

CURRICULUM AND SYLLABI

M.Tech.

in

MATERIALS SCIENCE AND TECHNOLOGY

(With effect from Academic Year 2018-2019)



**DEPARTMENT OF MECHANICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY CALICUT
CALICUT - 673601**

DEPARTMENT OF MECHANICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY CALICUT

Vision of the Institute

International standing of the highest calibre

Vision of the Department

To impart nationally and internationally recognized education in Mechanical Engineering, leading to well-qualified engineers who are innovative contributors to the profession and successful in advanced studies and research.

Mission of the Institute

To develop high quality technical education and personnel with a sound footing on basic engineering principles, technical and managerial skills, innovative research capabilities, and exemplary professional conduct to lead and to use technology for the progress of mankind, adapting themselves to changing technological environment with the highest ethical values as the inner strength.

Mission of the Department

To offer high quality graduate and post graduate programs in the fields of Mechanical Engineering and to prepare students for professional career and higher studies promoting excellence in teaching, research, entrepreneurship, collaborative activities with ethical values, making positive contributions to the society.

M. Tech. in Materials Science and Technology

PEOs

PEO 1: To train students with in-depth and advanced knowledge to become highly-skilled professionals in the areas of materials science and technology and allied fields, and to make capable of analysing and solving complex material science related problems.

PEO 2: To enable graduates to carry out innovative and independent research work in academia/industry to enhance the knowledge base in materials science and technology and to disseminate the knowledge.

PEO 3: To prepare the students to exhibit a high level of professionalism, integrity, social responsibility and life-long independent learning ability.

POs

PO1: An ability to independently carry out research/investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: Students should be able to demonstrate a degree of mastery over the area as per the Materials Science and Technology programme. The mastery should be at a level higher than the requirements in the appropriate bachelor programme.

PO4:An ability to acquire and share in-depth knowledge in the area of material science and technology.

PO5:An ability to analyse complex problems in the field of material science and technology critically and arrive at optimal solutions.

PO6: An ability to use modern computer/ software tools to model and analyse problems related to materials science and technology

**Curriculum for M. Tech. in Materials Science and Technology
(2018 Admissions)**

Semester-1					
Code	Title of Course	L	T	P/S	C
MA6001D	Mathematical Methods	3	-	-	3
ME6501D	Mechanical Behaviour of Materials	3	-	-	3
ME6502D	Ferrous and Non-Ferrous Metallurgy	3	-	-	3
	Elective-1	3	-	-	3
	Elective-2	3	-	-	3
ME6591D	Materials Science Lab 1	--	-	3	2
	Total	17			

Semester-2					
Code	Title of Course	L	T	P/S	C
ME6511D	Composite Materials: Mechanics, Manufacturing and Design	3	-	-	3
ME6512D	Ceramic Science and Technology	3	-	--	3
ME6513D	Metal Casting and Joining	3	-	-	3
	Elective-3	3	-	-	3
	Elective-4	3	-	-	3
ME6592D	Materials Science Lab 2	--	-	3	2
ME6593D	Seminar/Mini Project	--	-	2	1
	Total	18			

Semester 3					
Code	Title of Course	L	T	P/S	C
ME7594D	Project (Part-I)	--	-	20	12
	Total	12			

Semester 4					
Code	Title of Course	L	T	P/S	C
ME7595D	Project (Part-II)	--		20	13
	Total	13			

L: Lecture, T: Tutorial, P, Practical, S: Seminar, C: Credit

Total Credits: 60

Notes

1. A minimum of 60 credits have to be earned for the award of M. Tech. degree in this programme.
2. Communicative English and Audit courses are optional.
3. Students may choose any PG level course offered in the Institute with the approval from the Programme Coordinator.
4. It is desirable for students to undergo *Two Months* Industrial Training/Internship during summer vacation.

5. Students are permitted to audit course/s in the Third and Fourth Semesters of the programme. Only a maximum of two audited courses for which a minimum pass (P) grade secured shall be recorded in the grade card.

