 5351	Computational Modelling of Materials	3	0	0	3
3	ME 5138	Additive Manufacturing	3	0	0	3
4.	ME 5239	Manufacturing Management	3	0	0	3
5.	ME 5353	Advanced Casting and Joining Processes	3	0	0	3

Detailed Syllabi

ME 5301	**Advanced Material Science**	**L**	**T**	**P**	**C**
	M.Tech. (MMT), First Semester (Core)	3	0	0	3

Composites: Dispersion strengthened composites, particulate composites, Fiber reinforced composites, characteristics of fiber reinforced composites, Fiber reinforced system and applications, Laminar composites materials, Application of laminar composites.

Polymers: Typical Thermoplastics, structure property relationship in thermoplastics, effect of temperature on thermoplastics, Mechanical properties of thermoplastics.

Micro-electro mechanical systems (MEMS) & NANO Micromachining, Importance of different levels of structure to the material behavior, Technological significance.

Powder metallurgy: Powder metals, P/M process, P/M materials, P/M heat treatment, P/M applications.

Texts/References:

1. J. F. Shackesford and MK. Muralidhana, Introduction to Material Science, Pearson Education.
2. DR. Askeland and PP. Phule, Essentials of materials Science and Engineering, CENGAGE Learning.
3. Advanced Topics in Material Science and Engineering. J L Lopez, Kluwer Academic.
4. Powder metallurgy. B K Datta, PHI.
5. Materials Science and Engineering, an Introduction, William D. Callister. John Willey and Sons Inc. Singapore.
6. Physical Metallurgy: Principle and Practice, V. Raghavan. Prentice Hall India Pvt Ltd.

Course Outcomes:

1. Ability to apply knowledge of mathematics, science and engineering.
2. Ability to use the techniques, skills and modern engineering tools necessary to engineering practice.
3. Ability to design machining/micromachining process to meet desired needs.
4. Ability to identify, formulate and solve engineering problems to frame design rules for polymer / composite /Nano materials.
5. Ability to communicate effectively.

ME 5302	**Structural Property Correlation of Engineering Materials**	**L**	**T**	**P**	**C**
	M.Tech. (MMT), First Semester (Core)	3	0	0	3

Introduction: Stiffness, Strength, and Toughness, Types of mechanical behaviour, Relevance, Measurement, data, Macroscopic, continuum behaviour, Physical mechanisms controlling behaviour.

Elasticity: Introduction, Stress, strain, compliance and stiffness tensors, Physical origin of elastic moduli, Generalized Hooke's law and its application to crystals, designing for modulus and Composites.

Continuum Plasticity: True stress-true strain, Necking and Considerer’s Criterion, Yield Criteria and yield locus, Normality, Isotropic and kinematic hardening, Plastic stress-strain relations.

Fracture: Importance of Fracture Mechanics, Griffith Fracture Theory, Crack Driving Force & Energy Release Rate, Modes of fracture, Stress intensity factors, Similitude, Role of Crack-tip Plasticity--Plastic Zone Size & Shape, K-dominance, Fracture Toughness-Microstructural Issues.

Fatigue: Total life approaches, Fatigue design approaches, HCF and LCF, Fatigue crack inhibition, Fatigue crack growth, Paris law and models, Threshold, Damage tolerant approach, Striations, Different stages of fatigue crack growth, Examples.

Mechanical Testing Behaviour: Mechanical Characterization: Mechanical Property characterization-Principles & characterization techniques related to tensile, compressive, hardness, fatigue, and fracture toughness properties. Deformation, Super plasticity Stress-strain diagram, Determination of YS, UTS, MoE, %E, %RA, Hardness testing, true stress-strain diagram, stretcher strain characteristics, effects of cold working, & n values, poison's ratio, Deep drawn quality of sheets, Impact test, bend test, shear test, Significances of property evaluation, SN curves and fatigue life, non-destructive testing, residual stress measurements, corrosion testing, wear & tear characteristics, slow strain rate characteristics.

Texts/References:

1. G E Dieter, Mechanical Metallurgy, McGraw-Hill
2. R W Hertzberg, Deformation and Fracture Mechanics of Engineering Materials, John Wiley & Sons
3. M F Ashby and DRH Jones, Engineering Materials 1, Butterworth-Heinemann
4. D Hull and D J Bacon, Introduction to Dislocations, Pergamon
5. Fracture Mechanics –T.L. Anderson, CRC Press.

Course Outcomes:

1. Outline various engineering material properties like elasticity, plasticity, fracture behaviour, fatigue
2. Compare various materials for specific engineering applications to avoid failure
3. Examine material characterization techniques for property evaluation of various engineering materials
4. Estimate material properties by standard testing practices
5. Plan for formulating material selection philosophies for engineering applications

ME 5303	**Composite Materials**	**L**	**T**	**P**	**C**
	M.Tech. (MMT), First Semester (Core)	3	0	0	3

Fibre Reinforced Plastics (FRP): Definition; Types; General properties and characteristics; Reinforcing materials –particles, fibers, whiskers; Properties of reinforcing materials; Matrix materials; Additives; Properties of FRP materials; Applications

Manufacturing Processes: Open mold processes –Hand layup, Spray up, Vacuum bag, Pressure bag & autoclave, Centrifugal casting, Filament winding; Closed mold processes –Compression molding, Resin transfer molding (RTM), Injection molding, Pultrusion; SMC & DMC products, etc.

Designing Fibre Reinforced Plastics: Design variables; Selection of fiber-matrix and manufacturing process; Effects of mechanical, thermal, electrical and environmental properties, Fiber orientation, Symmetric and asymmetric structure; Effects of unidirectional continuous and short fibers; Lamination theory; Design equations, Design for failure; FEA design packages; Design examples & case studies in FRP.

Engineering Ceramics And Metal Matrix Composites: Reinforcement materials; Matrix; Characteristics and specialized properties like –Weibull modulus, high temperature strengths, wear

& frictional property improvements; Selection criteria; Advantages and limitations in use of ceramics & MMCs; Fracture mechanics; Applications.

Ceramic & Polymer Metal Composites: CMC & PMC Characteristics, Various types, Advantages& Limitations, Applications. Role of Mixtures Reinforcement –Particles –Fibres. Carbon/Carbon Composites-Advantages, Limitations-Sol-Gel techniques –Chemical Vapor Deposits. Applications.

Texts/References:

1. Haslehurst. S.E. "Manufacturing Technology ", ELBS, London, 1990.
2. Krishnan K. Chawle. “Composite Material: Science and Engineering” Second Edition, Springer, 1998
3. T. W. Clyne, P.J. Withers, “An Introduction to metal matrix composites”, Cambridge University Press, 1993.
4. F. C. Campbell “Structural Composite Materials”, Materials Park, ASM International, 2010

Course Outcomes:

1. Students will be able to apply core concepts in mechanics of composite materials to solve engineering problems.
2. Select the most appropriate process for fabricating and characterization of composite component.
3. Ability to analyze problems with respect to macro mechanical behavior of lamina.
4. Ability to analyze problems with respect to micro mechanical behavior of lamina
5. Ability to analyze problems with respect to macro mechanical behavior of laminate.

ME 5310	**Seminar-I**	**L**	**T**	**P**	**C**
	M.Tech. (MMT), First Semester (Core)	0	0	3	2

Individual students are required to choose a topic of their interest from materials and manufacturing related topics preferably from outside the M.Tech syllabus and give a seminar on that topic about 30 minutes. A committee consisting of at least two/three faculty members shall assess the presentation of the seminar and award marks to the students. Each student shall submit two copies of a write up of his / her seminar topic. One copy shall be returned to the student after duly certifying it by the Chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

Evaluation shall be based on the following pattern:
Report = 40 marks
Concept/knowledge in the topic = 30 marks
Presentation = 30 marks
Total marks = 100 marks

Course Outcomes:

1. Prepare good slides and present a particular topic effectively.
2. Develop team spirit and leadership qualities through group activities.
3. Develop confidence for self-learning and overcome the fear of public presentations.
4. Update knowledge on contemporary issues, prepare technical report and do presentations on these issues.

ME 5131	Optimization Technique	L	T	P	C
	M.Tech. (MMT), First Semester (Elective-I)	3	0	0	3

Introduction: Definition of optimization and its importance; Basic terminologies – design variables/vector, cost/objective function, constraints and variable bounds, etc; Different types of optimization problems –based on number of variables, based on nature of variables, based on constraints, based on approaches used, based on number of objectives, etc.