Credit distribution	
Curricular composition	Credits
Theory courses	30
Laboratory courses	4
Seminar	1
Project works	25
Total credits	60

Stream-specific Elective Courses						
Sl. No.	Code	Title	L	T	P	C
1	ME6521D	Thermodynamics of Materials	3	-	-	3
2	ME6522D	Powder and Sintered parts	3	-	-	3
3	ME6523D	Corrosion Science and Technology	3	-	-	3
4	ME6524D	Science of solidification process	3	-	-	3
5	ME6525D	Characterisation of Materials	3	-	-	3

Other suggested Elective Courses						
Sl. No.	Code	Title	L	T	P/S	C
1	ME6622D	Behaviour and Selection of Materials	3	-	-	3
2	ME6623D	Industrial Tribology	3	-	-	3
3	ME6612D	Finite Element Method and Applications	3	-	-	3
4	ME6328D	Design of Experiments	3	-	-	3
5	CY6001D	Polymer Science and Engineering	3	-	-	3
6	PH6001D	Physics of Materials	3	-	-	3
7	NS6122D	Nano Materials for Energy and Environment	3	-	-	3
8	NS6130D	Elements of X-Ray Diffraction	3	-	-	3
9	NS6101D	Structure of Nanomaterials	3	-	-	3
10	NS6112D	Experimental Techniques in Nanotechnology	3	-	-	3

**Syllabi for M. Tech. in Materials Science and Technology
(2018 Admissions)**

MA6001D MATHEMATICAL METHODS FOR ENGINEERS

Pre-requisites: Nil

Total hours: 39

L	T	P	C
3	0	0	3

Module 1: (10 hours)

Linear Algebra: vector spaces, subspaces, basis, dimension, inner product spaces, Gram-Schmidt process, linear transformations, range and kernel, isomorphism, matrix of transformations and change of basis.

Module 2: (9 hours)

Series Solutions of ODE and Sturm-Liouville Theory: power series solutions about ordinary point, Legendre equation and Legendre polynomials, solutions about singular points; the method of Frobenius, Bessel equation and Bessel functions; Sturm-Liouville problem and generalized Fourier series.

Module 3: (10 hours)

Partial Differential Equations: first order PDEs, linear equations, Lagrange method, Cauchy method, Charpits method, Jacobi method; second order PDEs: classification, method of separation of variables, formulation and solution of wave equation, heat equation and Laplace equation.

Module 4: (10 hours)

Tensor Calculus: spaces of n -dimensions, coordinate transformations, covariant, contravariant and mixed tensors, fundamental operation with tensors, quotient law, the line element and metric tensor, conjugate tensor, Christoffel's symbols, covariant derivative.

References:

1. D. C. Lay, *Linear Algebra and its Applications*. Addison Wesley, 2003.
2. F. G. Florey, *Elementary Linear Algebra with Application*. Prentice Englewood, 1979.
3. W. W. Bell, *Special Functions for Scientists and Engineers*. Dover Publications, 2004.
4. I. Sneddon, *Elements of Partial Differential Equations*. McGraw Hill International, 1985.
5. B. Spain, *Tensor Calculus*, Oliver and Boyd, 1965.
6. K. S. Rao, *Introduction to Partial Differential Equations*, 3rd ed. Prentice-Hall, 2010.
7. S. L. Ross, *Differential Equations*, 3rd ed. John Wiley & Sons, 2004.
8. L.A.Pipes and L.R. Harwill, *Applied Mathematics for Engineers and Physicists*. McGraw Hill, 1971.
9. M.A. Aklonis and V.V. Goldberg, *An Introduction to Linear Algebra and Tensors*. Dover Publications, 1997.
10. P. K. Nayak, *Text book of Tensor Calculus and Differential Geometry*. PHI Learning, 2012.

ME6501 MECHANICAL BEHAVIOUR OF MATERIALS

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total Hours: 39

Module 1 (14 hours)

Concepts of crystals, Plastic deformation by slip and twinning, Slip systems in FCC, BCC and HCP lattices, Critical resolved shear stress for slip, Theoretical shear strength of solids, Stacking faults and deformation bands. Observation of dislocations, Climb and cross slip, Dislocations in FCC and HCP lattice, Interaction of dislocations, Dislocation sources and their multiplications. Strengthening from grain boundaries, Grain size measurements, Yield point phenomenon, Strain aging, Solid solution strengthening, Strengthening from fine particles, Fiber strengthening, Cold working and strain hardening, Annealing of cold worked metal.

Module 2 (15 hours)

Fracture in metals: Griffith theory of brittle fracture, Metallographic aspects of fracture, Fractography, Dislocation theories of brittle fracture, Ductile fracture, Notch effects, Strain energy release rate in fracture, Fracture toughness and design; Fatigue of metals: The S-N curve, Low cycle fatigue, Fatigue crack propagation, Effect of stress concentration on fatigue, Size effect, Surface effects and fatigue, Fatigue under combined stresses, Effects of metallurgical variables and fatigue, Corrosion fatigue, Design for fatigue, Effect of temperature on fatigue; Creep and stress rupture: Creep curve, Stress rupture test, Mechanism of creep deformation, Activation energy for steady state creep, Super plasticity, Fracture at elevated temperature, Creep resistant alloys, Creep under combined stresses.