Single variable unconstrained optimization: Global optimum point; Local optimum point; Stationary point; Optimality criteria; Graphical method for optimum point; Direct methods for bracketing the optimum point –Exhaustive search method and Bounding phase method; Refining the bracketed optimum point through region elimination methods –Interval halving method, Fibonacci search method and Golden section search method; Gradient based methods –Bisection method. Newton-Raphson method and Secant method.

Multi-variable unconstrained optimization: Optimality criteria; Unidirectional search; Direct methods – Simplex search method, Hooke-Jeeves pattern search method and Powell's conjugate direction method; Gradient based methods –Cauchy's steepest descent method, Newton's method, Marquardt's method, Conjugate gradient method and Variable metric method.

Multi-variable linear and constrained optimization: Definition and formulation of linear programming problem; unrestricted variables; slack variables; artificial variables; feasible design; infeasible design; basic solution; basic feasible solution; Simplex method for less-than-equal type of constraints; Simplex method for equality and greater-than-equal types of constraints.

Multi-variable nonlinear and constrained optimization: Kuhn-Tucker conditions; Sensitivity analysis; Transformation methods –interior penalty function method, exterior penalty function and method of multipliers; Direct methods –variable elimination method, complex search method and random search method; Gradient based methods –cutting plane method, sequential linear programming and feasible direction method.

Integer and mixed optimization: Penalty function method and branch-and-bound method.

Texts/References:

1. Kalyanmoy Deb, "Optimization for Engineering Design – Algorithms and Examples" Prentice Hall of India Pvt. Ltd.
2. Jasbir S. Arora, "Introduction to Optimum Design" McGraw-Hill International Editions
3. Ashok D. Belegundu and Tirupathi R. Chandrupatla, "Optimization Concepts and Applications in Engineering" Pearson Education

Course Outcomes:

1. Students will be able to get awareness about the real world problems, their understanding and ability to formulate mathematical models of these problems.
2. Students will be able to understand the major limitations and capabilities of deterministic operations research modeling as applied to problems in industry or government.
3. Student will learn to handle, solve and analyzing problems using linear programming and other mathematical programming algorithms.
4. Students will also be able to learn different techniques to solve Non- Linear Programming Problems.
5. Student will also able to learn different search techniques, which are based on iterative methods, to find optimal solutions of Non-Linear Programming Problems. Also students will be able to understand multistage decision problems.

ME 5332	Iron and Steel Manufacturing Process	L	T	P	C
	M.Tech. (MMT), First Semester (Elective-I)	3	0	0	3

Ferrous Metals: Iron-Carbon equilibrium diagram; effects of alloy additions; types of steel – plain carbon steels, low alloy steels, heat treatable steels, tool steels, die steels, stainless steels, special steels; international systems to classify steel grades – AISI/SAE, DIN, EN series/BS, BIS; automotive grades and compositions; mechanical, thermal, electrical and physical properties of steels, applications.

Steel Making: Principles of steel making, melting practices, development of steel making processes, physiochemical principles and kinetic aspects of steel making, carbon boil, oxygen transport mechanism, desulphurization, dephosphorization, slag-functions, composition control, properties and theories, raw materials for steel making and plant layout, effects of melting practices on end product, principle equipment used and applications of steel making processes.

Cast Iron: Types of Cast irons – grey cast irons, alloy CI, Spheroidal cast irons, white iron, malleable iron, vermicular cast irons; chemical compositions and properties.

Text books/References:

1. William D. Callister, Jr., "Materials Science and Engineering an Introduction", John Wiley & Sons, 6th Edition, Inc., 2004.
2. V. Raghavan, "Materials Science and Engineering", Prentice Hall of India Pvt. Ltd.,5th Edition, 2007
3. Hajra Choudhary, "Elements of Workshop Technology", Asia Publishing House, Vol. I & II; 1996
4. R.K. Jain and S.C. Gupta, "Production Technology", Khanna Publishers, 1997
5. H.M.T. "Production Technology", Tata McGraw Hill, 1990
6. Avner, S. H., "Introduction to Physical Metallurgy", second edition, McGraw Hill, 1985.
7. Henkel & Pense "Structure and Properties of Engineering materials", 2001
8. Flinn, R. A., and Trojan, P.K., "Engineering Materials and their Applications", Jaico, 4th Edition, 1999.
9. Ashby M.F., "Material Selection in Mechanical Design", Butter Worth 3rd Edition, 2005. Smithells Metals Reference Book, Eighth Edition

Course Outcomes:

1. Classify ferrous metals and alloys.
2. Student will gain knowledge on effect of alloying elements in ferrous metals.
3. Describe the different methods of processing of iron ores.
4. Enumerate modern trends in iron making blast furnace.
5. Student will be able determine kinetics of slag formation in furnaces.
6. Explain brief principles of alternative methods and their advantages and limitations.

ME 5333	Non-Ferrous Metals and Alloys	L	T	P	C
	M.Tech. (MMT), First Semester (Elective-I)	3	0	0	3

Aluminium and aluminium Base Alloys: Enhancing properties of aluminium for auto applications; classification system and grades of alloys; roles of alloy additions on properties; significance of various equilibrium diagrams in designing alloys; solution treatment (age hardening) and microstructural changes; chemical compositions & properties of aluminium alloys; environmental benefits of recycling. aluminium alloy melting practices; component forming processes – castings, extrusions, sheet forming and forgings, material defects and their significances on properties and performances on end product; automotive applications of aluminium alloys and manufacturing processes for body to power train components.

Magnesium And Titanium Base Alloys: Properties and benefits over other traditional metals; classifications of alloys; melting practices; manufacturing processes – casting, extrusion and forging processes; solution treatment and microstructures; alloy compositions and properties; surface coatings; auto applications and limitations.

Text books/References:

1. William D. Callister, Jr., "Materials Science and Engineering an Introduction", John Wiley & Sons, 6th Edition, Inc., 2004.
2. V.Raghavan, "Materials Science and Engineering", Prentice Hall of India Pvt. Ltd.,5th Edition, 2007
3. Hajra Choudhary, "Elements of Workshop Technology", Asia Publishing House, Vol. I & II; 1996.
4. R.K. Jain and S.C. Gupta, "Production Technology", Khanna Publishers, 1997
5. H.M.T. "Production Technology", Tata McGraw Hill, 1990
6. Avner, S. H., "Introduction to Physical Metallurgy", second edition, McGraw Hill, 1985.
7. Henkel & Pense "Structure and Properties of Engineering materials", 2001
8. Flinn, R. A., and Trojan, P.K., "Engineering Materials and their Applications", Jaico, 4th Edition, 1999.
9. Ashby M.F., "Material Selection in Mechanical Design", Butter Worth 3rd Edition, 2005. Smithells Metals Reference Book, Eighth Edition

Course Outcomes:

1. Classify non-ferrous metals and alloys.
2. Student will gain knowledge on effect of alloying elements in non-ferrous metals.
3. Describe the different methods of processing of ores.
4. Enumerate modern trends in furnace.
5. Student will be able determine kinetics of slag formation in furnaces.
6. Explain brief principles of alternative methods and their advantages and limitations.
7. Student shall be able to describe processes for extraction of non-ferrous metals.

ME 5334	**Physical and Chemical Characterization of Materials**	**L**	**T**	**P**	**C**
	M.Tech. (MMT), First Semester (Elective-I)	3	0	0	3

Analysis and Evaluation of Properties of Plastics, Elastomers and Composites: Molecular weight distribution, MFI, HDT & VICAT softening point, cold temperature behaviors, Rheological behaviors, hardness and impact properties, identification of polymers, weathering characteristics, cyclic temperature test, flammability, VOC and odor test, scratch resistance test, metal composition analysis, RoHS analysis Electrical properties of Materials – Dielectric constant, electrical resistivity, coefficient of thermal expansion & contraction, wire harness test.

Instrumental Techniques: FTIR spectrometer, Thermal analyzer, X-ray analyzer, Optical emission spectroscopy, Ion Chromatography, Gas and Liquid Chromatography, High strain rate tester, Non-destructive instruments, etc. New innovations in testing and characterization, X-ray Diffraction, Electron microscope (SEM, TEM), Scanning probe microscopy (SPM, AFM), Spectroscopic methods (EDS, FTIR); Mechanical behaviors, Thermal response, Fire retardancy, Chemical resistance and Electrical-Magnetic-Optical properties of ploymer nanocomposites;

Text books/References:

1. Material Characterization: Introduction to Microscopic & Spectroscopic Methods by Yang Leng
2. John Wiley & Sons (Asia) Pte Ltd.
3. ASM Handbook on Metals Handbook: Vol. 8 Mechanical Testing – 1978.
4. Dictionary of Materials and Testing, Second Edition by Joan Tomsic.\

Course Outcomes:

1. Understand and describe the fundamental principles behind the methods of characterization which are included in the curriculum.
2. Analyze, interpret and present observations from the different methods.
3. Evaluate the uncertainty of observations and results from the different methods.
4. Assess which methods of characterization are appropriate for different material problems.

ME 5335	**Statistical Quality Control and Management**	**L**	**T**	**P**	**C**
	M.Tech. (MMT), First Semester (Elective-I)	3	0	0	3

Unit I: Procurement of various products; evaluation of supplies; capacity verification; development of sources; Procurement procedure; Methods and techniques of manufacture; inspection and control of the product.

Organizational structure and design; quality function; decentralization; designing and fitting; attitude of top management; cooperation of groups; operator's attitude; responsibility; causes of apparatus error and corrective methods.

Unit II: Philosophy; cost of quality; overview of the works of Juran, Deming, Crosby, Taguchi; PDCA cycle; quality control; quality assurance;total quality management; vendor quality assurance; ISO 9000 and its concept of quality management.

Defect diagnosis and prevention defect study; identification and analysis of defects, correcting measure, the difference between reliability and quality; factors affecting reliability; different measures of reliability; time to failure distributions; MTBF; MTTF; concept of risk analysis.

Unit III: Inspection by sampling; acceptance sampling; statistical approaches; single, double and multiple sampling plans; statistical design of experiments; control charts; statistical tools; statistical quality control.

Text books/References:

1. Bewoor: Metrology & Measurement: McGraw-Hill Publishers
2. Gupta: Total Quality Management: McGraw-Hill Publisher, 2/e
3. Mahajan: A text book of metrology: Dhanpat Rai and Co.

Course Outcomes:

1. Understand the philosophy and basic concepts of quality improvement.
2. Demonstrate the ability to use the methods of statistical process control.
3. Demonstrate the ability to design, use, and interpret control charts for variables.
4. Demonstrate the ability to design, use, and interpret control charts for attributes.

5. Perform analysis of process capability and measurement system capability.
6. Design, use, and interpret exponentially weighted moving average and moving average control charts.

ME 5346	**Failure Analysis and Prevention**	**L**	**T**	**P**	**C**
	M.Tech. (MMT), First Semester (Elective-II)	3	0	0	3

Fundamentals of Failure Analysis: Importance of failure analysis for automotive components, Steps in typical failure analysis: Collection of background data (review documentation and speak with appropriate individuals), Selection of failed and unfailed samples for examination, Preliminary examination of the failed part, Non-destructive evaluation, Mechanical testing, Macroscopic examination and analysis, Microscopic examination and analysis, Determination of failure mode, Chemical analysis, Fracture mechanics considerations, Full scale testing under service conditions, Analysis of the evidence, Formulation of conclusions, Recommendations to prevent reoccurrence, Sample preparation methods for failure analysis, Selection of locations/samples for failure analysis.

Introduction to Failure Analysis: Failure mode identification methods, Failure mechanisms: Fatigue failures, fractography, effect of variables: part shape, type of loading, stress concentration, metallurgical factors, etc. Wear failures, adhesive, abrasive, erosive, corrosive wear. Corrosion failures, types of corrosion: uniform, pitting, selective leaching, intergranular, crevice, etc. Elevated temperature failures, creep, thermal fatigue, micro structural instability, and oxidation. Causes of failure in components: Misuse or Abuse, Assembly errors, Manufacturing defects, Improper maintenance, Fastener failure, Design errors, Improper material, Improper heat treatments, Unforeseen operating conditions, Inadequate quality assurance, Inadequate environmental protection/control, Casting discontinuities. Data compilation and identification of root cause.

Types of Failures in Components: Fatigue failures, Corrosion failures, Stress corrosion cracking, Ductile and brittle fractures, Hydrogen embrittlement, Liquid metal embrittlement, Creep and stress rupture.

Methods and Equipment for Failure Analysis: Selection of suitable testing methods for failure analysis Selection of metallurgical equipments for failure analysis SEM-EDAX.

Prevention of Failure

Text books/References:

1. “Understanding How Components Fail” by Donald J. Wulpi; ASM International Publication.
2. “Analysis of Metallurgical Failures: by Vito J. Colangelo; Francis A. Heiser Wiley Publication.
3. ASM Handbook Vol.11 - Failure Analysis and Prevention, ASM International Publication, 1995.
4. “Metallurgy of Failure Analysis” by A K. Das; by McGraw-Hill Professional Publication.
5. Metallurgical Failure Analysis by Charlie R. Brooks; Ashok Choudury; McGraw-Hill Publication.
6. Automotive Component Failures by A. M. Heyes
7. Handbook of Case Histories of Failure Analysis, Vol 2. by A Esaklul Khlefa.
8. Handbook of Case Histories of Failure Analysis, Vol 1 by C.Uhietal Robert.
9. Metallography Principles and Practice by Voort, George F. Vander; ASM International Publication.

Course Outcomes:

1. Understand the process of materials selection and be able to use available tools for making decisions on materials selection for engineering applications.
2. Understand the variety of fabrication routes and be able to use available tools to identify an

appropriate fabrication route for a selected material for any engineering applications

3. Understand the importance of environment with respect to energy consumption and recyclability of engineering components in selection of materials and fabrication process
4. Understand and be able to identify the common modes of failure of engineering components
5. Have, and be able to use, a framework for assessing engineering failures, including determining the mode of failure and making recommendations on failure prevention.
6. To be able to incorporate the materials failure knowledge in selecting appropriate materials for engineering applications
7. To work as a team member, plan and make decisions through effective communication.
8. To be able to write a professional engineering report.
9. Understand the need to undertake lifelong learning

ME 5347	**Advances in Polymeric Materials**	**L**	**T**	**P**	**C**
	M.Tech. (MMT), First Semester (Elective-II)	3	0	0	3

Polymeric Materials: Polymerization – Thermosets Vs Thermoplastics – Classes and types of polymers; Properties and limitations of plastic material species; Additives; Auto applications – exterior, interior, engine and fuel line, transmission systems, electrical and electronic components.

Manufacturing Processes: Injection molding, Reaction injection molding (RIM), Transfer molding, Extrusion, compression molding, blow molding, scopes and limitations of various manufacturing processes, mold making, safety in handling of materials, hands on training on processes, selection criteria for auto applications, economics.

Elastomers: Physics of raw and vulcanized rubbers; Kinetic and thermodynamics theory of rubber elasticity; Stress strain relationships for the vulcanized rubbers; Molecular basis for the material to act as rubber; Study of various additives like peptizers, antioxidants, accelerators, activators, fillers, carbon black, chords and fabrics, blowing agents, colorants, processing aids like – tackifiers, plasticizers, extender oils etc. Characterization of compounds, rheological behaviors, properties influenced by compounding ingredients. Processing of rubbers by - extrusion, calendaring and injection molding. Manufacturing techniques of auto components – tires, belts, hoses, mounts wiper blades, seals, O rings, etc. Study of major synthetic auto rubbers like – NR, SBR, BR, IIR, NBR, SBR, fluorocarbons, silicone, etc – their functional properties and needs of auto industries; uses in fuel systems, chassis and body components, NVH applications.

Design in Plastics and Elastomers: Selection of polymers, additives and process; Effects of mechanical, thermal, electrical properties, importance of environmental factors, structural analysis; Mold design; Part geometry; Gating, cooling, ejection, joining and assembling; Geometric tolerances; Safety factor & failure criteria; Machining, finishing and decorating, etc. Designing in rubbers, effects of material, process and environment parameters, life cycle analysis, design software packages, failure mechanics.