Module 3 (10 hours)

Tension test: Stress-strain curves, Instability in tension, Ductility measurement, Effect of strain rate, temperature and testing machine on flow properties, Stress relaxation testing, Notch tensile test, Anisotropy of tensile properties. Hardness test: Brinell, Rockwell and Vickers hardness, flow of metal under the indenter, relationship between hardness and flow curve, micro hardness testing, Hardness at elevated temperatures.

References

1. Dieter M. George, *Mechanical Metallurgy*, Tata McGraw- Hill Inc., 2013.
2. Callister, W. D., *Materials Science and Engineering An Introduction*, 9th Edition., John Wiley, 2013.
3. Frank A McCLINOCK and ALI S ARGON, *Mechanical behaviour of Materials*, Addison-Wesley Pub. Co., 1966
4. Richard W Hertzberg, *Deformation and fracture mechanics*, John Wiley & Sons, 5th Edition 2012
5. Reed Hill and Robert E , *Physical Metallurgy Principles*, East West Press, 2008
6. Hyden W. M., *Structure and properties of Materials*, Vol. 3, Wiley 1965
7. Honeycombe, *Plastic deformation of Metals* , , Arnold Press, second edition
8. Avner, S. H., *Introduction to Physical Metallurgy*, 2 nd ed., Tata McGraw Hill, 1982

ME6502D FERROUS AND NON-FERROUS METALLURGY

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total Hours: 39

Module 1 (13hours)

Ferrous Foundry; Melting units: cupola and its operation, design of cupola, charge calculation, electric arc furnace and induction furnace, design, fabrication and control of composition – selection – recent developments.

Solidification of Metals: General thermodynamic and kinetic considerations, rate of reaction, Arrhenius equation, activation energy. Process of nucleation and growth, thermodynamical theory and nucleation, homogeneous and heterogeneous nucleation in solids, growth of new phase in solution, dendritic and cellular growth, freezing of ingots.

Module 2 (13hours)

Cast Iron Metallurgy: Details of various cast irons, casting characteristics and mechanical properties. effect of various elements in cast irons, trace elements, type of graphites, sizes, solidification, nucleators, cooling rate, growth process, inoculants in mould process, theory of inoculation, chill testing and composition control, effect of alloying elements, fluidity, inverse chill, sub-surface blow holes, dispersed shrinkage porosity, specification of cast iron, malleable iron, blackheart, composition control, S.G. iron: production, properties, treatment and applications.

Module 3 (13hours)

Steel and Non-Ferrous Metallurgy: Composition, structure, Fe-FeC diagram, solidification process, effect of structure on properties, heat treatments of castings, liquid quench and temper, alloy steels, measurements of hardenability and its significance, production, heat treatment, solidification of steels. General demand survey of non-ferrous metals and alloys, melting units, properties of liquid metal and their significance in foundry practice, oxidation, solution of gases in metals, fluidity, hot tear, shrinkage, grain refinement, modification. various types of defects in non-ferrous alloys, details of aluminium, copper and magnesium base alloys.

References

- 1 M. C. Flemings, *Solidification process*–, McGraw-Hill, 1974
2. W. G. Winegard, *An Introduction to the Solidification of Metals*–, 1964
3. Murphy, *Non-Ferrous Foundry Metallurgy*– 1954
4. W. H. Dennis, *Metallurgy of NonFerrous Metals*– 1966
5. Geine, Loper & Rosenthal, *Principles of Metal Casting*–, Indian edition
6. Reed Hill and Robert E, *Physical Metallurgy Principles*, East West Press, 2008

ME6591D MATERIALS SCIENCE LABORATORY - I

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Total Hours: 39

Clear understanding and practice of sample preparations for optical microscopy and scanning electron microscopy analysis, Usage of optical microscopy technique to analyse grain boundaries, precipitates and interpretation of images; Understanding of flaw detection techniques; Advanced material characterization techniques; Ability to perform various heat treatment processes; Hands on practice of alloy casting and sample preparation for mechanical testing; Ability to perform various mechanical property analysis based on standards and result analysis capability.