Foams, Adhesives, Coatings and Paints, PU & Latex foams: Formulations and manufacturing Control of various foam properties – density, modulus of elasticity, compression set, dynamic properties, etc. Adhesives - Condensation polymerization of products like phenol formaldehyde (Phenolic resins), Amino resins, Polyester resins, Alkyl resins, Epoxy resins, Polyurethane resins, Polyamide resins; Additional polymerization products like – Vinyl resins, Vinyl alcohol resins, vinylidine resins, Styrene resins and Acrylic resins. Protective coatings and Paints - Organic paints and coatings, metal coatings, ceramic coatings, Linings, primers, varnishes, enamels, galvanizing, anodizing, black iodizing, electro plating, CVD & PVD surface coatings Other Materials - Seals and Gaskets, Automotive glasses, Refractory materials

Text books/References:

1. Kalyan Sehanobish, “Engineering Plastics and Plastic Composites in Automotive Applications”, SAE International, April 2009
2. Francis Gardiner and Eleanor Garmson “Plastics and the Environment” Smithers Rapra, 2010
3. Mahendra D Baijal “Plastic Polymer Science and Technology”, John Wiley & Sons, 1982
4. Natti S. Rao, Gunter “Design Formulas for Plastic Engineers” Hanser Publishers 2nd Edition, 2004
5. John Moalli “Plastics Failures”, Plastics Design Library, William Andrew Inc, 2001

Course Outcomes:

1. Isolate the key design features of a product which relate directly to the material(s) used in its construction
2. Indicate how the properties of polymeric materials can be exploited by a product designer
3. Describe the role of rubber-toughening in improving the mechanical properties of polymers
4. Identify the repeat units of particular polymers and specify the isomeric structures which can exist for those repeat units
5. Estimate the number- and weight-average molecular masses of polymer samples given the degree of polymerisation and mass fraction of chains present.

ME 5348	**Advanced Ceramics for Strategic Applications**	**L**	**T**	**P**	**C**
	M.Tech. (MMT), First Semester (Elective-II)	3	0	0	3

Introduction: Oxide and non-oxide ceramics, their chemical formulae, crystal and defect structures, nonstoichiometry and typical properties.

Powder Preparation: Physical methods (different techniques of grinding), chemical routes - co-precipitation, sol-gel, hydrothermal, combustion synthesis, high temperature reaction (solid state reaction). Basic principles and techniques of consolidation and shaping of ceramics: powder pressing-uniaxial, biaxial and cold isostatic and hot isostatic, injection moulding, slip casting, tape-casting, calendaring, multilayering.

Sintering: different mechanisms and development of microstructure (including microwave sintering). Preparation of single crystal, thick and thin film ceramics. Mechanical behaviour: fracture mechanics and tribology. Engineering applications: at room and high temperatures (including armour application)

Electrical behaviour: Insulating (dielectric, ferroelectric, piezoelectric, pyroelectric) semiconducting, conducting, superconducting and ionically conducting, specific materials and their applications. Magnetic behaviour: basic principles, materials and their applications.

Transparent ceramics, coatings and films: Preparation and applications Porous ceramics and ceramic membrane: fabrication techniques and applications in separation technology. Bio-medical applications of ceramic materials Ceramics for energy and environment technologies (fuel cell, lithium battery, gas sensor and catalytic support) Ceramics matrix composites: different types, their preparation and properties (including nano-composites) Exotic ceramics: functionally graded, smart/ Intelligent, bio-mimetic and nanoceramics - basic principles, preparation and applications.

Text books/References:

1. Fundamental of Ceramics by Michel W. Barsoum, McGraw Hill International edition, 1997
2. Modern Ceramic Engineering by David. W. Richerson, Mercel Dekker, NY 1992
3. Ceramic Processing and Sintering by M. N. Rahman, Mercel Dekker, 2003
4. Handbook of Advanced Ceramics by S. Somiya, Academic Press 2003
5. Handbook of Advanced Ceramics, Parts 1 and 2, S. Somiya, Aacdemic Press, 2006

Course Outcomes:

1. Describe different approaches to how ceramic powders are prepared from solid and liquid precursors
2. Describe nucleation and growth theory
3. Describe how different inorganic and ceramic materials can be made by innovative methods
4. Describe different routes to films and coatings
5. Describe the principles of wetting, deagglomeration and adsorption and explain how this can be used for ceramics fabrication
6. Explain how stable suspensions of ceramic powders can be made and explain the theoretical considerations needed to make the stable suspensions
7. Describe the principles of drying of ceramic green bodies and wet films
8. Describe the principles of densification, grain growth and microstructure development in polycrystalline solids
9. Explain the different steps of solid state and liquid phase sintering and be able to choose the optimal sintering conditions for a given material
10. Describe the relation between micro/nanostructure and properties for a given material
11. Be able to use the aquired knowledge on own research problems

ME 5349	**Material Selection and Safety**	**L**	**T**	**P**	**C**
	M.Tech. (MMT), First Semester (Elective-II)	3	0	0	3

Introduction: Materials in design, Classes of engineering material, Technologically important material properties. Criteria of selection of materials like properties, cost, manufacturing process, availability, legal and safety factors.

Design Process: Types of design, Design tools and materials data, Function, material, shape and process, Selection of material - Factors of safety in design – fatigue, fracture & creep behaviour of materials, Notch sensitivity - Principles of design optimization - Future trends - CAD - Euler's formula – Theories of failure - Rankine's formula - Tetmajer's formula - Johnson formula - Design of push - rods –eccentricity loaded columns - Reduction of stress concentration.

Materials processing and design: Processes and their influence on design, Process attributes, Systematic process selection, Screening: process selection diagrams, Ranking: process cost.

Materials selection - the basics: The selection strategy, Deriving property limits and material indices, The selection procedure, The structural index.

Selection of material and shape: Shape factors, The efficiency of standard sections, Material limits for shape factors, Material indices which include shape.

Multiple constraints and compound objectives: Selection by successive application of property limits and indices, Systematic methods for multiple constraints, Compound objectives, exchange constants and value-functions

Materials for Corrosion and Wear Resistance: Types of corrosion, Corrosion Prevention Strategies – Design and Coatings materials, Types of wear, materials and coatings for wear resistance.

Materials for High and Low Temperatures: Characteristics of High temperature materials, High temperature steels and super alloys, Refractory materials, ductile to brittle transition, low temperature materials.

Materials, aesthetics and industrial design: Aesthetics and industrial design, Why tolerate ugliness? The market pull: economy versus performance, Materials and the environment: green design

Materials selection: Case studies.

Text books/References:

1. Michael F. Ashby: Materials Selection in Mechanical Design: Butterworth Heinemann, 2nd Edition, London UK, 1999.
2. Mahmoud M. Farag: Materials and Process Selection for Engineering Design, CRC Press, 3rd Edition, 2013.
3. U. C. Jindal: Machine Design, Pearson Education India, 2010.
4. Gladius Lewis: Selection of Engineering Materials: Prentice Hall Inc. New Jersey, USA, 1995.
5. Charles J A and Crane. F A.A.: Selection and Use of Engineering Materials: Butterworth, 3rd Edition, London UK, 1996.

Course Outcomes:

1. Explain the process of materials selection and be able to use available tools for making decisions on materials selection for engineering applications;
2. Explain the variety of fabrication routes and be able to use available tools to identify an appropriate fabrication route for a selected material for any engineering application;
3. Recognise the importance of environment with respect to energy consumption and recyclability of engineering components in selection of materials and fabrication proces;
4. Identify the common modes of failure of engineering component;
5. Apply a framework for assessing engineering failures, including determining the mode of failure and making recommendations on failure prevention;
6. Demonstrate the ability to incorporate the materials failure knowledge in selecting appropriate materials for engineering application;
7. Demonstrate the ability to work as a team member, plan and make decisions through effective communication;
8. Write a professional engineering report; and
9. Recognise the need to undertake lifelong learning.

ME 5305	Mechanical Metallurgy	L	T	P	C
	M.Tech. (MMT), Second Semester (Core)	3	0	0	3

Metallurgical fundamentals: Introduction, Concepts of Crystal Geometry, Lattice Defects, Deformation by Slip, Slip in a Perfect Lattice, Slip by Dislocation Movement, Critical Resolved Shear Stress for Slip, Deformation of Single Crystals, Deformation by Twinning, Stacking Faults, Deformation Bands and Kink Bands, Microstrain Behavior, Strain Hardening of Single Crystals.

Dislocation Theory: Introduction, Observation of Dislocations, Multiplication of Dislocations, Dislocation-Point Defect Interactions, Dislocation Pile-Ups, Strengthening Mechanisms: Introduction, Grain Boundaries and Deformation, Strengthening from Grain Boundaries, Low-Angle Grain, Boundaries, Cold-Worked Structure, Strain Hardening, Annealing of Cold-Worked Metal, Bauschinger Effect, Preferred Orientation (Texture).

Plastic Forming of Metals: Fundamentals of Metalworking: Classification of Forming Processes, Mechanics of Metalworking, Flow-Stress Determination, Temperature in Metalworking, Strain-Rate Effects, Metallurgical Structure, Friction and Lubrication, Deformation-Zone Geometry, Hydrostatic Pressure, Workability, Residual Stresses, Forging, Rolling of Metals, Extrusion: Drawing of Rods, Wires, and Tubes, Sheet-Metal Forming, Machining of Metals

Texts/References:

1. Mechanical Metallurgy by George E. Dieter.
2. Introduction to Physical Metallurgy – SH Avner, TATA Mc GRAW HILL
3. Mechanical Behavior of Materials", T. H. Courtney, McGraw Hill Book Company.
4. Mechanical Metallurgy, Principles and Applications", M. A. Meyers and K. K. Chawla, Prentice-Hall, Inc.
5. Materials Science and Engineering", W.F. Smith, McGraw Hill Book Company.
6. Materials Science and Engineering", 3rd Ed., W.D. Callister, John Wiley and Sons.

Course Outcomes:

1. Student will able to differentiate various nanostructure materials on the basis of dimensionality.
2. The course covers properties of a range of nanostructured materials found in nature and in technology.
3. Student will gain understanding on synthetic aspects for the design of nanostructured materials.
4. Students will gain understanding between the relation between a materials nanostructure and its properties.

ME 5306	Fabrication of Engineering Materials	L	T	P	C
	M.Tech. (MMT), Second Semester (Core)	3	0	0	3

Ferrous metals: Iron-Carbon equilibrium diagram; Effects of alloy additions; Types of steel – plain carbon steels, low alloy steels, heat treatable steels, tool steels, die steels, stainless steels, special steels; International systems to classify steel grades – AISI/SAE, DIN, EN series/BS, BIS; Automotive grades and compositions; Mechanical, thermal, electrical and physical properties of steels, applications.

Steel making: Principles of steel making, melting practices – Development of steel making processes, physiochemical principles and kinetic aspects of steel making, carbon boil, oxygen transport mechanism, desulphurization, dephosphorization, slag-functions, composition control, properties and theories, raw materials for steel making and plant layout, Effects of melting practices on end product. Principle equipment used and applications of steel making processes.

Cast iron: Types of Cast irons – grey cast irons, alloy CI, Spheroidal cast irons, white iron, malleable iron, vermicular cast irons; Chemical compositions and properties.

Aluminium and aluminium base alloys: Enhancing properties of aluminium for auto applications; Classification system and grades of alloys; Roles of alloy additions on properties; Significance of various equilibrium diagrams in designing alloys; Solution treatment (age hardening) and microstructural changes; Chemical compositions & properties of aluminium alloys; Environmental benefits of recycling. Aluminium alloy melting practices; Component forming processes – castings, extrusions, sheet forming and forgings, material defects and their significances on properties and performances on end product; Automotive applications of aluminium alloys and manufacturing processes for body to Power train components.

Magnesium and titanium base alloys: Properties and benefits over other traditional metals; Classifications of alloys; Melting practices; Manufacturing processes – Casting, extrusion and forging processes; Solution treatment and microstructures; Alloy compositions and properties; Surface coatings; Auto applications and limitations.

Texts/References:

1. William D. Callister, Jr., "Materials Science and Engineering an Introduction", John Wiley & Sons, 6th Edition, Inc., 2004. \
2. V. Raghavan, "Materials Science and Engineering", Prentice Hall of India Pvt. Ltd., 5th Edition, 2007
3. Hajra Choudhary, "Elements of Workshop Technology", Asia Publishing House, Vol. I & II; 1996
4. R. K. Jain and S.C. Gupta, "Production Technology", Khanna Publishers, 1997
5. H.M.T. "Production Technology", Tata McGraw Hill, 1990
6. Avner, S. H., "Introduction to Physical Metallurgy", second edition, McGraw Hill, 1985.
7. Flinn, R. A., Trojan, P.K., "Engineering Materials and their Applications", Jaico 4th Edition, 1999.
8. Ashby M. F., "Material Selection in Mechanical Design", Butter Worth 3rd Edition, 2005. Smithells Metals Reference Book, Eighth Edition

Course Outcomes:

1. Conceptually explain the classification schemes that are used to categorize engineering materials.
2. Use binary phase diagrams to predict microstructures and also to understand precipitation hardening.
3. Understand how thermal treatments affect the microstructure and, thus, properties of materials.
4. To promote an understanding of the relationship between material structure, processing and properties.
5. To give students the background required to pursue further studies in materials processing, design and related engineering fields.

ME 5307	**Modern Manufacturing Methods**	**L**	**T**	**P**	**C**
	M.Tech. (MMT), Second Semester (Core)	3	0	0	3

Introduction to Modern Manufacturing Methods, their needs in today's manufacturing scenario, identification and characteristics of these processes, conventional versus modern manufacturing methods.

Mechanical Processes: Abrasive jet machining, Water jet machining, Abrasive water jet machining, Abrasive flow machining, Ultrasonic machining, Ultrasonic welding, their working principles, equipments, process capabilities, applications, advantages and limitations.

Chemical and Electrochemical Processes: Chemical machining, Photo chemical machining, Electrochemical machining, drilling, grinding, deburing, their working principles, equipments, process capabilities, applications, advantages and limitations.

Electrothermal Processes: Electro discharge machining (EDM), Electrodischarge wire cutting or wire EDM, Electrodischarge grinding, Electrochemical discharge grinding, their working principles, equipments, process capabilities, applications, advantages and limitations.

Electron Beam Machining, Electron Beam welding, Plasma arc cutting, Ion beam machining.

Laser Processing: Process principle, type of laser, equipments, and laser processes: drilling, cutting, machining, welding, heat treating, cladding; applications, advantages and limitations.

High energy rate forming: Electromagnetic forming, explosive forming, electrohydraulic forming, their process principles, applications.

Introduction to some emerging trends in manufacturing: Micro manufacturing, manufacturing processes lead towards micro-manufacturing, micro electro mechanical systems (MEMS), Rapid prototyping, concept of nanotechnology.

Texts/References:

1. V. K. Jain, Advanced Machining Processes, Allied Publishing Pvt. Ltd.
2. G. F. Benedict, Nontraditional Manufacturing Processes, Marcel Dekker Inc
3. P. K. Mishra, Nonconventional Machining, Narosa Publishing House
4. A. Ghosh & A. K. Mallik, Manufacturing Science, Affiliated East-West Press Pvt. Ltd.
5. G. Boothroyd & W. A. Knight, Fundamentals of Machining and Machine Tools, CRC Press Taylor & Francis Group
6. A McGeogh, Advanced Methods of Machining, Chapman & Hall
7. N. P. Mahalik, Micro manufacturing and Nano-Technology, Springer

Course Outcomes:

1. To introduce students to the basic concepts of modern manufacturing with particular emphasis on forming and machining processes.
2. To introduce students to the scientific principles underlying in machining processes so as to enable them to calculate performance measures like material removal rate.
3. To develop knowledge of appropriate process parameters applicable for various advanced machining processes and their effects on performance measures.
4. To introduce students to the machining setups to develop knowledge of machine tools used in advanced manufacturing.
5. To make students aware of the necessity of modern manufacturing processes and for the best use of these processes for material processing with particular emphasis on safety and environmental considerations.

ME 5308	MMT - Lab	L	T	P	C
	M.Tech. (MMT), Second Semester	0	0	3	2

List of Experiments

1. To prepare heat treatment specimen for mild steel samples by using quenching process.
2. Metallographic Investigation of Bare and Heat Treated Ferrous Alloy.
3. Brinell hardness Test of Bare Mild Steel and After Heat Treatment.
4. Tensile Testing of Bare and Heat Treated Ferrous Alloy.
5. Micro-Hardness Test of Bare Mild Steel and After Heat Treatment.
6. Tensile and Fracture Testing Of Thermosetting Polymer.
7. Preparation f Laminates y Hand Lay Up.
8. Tensile Testing Of Laminated Composite.
9. Synthesis of Particle under Planetary Ball Mill and Analysis of Particle Size.
10. Synthesis of Nanoparticle by Sol-Gel Method.
11. Thermal Analysis Method.

Course Outcomes:

1. Characterization of polymers in terms of physical, chemical and mechanical.
2. Characterization of composites in terms of physical, chemical and mechanical.
3. To know the significance of thermal characterization techniques and obtain parameters by using DSC.