List of suggested experiments and exercises:

1. Polishing Etching and microstructure analysis of Mild steel, Aluminium and Copper
2. Study of variation in Microstructure of dual phase stainless steels after heat treatment
3. Hardness analysis of polymer, Aluminium and mild steel (Before and after heat treatment)
4. Temperature Data Acquisition System
5. Study of Ultrasonic Flaw detector
6. Atomic Force Microscopy
7. Scanning electron microscopy
8. Casting of Aluminium alloy
9. Specimen preparation and tensile and compressive test of Aluminium alloy
10. Specimen preparation and impact testing of Aluminium alloy.

References:

1. George E Dieter, *Mechanical Metallurgy*, 3rded, McGraw Hill, 2017
2. W. D. Callister, *Materials Science and Engineering*, 9th ed. John Wiley, 2013.
3. S. H. Avner, *Introduction to Physical Metallurgy*, 2nd ed., Tata McGraw Hill, 1982.
4. R. Abbaschian and R. E. Reed-Hill, *Physical Metallurgy Principles*, 4th ed. Affiliated East-West Press, 2009.
5. Z. D. Jastrzebiski, *Nature and Properties of Engineering Materials*, 2nd ed. John Wiley & Sons, 1977.

ME6511D COMPOSITE MATERIALS: MECHANICS, MANUFACTURING AND DESIGN

Pre-requisite: Nil

Total Hours: 39

L	T	P	C
0	0	3	2

Module 1 (13 hours)

Difference between composites and alloys, Classification of composites based on types of reinforcement, Strengthening mechanisms, Composites for construction, Variation in properties of composites, Classification based on type of matrix, Fibers, Interfaces, and Theories of Adhesion in Interfaces. Manufacturing of PMCs – Contact Moulding, Compression molding, Vacuum Bag moulding, Pultrusion, Filament winding, RTM, RFI; Manufacturing of MMCs – Continuously reinforced MMCs and Discontinuously reinforced MMCs, Manufacturing of CMCs – Powder consolidation, Polymer Infiltration & Pyrolysis, CVD.

Analysis of Continuous Fiber Composites: Derivation for density of composite, Longitudinal Stiffness of unidirectional composite, Fraction of load carried by fibers, Longitudinal tensile strength, Critical fiber volume fraction, minimum fiber volume fraction,

Module 2 (13 hours)

Failure modes in longitudinal tension, Transverse Tensile loading, Transverse stiffness, Transverse tensile strength, Longitudinal compressive loading, Failure modes, Prediction of Shear modulus, Major and minor Poisson ratio. Discontinuous Fiber Composites: Load transfer mechanisms, Derivation for critical fiber length, effective fiber reinforcement, Average fiber stress, longitudinal tensile strength, Single fiber fragmentation test

Analysis of Unidirectional Lamina: Deformation of Isotropic material and Anisotropic Materials, Deformation of Generally orthotropic Material & Specially Orthotropic Material, Stress-strain relations for isotropic lamina, Isotropic lamina in plane stress conditions, Compliance matrix and stiffness matrix

Module 3 (13 hours)

Stress and strain transformations under plane stress conditions, Coordinate Axis in thin lamina, In-plane stress, Out of plane Stress, Elastic properties of unidirectional lamina, Stress-strain relations for specially orthotropic lamina, Stress-strain relations for general orthotropic lamina, Derivation for E_{xx} , E_{yy} , G_{xy} , m_x and m_y .

Analysis of Laminated Composites: Types of laminates and lamination code, Lamination theory, Laminate Geometry, Laminate Strains and Curvatures, Laminate forces and moments, Elements in the stiffness matrices, Extensional stiffness matrix, Coupling stiffness matrix, Bending Stiffness matrix. Analysis of laminates subjected to thermal stresses and hygroscopic stresses. Failure Theories: Criteria of failure for isotropic material Von Mises criterion for metals, Criteria for failure in orthotropic material, Maximum stress theory, Maximum strain theory, Tsai hill theory or Maximum work theory.

References

- 1 B.D. Agarwal, L.J. Broutman and K. Chandrashekhara, *Analysis and performance of fiber composites*, 4th Edition, John Wiley & Sons, Inc., 2017.
- 2 P.K. Mallick, *Fiber Reinforced Composites: Materials Manufacturing and Design*, 3rd Edition, CRC Press., 2008
- 3 Autar K. Kaw, *Mechanics of Composite Materials*, 2nd Edition, CRC Taylor & Francis Group, 2005.
- 4 Daniel Gay, Suong V. Hoa, *Composite Materials, Design and Applications*, 2nd Edition, CRC Taylor & Francis Group, 2007.