ME 5320	Seminar-II	L	T	P	C
	M.Tech. (MMT), Second Semester (Core)	**0**	**0**	**2**	**1**

Individual students are required to choose a topic of their interest from engineering domain preferably from outside the M.Tech syllabus. Evaluation will be executed based on Clarity on the topic, Literature review, Content, Presentation, Response to Questions.

Course Outcomes:

At the end of the course the student will be able to-

1. Identify and compare technical and practical issues related to Engineering domain.
2. Prepare report with proper citation.
3. Analyse technical issues and develop competence in presenting it.

ME 5336	Powder Metallurgy	L	T	P	C
	M.Tech. (MMT), Second Semester (Elective-III)	3	0	0	3

Processing Techniques: Introduction, Different methods of powder production viz Milling, atomization, Reduction, Electrolysis, Carbonyl process.

Characterization of powders: Chemical composition, Structure, Morphology, Shape, Size, Distribution, Surface area, Powder flow, Apparent density, Tap density, Compressibility, Porosity.

Consolidation: Powder mixing and blending, Compaction techniques, Uniaxial, Isostatic compaction, Extrusion, Forging, Rolling, Injection molding, Tape forming, Slip casting, Sol-gel casting, Types of processes, Tooling and Die design.

Sintering: Sintering mechanism, atmospheres and equipments, types of sintering methods: Solid state sintering, Liquid phase sintering, Reaction sintering, Hot pressing, Hot isostatic pressing, Self-propagating combustion sintering, Sintering atmosphere.

Applications of powder metallurgy: Application of Powder Metallurgy: Nanostructured Materials, Heterogeneous Microstructures Application and uses of powder metallurgy products viz Filters, Contact materials, Bearing, Structural parts.

Text Books/References:

1. An introduction to powder Metallurgy, F. Thummler and R. Oberacker, The Institute of Materials, 1993.
2. ASM Handbook, powder Metallury Technologies and Applications, vol.7, ASM International, 1998.

Course Outcomes:

1. To introduce the students with important materials processing technique.
2. To familiarize the students with the principles of powder metallurgical technique.
3. To introduce the students with few case studies where powder metallurgical techniques are successfully used to produce super-hard and intricate materials parts.

ME 5337	**Biomaterials**	**L**	**T**	**P**	**C**
	M.Tech. (MMT), Second Semester (Elective-III)	3	0	0	3

Introduction: Introduction to Biomaterials, Background history, classification, uses, problems with biomaterials, History, Evolution, polymer, metal, ceramic and natural biomaterials.

Properties: Properties (mechanical and physicochemical) stress, strain, elastic modulus etc., Poisson's ratio shear/bulk modulus, viscoelastic ity, creep, recovery, human bone, etc. (numerical), elastic, viscoelastic materials, porosity, models(numerical). Biodegradation and Bioresorption, degradation mechanism, Oxidative, enzymatic degradation, autocatalysis etc. Biofilm, definition, types of bacteria and their responses, Factors affecting bacterial resistance in biofilm, persister cells, Biofilm prevention strategies, Biofilm growth modeling parameters.

Characterization: Biomaterials/biofilm characterization using analytical tools, SEM,TEM,AFM etc, XRD, TGA, DSC other spectroscopy, UV spectroscopy, FTIR, FT Raman, mass spectroscopy, MALDI, TOF etc, Biofilm characterization. Metallic biomaterials, orthopedic, dental alloys, Bone replacement criterion, THR, TKR,

Basics of Crystal structure: Planes, Basics of Defects in solids. Properties of metallic biomaterials like bio corrosion, electrochemical corrosion etc, Polymeric biomaterials, classification, applications, Structure of polymers, properties, Blending, mixing and composite- applications, drug delivery system, Natural biopolymers, classification, applications etc, scaffolds, Natural biopolymers, protein, collagen, HA etc.

Applications of Biomaterials: Biopolymers-Proteins, Hydrogels, types, classification, applications etc. Bio-Ceramics, classification, advantages, bio glass, numerical, Biomaterials Cardiovascular, ocular etc., Biomaterials for urinary/dental/skin applications, Biomaterials sterilization, device failure.

Text Books/References:

1. Biomaterials: An Introduction, J B Park & RS Lakes, (Plenum Press : New York).
2. Biomaterials Science - Ratner, Hoffman, Schoen, Lemons (Elsevier; ISBN 0-12-582461.
3. Biomaterials - Temenoff and Mikos (Pearson Prentice Hall; ISBN 0-13-009710-1).
4. Materials Science and Engineering: An Introduction - Callister (John Wiley and Sons; ISBN 0- 471-13576-3).
5. Science and Engineering of Materials - Askland and Phule (Thomson; ISBN 0-534-55396-6)

Course Outcomes:

1. To understand characterization of biomaterials
2. To understand applications of biomaterials
3. To understand structure and properties of biomaterials
4. To know the various issues associated with implant materials

ME 5134	**Non Destructive Testing of Materials**	**L**	**T**	**P**	**C**
	M.Tech. (MMT), Second Semester (Elective-III)	3	0	0	3

Introduction: Review of destructive testing, limitations of destructive testing, need for non-destructive testing, fundamentals and introduction to non-destructive testing, scope and limitations of NDT, Visual examination methods, different visual examination aids.

Dye penetrant Testing: Principle, procedure, characteristics of penetrant, types of penetrants, penetrant testing materials, fluorescent penetrant testing method– sensitivity, application and limitations

Magnetic Particle Testing: Important terminologies related to magnetic properties of material, principle, magnetizing technique, procedure, equipment, fluorescent magnetic particle testing method, sensitivity, application and limitations

Ultrasonic Testing: Basic principles of sound propagation, types of sound waves, principle of ultrasonic testing, methods of ultrasonic testing, their advantages and limitations, piezoelectric material, various types of transducers/probe, calibration methods, use of standard blocks, technique for normal beam inspection, flaw characterization technique, defects in welded products by ultrasonic testing, thickness determination by ultrasonic method, study of a, b and c scan presentations, advantage, limitations acoustic emission testing, principles of acoustic emission testing and techniques

Radiographic testing: Radiographic testing: X-ray and Gamma-Ray radiography, their principles, methods of generation, industrial radiography techniques, inspection techniques, applications, limitations, types of films, screens and penetrameters. Interpretation of radiographs, safety in industrial radiography

Leak and pressure testing: Leak and pressure testing: definition of leak and types, principle, various methods of pressure and leak testing, application and limitation

Eddy current testing: Eddy current testing: principle, instrument, techniques, sensitivity, application, limitation of thermal methods of NDT.

Materials characterization: Basic principles, interaction of radiation and particle beams with matter, diffraction methods, images, optical, scanning, transmission electron, scanning tunneling and field ion microscopy, microanalysis and spectroscopy, energy dispersive, wavelength dispersive, Auger processes, electron, ion growth, secondary-ion mass spectrometry (SIMS), electron spectroscopy for chemical analysis (ESCA), Differential thermal analysis (DTA), Differential Scanning Calorimetry (DSC).

Texts/References:

1. Barry Haul, Vernon John: Non Destructive Testing, Springer – Verlag New York Inc., 2012.
2. Paul E Mix: Introduction to Nondestructive Testing: A Training Guide, Willey – Blackwell, 2005.
3. Ravi Prakash: Non-Destructive Testing Techniques, New Academic Science Ltd., 2009.
4. Baldev Raj: Practical Non Destructive Testing, Narosa Publishing House, 2009.
5. Yang Leng: Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Wiley VCH, 2013.
6. Khangaonkar P R: An Introduction to Material Characterization, Penram International. Publishing (India) Pvt. Ltd., 2008.

Course Outcomes:

1. Be differentiate between destructive and non-destructive testing methods.
2. Be able to identify the types of equipment used for each non destructive testing.
3. Be able to explain the purpose of the equipment, application, and standard techniques required to perform major non-destructive testing of materials and components.
4. Be able to go to specific code, standard, or specification related to each testing method.
5. Acquire the knowledge and essential skills to identify strengths and weaknesses in materials used in fabrication

ME 5339	**Nano Structured Materials**	**L**	**T**	**P**	**C**
	M.Tech. (MMT), Second Semester (Elective-III)	3	0	0	3

Unit I: Introduction to nanotechnology and the two approaches (bottom up and top down) followed for the synthesis of nanomaterials.

Unit II: Synthetic methodologies: i) Sol-gel. ii) Micromulsion. iii) CVD,PVD,Molecular beam epitaxy. iv) Vapor (solution)-liquid-solid growth, (VLS or SLS). v) Spary Pyrolysis. vi) Template based synthesis. vii) Lithography.