ME6512D CERAMIC SCIENCE AND TECHNOLOGY

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (13 hours)

Introduction, properties, type of bonds in ceramics, applications of ceramics, advanced and traditional ceramics, refractories, cement, glass and glass ceramics, types of ceramics, classification by composition, processing technique, properties and applications, crystal structure structural rules, common ceramic structures, rocksalt structure, zinc blend structure, corundum, silicate structures, glass, etc., ceramic raw materials, synthesis of powders, powder characteristics, effect of impurities.

Module 2: (13 hours)

Production process for ceramics, Bayer process, pyrolysis, hydrolysis and electric discharge methods of synthesis, powder preparation, slip casting, extrusion, injection molding, tape casting, dry pressing, hot pressing, iso-static pressing, reaction sintering, firing process, finishing process for ceramics. Production, properties and applications of typical ceramics, Boron nitride, silicon nitride, zirconia, Alumina etc.

Testing and property evaluation of ceramics, flexural strength: requirements, fixtures, surface conditions, tensile strength, elastic constants : bending response method, ultrasonic pulse method, hardness: Rockwell and micro hardness, fracture toughness: large -scale and micro-scale crack methods, four point bend test, creep, high temperature property evaluation

Module 3: (13 hours)

Ceramic composites: preform processing, yarn infiltration, preform infiltration, sol-gel infiltration, chemical vapour route, polymer pyrolysis, liquid infiltration techniques, Lanxide process. Ceramics sensors, Capacitors, ceramic cutting tools, cermets. Bioceramics, Calcium phosphates, Ca/P ratio, hydroxyapatite, tri calcium phosphate, bioinert, bioactive and bioresorbable ceramics, cements

References:

1. W.D. Kingery, H.K. Bowen and D.R. Uhlmann, *Introduction to Ceramics.*, John Wiley and Sons, 3rd Edition 2016
2. J.S. Reed, *Introduction to the Principles of Ceramic Processing.* John Wiley and Sons 2nd edition.1990
3. Ceramic Fabrication Processes, . John Wiley & Sons, Inc., New York, und Chapman & Hall, Ltd., London 1958.
4. von W. D. Kingery, *Handbook of properties of technical & engineering ceramics*, Part 2. Handbook of Properties of Technical & Engineering Ceramics, Roger Morrell. Author, R. Morrell. Edition, illustrated. Publisher, H.M.S.O, 1985
5. Ed. B.F. Dyson, R.D. Lohr and R. Morrel, *Mechanical Testing of High Engineering Ceramics at High Temperatures* Elsevier Science Publications Ltd, 1989

ME6513D METAL CASTING AND JOINING

L	T	P	C
3	0	0	3

Pre-requisites: Nil

Total Hours: 39

Module 1: (19 hours)

Solidification of metals: mechanism of solidification, solidification with predominant interface resistance, solidification with constant surface temperature, solidification with predominant resistance in mould and solidified metal; flow of molten metal in moulds; furnaces and melting practices; patterns: pattern allowance, design considerations, shrinkage and machining allowance; Casting processes: comparison, sand casting, shell moulding, silicate bonded sand process (CO₂ process), expanded polystyrene process, plaster mould casting, ceramic mould casting, investment casting, permanent mould casting, slush casting, die casting, centrifugal casting, squeeze casting, semisolid casting (rheocasting, thixoforming); casting techniques for single crystal components; rapid solidification; residual stress; casting design: gating system design, riser design; use of CAD in the design of gating and risering; casting alloys; economics of casting; design rules for castings; inspection of casting; casting defects: case studies with specific examples of sand cast and permanent mould cast parts.

Module 2: (10 hours)

Joining processes: classification; welding: welding power sources; Arc and Arc characteristics: Behaviour of arc with variation in current and voltage; analysis of metal transfer: free light and short circuiting metal transfer; Welding electrodes: ISI specifications for electrodes gas metal reactions; sensitivity to hydrogen porosity; weld pool solidification; contraction and residual stress crack sensitivity; dilution and uniformity of the weld deposit; newer welding processes such as Plasma arc, Laser beam, Electroslag, Ultrasonic welding, friction stir welding; joining by brazing and soldering; surface energy and contact angle; capillary action in brazing and soldering; joining plastics; adhesive bonding; residual stress and stress concentration in adhesive bonding.

Module 3: (10 hours)

Metallurgy of welding: heat flow in welding; temperature distribution; cooling rate; metallurgical transformation in and around weldment; heat affected zone (HAZ); metallurgy of weld metal and HAZ for carbon steels; ferritic steels; austenitic steels; high alloy steels; aluminium and its alloys; copper and its alloys; magnesium and its alloys; weld quality; weldability of plain carbon steels, stainless steels, cast iron, aluminium and its alloys; testing of welded joints; welding design and process selection.

References:

1. A. Ghosh, and A. K. Mallik, *Manufacturing Science*, Affiliated East West Press, 2nd edition , 2010.
2. R. Heine, and P. Rosenthal, *Principles of Metal Casting*, Tata McGraw Hill, 2017.
3. A. Richard, Little., *Welding and Welding Technology*, Tata McGraw Hill, 2017.
4. R. S. Parmer, *Welding processes and Technology*, Khanna Publishers, 3rd edition, 2003.
5. American Welding Society, *Welding Handbook*, 9thed.
6. ASM Hand Book, Volume 15. *Casting*, 15th ed., 2008

ME6592D MATERIALS SCIENCE LABORATORY 2

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Total Hours: 39

Clear understanding of potentiodynamic polarization test and its theory; Practice to conduct long heat treatment processes using programmable furnace; Analysis of tool wear; Development of metal matrix composite and analysis of its properties; Mechanical Analysis of structural components with analysis software tools.

List of suggested experiment and exercises:

1. Electrochemical Corrosion analysis of ferrous and non-ferrous materials
2. T6 heat treatment of Aluminium alloy
3. Eddy current flaw detector analysis of surface defects
4. Tool wear analysis
5. Preparation of ceramic reinforcement of micro size to Nano size by Ball mill
6. Development of Aluminium metal matrix composite.
7. Sample preparation and Tensile testing of Aluminium composite
8. Sample preparation and Charpy impact testing of Aluminium composite
9. Abacus analysis of bending of beams
10. Ansys analysis

References:

1. Nestor Perez, *Electrochemistry and corrosion science*, 2nd ed. Sprinjer, 2004.
2. George E Dieter, *Mechanical Metallurgy*, 3rded, McGraw Hill, 2007
3. W. D. Callister, *Materials Science and Engineering*, 9th ed. John Wiley, 2013.
4. Richard W Heine, Carl R Loper and Philip C Rosenthal, *Principles of metal casting*, 2nd ed. 2017
- 5.V. Ramamurthy, *Computer Aided Mechanical Design and Analysis*, 4th ed. Tata McGraw Hill, 2000.

ME6393D SEMINAR / MINI PROJECT

Pre-requisite: Nil

L	T	P	C
0	0	2	1

Total hours: 26

Students are free to select either Seminar or Mini Project after consulting with Programme Coordinator/Course Faculty.

SEMINAR

Each student shall prepare a seminar paper on any topic of interest related to the core/elective courses undergone in the first semester of the M. Tech. programme. He/she shall get the paper approved by the Programme Coordinator/Faculty Members in the concerned area of specialization and shall present it in the class in the presence of the Faculty in-charge of seminar class. Every student shall participate in the seminar. Grade will be awarded on the basis of the student's paper, presentation and his/her participation in the seminar.

MINI PROJECT

Students can select a research problem pertaining to the area of specialization of the M. Tech. programme by consulting a faculty in the department. The student has to identify an appropriate methodology and solve the problem. The student shall submit a report. The mini project will be evaluated by the faculty in-charge of the mini project.

ME7394D PROJECT (PART-I)

L	T	P	C
0	0	20	12

Students are encouraged to identify the area of the project work and conduct the literature review during the second semester itself. The project work starts in the third semester. The topic shall be research and development oriented. The project work can be carried out at the institute or in an industry/research organization. Students desirous of carrying out project work in an industry or in other organizations have to fulfill the requirements as specified in the "Ordinances and Regulations for M. Tech." The student is expected to complete the research problem definition, formulation and preliminary work (pilot study) in the third semester. There shall be evaluations of the project work during and at the end of the third semester by a committee constituted by the department.

ME7395D PROJECT (PART-II)

L	T	P	C
0	0	20	13

The project work started in the third semester will be extended to the end of the fourth semester. There shall be evaluations of the project work by a committee constituted by the department during the fourth semester. The student shall submit the thesis based on the recommendation of the departmental evaluation committee. There shall be viva-voce examination conducted by an evaluation committee with an external examiner.