Unit III: Various kind of Nanostructures: i) Carbon fullerenes and CNT. ii) Metal and metal oxide nanowires. iii) Self assembly of nanostructures. iv) Core-shell nanostructures. v) Nanocomposites.

Unit IV: Physical Properties of nanomaterials: i) Photocatalytic. ii) Dielectric. iii) Magnetic. iv) Optical. v) Mechanical.

Text books/References:

1. William D. Callister, Jr., “Materials Science and Engineering an Introduction”, John Wiley & Sons, 6th
2. Edition, , Inc., 2004.
3. Guozhong Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press 2004.
4. T. Pradeep, Nano: The Essentials Understanding nanoscience and nanotechnology, Tata McGraw-Hill Publishing Company Limited NEW DELHI, 2007.
5. Nanomaterials Synthesis, Properties and Applications Edited by A S Edelstein and R C Cammarata, IOP Publishing Ltd 1996.

Course Outcomes:

1. Students will able to understanding of important issues related to metallurgical fundamentals of materials.
2. At the end of the course, student will be able to Identify advanced materials for technological and scientific problems.
3. Student will be able to Identify advanced instruments available for characterization of materials.
4. Student will be able to analyze defects and fracture surfaces of materials.
5. Student will gain understanding and Interpret the relationship between structure of a material and its mechanical properties

ME 5340	**High Temperature Materials**	**L**	**T**	**P**	**C**
	M.Tech. (MMT), Second Semester (Elective-III)	3	0	0	3

Unit I: Fe-based, Ni-based and Co-based superalloys, Effect of composition, strengthening mechanism: solid solution strengthening, precipitation hardening and grain boundary strengthening, tetragonal closed packed phases and its effect on the properties of superalloys, solidification of single crytals.

Unit II: Titanium and its alloys, refractory materials and its alloys, high temperature ceramic materials, cermets, cemented carbides.

Unit III: 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

Unit IV: Fatigue resistance, corrosion resistance and effect of alloying elements, oxidation resistance, formability, weldability of superalloys, fluidity, application of superalloys.

Text/References:

1. Donachie, A technical guide on Super alloys, A.S.M. Ohio, 2002
2. C. T.Sims & N. C. Hagel, super alloys, JohnWiley Publishers, 1972
3. Betteridge, The Nimonic Alloys - Edward Arnold Publishers Ltd., London, 1959
4. Raj R, ‘Flow and Fracture at Elevated Temperatures’, American Society for Metals, 1985

Course Outcomes:

1. Conceptually explain the classification schemes that are used to categorize engineering materials.
2. Use binary phase diagrams to predict microstructures and also to understand precipitation hardening.
3. Understand how thermal treatments affect the microstructure and, thus, properties of materials.
4. To promote an understanding of the relationship between material structure, processing and properties.

ME 5350	Surface Engineering	L	T	P	C
	M.Tech. (MMT), Second Semester (Elective-IV)	3	0	0	3

Introduction: Significance of surface engineering; Solid surfaces and its classification; Surface measurement- surface profilomerty, optical microscopy, electron microscopy; Tribology- lubrication, friction and wear; wear and its classification;

Surface Treatment: Importance and classification; Microstructural and Thermochemical treatment; Physical vapor deposition (PVD); Electroplating; Sputter deposition; Chemical vapor deposition (CVD); Ion implantation; Electron beam technogy.

Thermal Spraying Techniques: Flame Spraying, Atmospheric Plasma Spraying (APS), Vacuum Plasma Spraying (VPS), High-Velocity Oxy-Fuel (HVOF) Spraying.

Laser surface engineering: Laser transformation hardening; Laser remelting; Laser alloying, Laser cladding; Laser ablation; Pulsed laser deposition; Laser doping; Laser surface texturing; Laser shock peening.

Basic concepts of corrosion: Importance, corrosion theories, kinetics and mechanism of corrosion processes. Different forms of corrosion and their control methods. Environmental aspects: Atmospheric corrosion, underground corrosion, biological corrosion – mechanisms and control measures.

Text/References:

1. T. Burakowski, T. Wierzchon, "Surface Engineering of Metals-Principles, equipment and technologies", CRC Press.
2. R. W. Revie, H. H. Uhlig, "Corrosion and Corrosion Control-An Introduction to Corrosion Science and Engineering" Fourth Edison, John Wiley & Sons.
3. Prasanta Sahoo, "Engineering Tribology", PHI Learning Pvt Limited.
4. D. R.Gabe, "Principles of Metal Surface Treatment and Protection", Second Edison, Pergamon Press.

Course Outcomes:

1. Understanding in surface fundamentals and its role in tribology.
2. Compare the use of different surface treatment techniques.
3. Select appropriate application of surface modification process.
4. Understand different types of corrosion and its effect.

ME 5351	Computational Modelling of Materials	L	T	P	C
	M.Tech. (MMT), Second Semester (Elective-IV)	3	0	0	3

Unit–1: Introduction and Basic concepts, Theoretical Background, Basic equations for interacting electrons and nuclei, Coulomb interaction in condensed matter, Independent electron approximations, Exchange and correlation, Periodic solids and electron bands, Structures of crystals: lattice + basis, The reciprocal lattice and Brillouin zone, Excitations and the Bloch theorem.

Unit-2: Time reversal and inversion symmetries, Integration over the Brillouin zone and special points Density of states Uniform electron gas and simple metals. Non-interacting and Hartree-Fock approximation, The correlation hole and energy. Density functional theory: foundations, Thomas-Fermi-Dirac approximations: example of a functional. The Hohenberg-Kohn theorems, constrained search formulation of density functional theory, Extensions of Hohenberg-Kohn theorems, The Kohn-Sham ansatz. Replacing one problem with another: The Kohn-Sham variational equations Exc, Vxc and the exchange correlation hole meaning of the eigenvalue. Intricacies of exact Kohn-Sham theory.

Unit-3: Functionals for exchange and correlation, The local spin density approximation (LSDA), Generalized-gradient approximation (GGAs) , LDA and GGA expressions for the potential Vxc(r), Non-collinear spin density, Non-local density formulations: ADA and WDA, Orbital dependent functionals I: SIC and LDA+U. Orbital dependent functional II: OEP and EXX, Hybrid functionals , Tests of functionals Solving Kohn-Sham equations – Self-consistent coupled Kohn.Sham equations - Total energy functionals, Achieving self-consistency-Numerical mixing schemes, Force and stress.

Unit-4: Determination of electronic structure – Atomic sphere approximation in solids, Plane waves and grids: basics - The independent particle Schrodinger equation in a plane wave basis. The Bloch theorem and electron bands – Nearly free-electron-approximation - Form factors and structure factors. Plane-wave method - ‘Ab initio’ pseudopotential method - Projector augmented waves (PAWs) - Simple crystals: structures, bands, - Supercells: surfaces, interfaces, phonons, defects - Clusters and molecules. Localized orbitals: tight-binding – Tight-binding bands: illustrative examples - Square lattice and CuO2 planes - Examples of bands: semiconductors and transition metals - Electronic states of nanotubes. Localized orbitals: full calculations – Solution of Kohn-Sham equations in localized bases. Analytic basis functions: gassians – Gassian methods: ground state and excitation energies - Numerical orbitals – Localized orbitals: total energy, force, and stress - Applications of numerical local orbitals - Green’s function and recursion methods - Mixed basis.

Unit-5: Augmented plane waves (APW’s) and ‘muffin-tins’ – Solving APW equations: examples Muffin-tin orbitals (MTOs). Linearized augmented plane waves (LAPWs) - Applications of the LAPW method - Linear muffin-tin orbital (LMTO) method - Applications of the LMTO method - Full potential in augmented methods - Molecular dynamics (MD): forces from the electrons - Lattice dynamics from electronic structure theory - Phonons and density response functions - Periodic perturbations and phonon dispersion curves – Dielectric response functions, effective charges - Electron-phonon interactions and superconductivity.

Text/References Books

1. H.Skriver, The LMTO Methods, Springer (1984).
2. Electronic Structure Basic Theory and Practical Methods Richard M. Martin, Cambridge University Press (2004).
3. Modeling Materials Continuum, Atomistic and Multiscale Techniques ELLAD B. TADMOR, Cambridge University Press (2012).
4. Atomic and Electronic Structure of Solids, Efthimios Kaxiras, Cambridge University Press (2003).
5. Computational Chemistry of Solid State Materials, *Richard Dronskowski*, WILEYVCH (2005).
6. Mizutani U. Introduction to the Electron Theory of Metals (CUP,2001).
7. Roessler U. Solid State Theory.. An Introduction (2ed., Springer, 2009).

Course Outcomes:

1. The emphasis of the course is on getting practical experience in designing and performing computer modelling and simulations.
2. Students who have taken the previous course have immensely benefited from this course
3. There have been many other students, who, without any prerequisite knowledge of quantum mechanics, statistical mechanics etc. have grasped the underlying concepts and have successfully applied the learning from this course to their research work.

ME 5138	Additive Manufacturing	L	T	P	C
	M.Tech. (MMT), Second Semester (Elective-IV)	3	0	0	3

Introduction: Overview and History of Additive Manufacturing, CAD-CAM and its integration, Traditional Prototyping Vs. Rapid Prototyping (RP), Benefits of AM, Classification of Additive Manufacturing Processes: Additive, Subtractive, Formative, Generic AM Process, Applications in Product Development.

Cad Modelling and Data Processing: Introduction, Data Processing for Additive Manufacturing Technology: 3D solid modeling software and their role in AM, CAD model preparation, Data interface for Additive Manufacturing: Creation of STL file, Problem with STL file, STL files Manipulation, Beyond the STL file, Additional Software to Assist AM; Part orientation, Support Structure Design, Model Slicing Algorithms and Contour Data Organization, Direct and Adaptive Slicing, Tool Path Generation; Software for Additive Manufacturing Technology: MIMICS, MAGICS.

Additive Manufacturing Processes: Classification, Liquid Based System: Stereolithography Apparatus, Solid Ground Curing, Polyjet: Process Physics, Material and Technological Aspects, Process Parameters, Advantages, Applications and Case Study; Solid based system-Fused Deposition Modeling, Laminated Object Manufacturing, Contour Crafting: Process Physics, Material and Technological Aspects, Process Parameters, Advantages, Applications and Case Study; Powder based system: Selective Laser Sintering, Selective Laser Melting, Laser Engineered Net Shaping, Electron Beam Melting, Three Dimensional Printing: Process Physics, Material and Technological Aspects, Process Parameters, Advantages, Applications and Case Study; Other Associated Technology, Metal and Hybrid Systems.

Post Processing: Support Material Removal, Surface Texture Improvement, Accuracy Improvement, Aesthetic Improvement, Preparation for use as a Pattern, Property Enhancements using Non-Thermal and Thermal Techniques.

Issues in Additive Manufacturing: Variation from one AM Machine to Another, Pre- & Post processing, Metal System, Accuracy Issues in Additive Manufacturing, Strength of AM Parts, Surface Roughness Problem in Additive Manufacturing, Part Deposition Orientation and Issues like Shrinkage, Swelling, Curl and Distortion; Materials, Machine Design: Larger Scale or Smaller Scale, Layer Forming Quality, Material Delivery, Cost, Reliability, Operation and Others.

Reverse Engineering: Introduction, Measuring Device- Contact type and Non-Contact Type, CAD Model Creation from point Clouds, Preprocessing, Point Clouds to Surface Model Creation, Medical Data Processing: Types of Medical Imaging, Software for Making Medical Models, medical materials, Other Applications: Case study.

Recent Advances and Applications: Rapid Tooling (Direct and Indirect RT), New Materials Development, Bi-metallic parts, Application Examples for Aerospace, Defense, Aerospace, Automotive and Biomedical Applications of AM- Computer Aided Tissue Engineering (CATE), Case studies; Trends and Future Directions in Additive Manufacturing.

Texts/References:

1. Rapid Prototyping: Principles And Applications by C.K. Chua, K.F. Leong, C.S. Lim, 3rd Edition, World Scientific Publishing Co Pte Ltd

2. Rapid Prototyping: Theory & Practice, A. K. Kamrani, E. A. Nasr Springer
3. Additive Manufacturing, A. Bandyopadhyay, S. Bose CRC Press; 2nd edition
4. Rapid Prototyping: Principles and Applications in Manufacturing, R. Noorani Wiley

Course Outcomes:

1. Understand the broad range of AM processes, devices, capabilities and materials that are available.
2. Learn how to create physical objects that satisfy product development/prototyping requirements, using advanced/additive manufacturing processes and suitable materials.
3. Fabricate an actual multi-component object using advanced/additive manufacturing process.
4. Articulate the various trade-offs that must be made in selecting advanced/additive manufacturing processes, devices and materials to suit particular product requirements

ME 5239	**Manufacturing Management**	**L**	**T**	**P**	**C**
	M.Tech. (MMT), Second Semester (Elective-IV)	3	0	0	3

Strategy planning: Nature of production-inventory management systems. Strategic, Tactical and Operational decisions. General discrete location-allocation problems - features and formulations. Facility location models - median model - distribution model - brown and Gibson model

Tactical planning: Aggregate production planning - ways to absorb demand fluctuations - costs relevant to aggregate production planning - aggregate production planning models - Inventory management - EOQ decision rules - costs in an inventory system - simple lot size model

Scheduling: Operations scheduling - Flow shop - n jobs – 2 machine Johnson's rule, 2 Jobs –M machine, N-Jobs M machine Sequencing Job on parallel machine - Assembly Line Balancing- Project Scheduling-crashing of project network with cost trade off

MRP & MRP-II: Material Requirement Planning (MRP) - working of MRP - Use of MRP system - evolution from MRP to MRP II - master production scheduling - rough cut capacity planning - capacity requirement planning - Lot sizing in MRP II system.

SCM & quality management: Concept of supply management and SCM, Flow in supply chains, Key issues in supply chain management, Decision phases in supply chain, concept of quality management - standards for quality management - statistical process control - Taguchi method of quality control.

Texts/References:

1. H.G. Menon, “TQM in New Product Manufacturing”, McGraw Hill, 1992.
2. Hax and Candea, “Production and Inventory Management”, Prentice Hall, 1984.
3. Buffa. “Modern Production Management”, John Welley, 1983.

Course Outcomes:

1. Make management level decisions within a manufacturing environment including operations management, supply chain management.
2. Analyze planning, professional and engineering decisions within a manufacturing environment.
3. Evaluate cost effectiveness of manufacturing products, processes and operations.
4. Manage a sustainable supply chain using a variety of effective tools and techniques.

ME 5353	Advanced Casting and Joining Processes	L	T	P	C
	M.Tech. (MMT), Second Semester (Elective-IV)	3	0	0	3

Unit I: Design for moulding and casting, function of the gating system, permanent mould casting-centrifugal casting, investment casting mercast casting-continuous casting-low pressure casting, Interfacial Heat Transfer, Thermodynamics & metallurgical aspects in solidification of pure metals and alloys, Homogeneous and heterogeneous nucleation

Unit II: Risering curves, NRL, Caine method, Feeding distance, Gating systems and their characteristics. Type of gates and design consideration, Chills pattern design consideration, Sand testing, Advanced metal casting processes, Casting defects, Their causes & redressal.

Unit III: Arc welding power sources, Arc and arc characteristics, Behavior of arc with variation in current and voltage, Welding electrodes, ISI specification of electrodes, Electrode selection, Newer welding process- such as plasma arc, Laser beam, Electorate, Ultrasonic welding, Hybrid welding.

Unit IV: Welding metallurgy, weldability criteria, Different types of joint configuration-different types of welding position-design of weldments and joints, Heat flow is welding metallurgical transformation, Implication of cooling rate, HAZ, Weldability of plain carbon steels, SS, Al and its alloys, Residual stresses and distorting

Unit V: Inspection and testing of welding and casting – Defects, Destructive tests – Non-destructive testing techniques – surface treatments-safety aspects in welding processes- specific welding applications and innovations.

Text Books/References

1. Dr.R.S.Parmar "Welding processes and technology" Khanna Publishers.
2. H.S.Bawa "Manufacturing Technology-I" Tata Mc Graw Hill Publishers New Delhi, 2007.
3. Scrope Kalpakjian, "Manufacturing processes for Engineering Materials", Addision Wesley, 1997.

Course Outcomes:

1. To inculcate the principle, thermal and metallurgical aspects during solidification of metal and alloys.
2. To impart knowledge about principles/methods of casting with detail design of gating/riser system needed for casting, defects in cast objects and requirements for achieving sound casting.
3. To impart knowledge about welding behaviour of machine and process during welding, analysis of common and newer welding techniques and metallurgical and weldability aspects of different common engineering materials.