ME6521D THERMODYNAMICS OF MATERIALS

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total Hours: 39

Module 1 (15 hours)

First Law of Thermodynamics, heat, work, heat capacity, enthalpy and internal energy, Hess's Law- and Second Law of Thermodynamics, Entropy and Criterion for Equilibrium, Statistical interpretation of entropy, Boltzmann equation; Auxiliary Functions, Thermodynamic Relations, Maxwell's Equations, Gibbs-Helmholtz Equation, Examples, Heat capacity, enthalpy, entropy and the third law of Thermodynamics. Phase Equilibrium in a One Component System, Solid-Solid Equilibria, examples, Behaviour of gases, The vander Waals Gas, Non-ideal gases, examples.

Module 2 (12 hours)

Behaviour of Solutions: Raoult's and Henry's Law, Gibbs-Duhem Equation, Non-ideal solutions, Regular Solutions' Subregular Solutions, Examples. Gibbs Free Energy, Composition and Phase Diagrams of Binary Systems, Criteria for Phase Stability, Phase Diagrams of Binary Systems.

Module 3 (12 hours)

Reaction equilibrium in a Gas mixture and the equilibrium constant: Effect of Temperature and pressure, Reaction equilibrium in a system containing pure condensed phases and a Gas phase, Ellingham Diagrams., Effect of phase transformations, examples, Criteria for Reaction equilibrium in systems containing components in condensed solution, Gibbs Phase rule, Solubility of gases in metals, examples. Electrochemistry: Formation Cells, Concentration Cells, Pourbaix Diagrams.

References

1. Gaskell David R., *Introduction to the Thermodynamics of Materials*, Publishers, 2017. 6thed., Taylor & Francis
2. Hae-Geon Lee, *Material Thermodynamics: With emphasis on chemical approach*, World Scientific Publishing Company; 2011
3. David V. Ragone, *Thermodynamics of Materials*, Volume 1, J.W. Wiley 1995.
4. Robert T. DeHoff, *Thermodynamics in Materials Science*, McGraw-Hill, 2nd edition, 2006.
5. Y.K. Rao, *Stoichiometry and Thermodynamic Computations in Metallurgical Processes*, Cambridge University Press, 2009

ME6522D POWDER AND SINTERED PARTS

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total Hours:39

Module I (13 Hours)

Introduction: scope of powder metallurgy industries, PM process, comparison of powder metallurgy process with alternate near net shape producing technologies (viz.casting, forging and machining), versatility and benefits of Powder Metallurgy, problems of Indian powder metallurgy industries, unique applications of powder metallurgy process, Secondary operations, Powder production techniques-mechanical, atomisation, chemical- reduction and carbonyl and electro-chemical processes; Powder properties and their characteristics, Particle size distribution, Types of distribution function, Sampling of powders-sieve analysis, Microscopy, Sedimentation analysis; Specific surface and other technological properties; Powder conditioning; relation between characterization of the powders and method of production, pre-compacting processes, mixing, milling, lubricant addition etc

Module II (13 Hours)

Compaction : classification, stages of compaction, effect of different variables on the density and stress distribution in the green compacts, compacting processes, Hot Iso-static Pressing (HIP), Cold Iso-static Pressing; Pressing equipments and tooling; defects in compacts; alternate shaping processes, :powder rolling, slip casting, injection molding, Explosive molding etc.; effect of variables on densification in single component system.

Module III (13 Hours)

Sintering-stages, single component, material transport mechanisms; Model studies; Powder shrinkage experiments; Sintering diagrams and sintering anomalies, Multi-component sintering-solid phase and liquid phase, infiltration, activated sintering, reaction sintering, hot consolidation of powders, post-sintering treatment; evolution of microstructure; Sintering atmospheres and equipments; Production routes in practice; Products of PM-Automobile components, Bearings, Cutting tools -HSS and Carbides, Ceramic components etc.

References:

1. F Thummler and R Oberacker *An introduction to Powder Metallurgy*, The Institute of Materials,1994 The University Press, Cambridge Great Britain.ISBN0-901716-26-X
- 2.ASM Handbook: *Powder Metal Technologies and Applications*(ASMHandbook,Vol7), 1984.
3. P C Angelo & R Subramanian, *Powder Metallurgy*, PHI Pvt Ltd, 2015

ME6523D CORROSION SCIENCE AND TECHNOLOGY

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total Hours: 39

Module 1 (9 hours)

Corrosion: electrochemical principles, Electrode potential, Nernst equation. oxy-reduction potentials; General characteristics of electrochemical corrosion, electrochemical heterogeneity of metallic materials, models of corrosion cell; Corrosion thermodynamics – Pourbaix diagrams; Polarization of the corrosion cell; Activation controlled kinetics and concentration polarization, Evans diagrams, partial corrosion reactions- anodic dissolution of metals; Cathodic reactions – oxygen reduction and hydrogen evolution.

Module 2 (15 hours)

Corrosion of materials in natural environments; Atmospheric corrosion, general characteristics, mechanism and prevention; soil corrosion – general characteristics, mechanism and prevention. Localized corrosion damages and materials failure- passivity and transpassivity of metals, breakdown of passivity and pitting corrosion. Stress – corrosion cracking of materials. Inter-granular corrosion failure. Corrosion failure of ceramic materials; mechanisms of corrosion of ceramics, effect of chemical, phase composition and structure on corrosion resistance. Corrosion degradation of concrete.

Module 3 (15 hours)

Environmental degradation and corrosion of polymer materials - Destruction of polymers – types and mechanism. Effect of composition and structure on environmental degradation of polymer materials. Methods for protection of materials. Overview of corrosion prevention methods. Chemical and electrochemical surface treatment of metals. Metallic, inorganic and organic protective coatings. Application of inhibitors. Electrochemical methods for corrosion protection. Corrosion control and monitoring. Principles of material selection. Corrosion testing and monitoring.

References

1. Fontana, Mars G, *Advances in corrosion science and technology* vol 6. 2012
2. Landolt, Dieter, *Corrosion and surface chemistry of metals* -- 2007
3. Uhlig, Herbert, *Corrosion and corrosion control* – 4th edn, 1984

ME6524D SCIENCE OF SOLIDIFICATION PROCESS

Pre-requisite: Nil

Total Hours: 39

L	T	P	C
3	0	0	3

Module 1 (13 hours)

Phase equilibrium: Introduction, Thermodynamics and stability of phases, Classification of phase transformations, Order of transformation, Gibbs rule and application, Phase diagrams construction and interpretation. Liquid-solid transformation: Nucleation, homogeneous and heterogeneous, Growth continuous and lateral; Interface stability; Alloy solidification cellular and dendritic, Eutectic, off-eutectic, peritectic solidification; Welding, casting and rapid solidification.

Length scale, Thermodynamics of solidification- equilibrium, Undercooling, Hierarchy of equilibrium, Local Interface equilibrium, Interface non-equilibrium, Macro scale Phenomena-formation of macrostructures, relevant transport equations. Mathematics of diffusive transport,

Module 2 (15 hours)

Macro mass Transport-solute diffusion controlled segregation, analysis of solute redistribution, Fluid flow controlled segregation, macro energy transport, governing equations, boundary conditions, Analytical solutions for steady state and non-steady state casting solidification. Macro modeling of solidification: numerical approximation methods. Multi scale phenomena and interface Dynamics.

Role of kinetics, heterogeneous and homogeneous kinetics, Role of heat & mass transfer in metallurgical kinetics, rate expression, Effect of Temperature and concentration on reaction kinetics: effect of temperature (Arrhenius Equation), Effect of concentration (order of a reaction), significance and determination of activation energy, Kinetics of solid-fluid reaction: kinetic steps, rate controlling step, definition of various resistances in series, shrinking core model, chemical reaction as rate controlling step, Product layer diffusion as rate controlling step, Mass transfer through external fluid film as rate controlling step, heat transfer as the rate controlling step.

Module 3 (11 hours)

Solid state diffusive transformation: Classification, Nucleation and growth - homogeneous and heterogeneous mechanism, Precipitate growth under different conditions, Age hardening, Spinodal decomposition, Precipitate coarsening, Transformation with start range diffusion, Moving boundary transformations, recrystallization, grain growth, eutectoid transformation, discontinuous reactions. Pearlitic and bainitic transformation: Factors influencing pearlitic transformation, Mechanism of transformation, Nucleation and growth, Orientation relationship, Degenerate pearlite. Bainite mechanism of transformation, Orientation relationships, Surface relief, Classical and non-classical morphology, Effect of alloying elements.

References

1. Doru Michael Stefanescu, *Science and Engineering of Casting Solidification*, Kluwer Academic/Plenum publishers 3rd edition, 2016
2. Oystein Grong, *Metallurgical modeling of welding*, 2nd Edn, Institute of materials, 1997.
3. Koenraad Janssens, Dierk Raabe, Ernest Kozeschnik, Mark Miodownik, Britta Nestler, *Computational materials Engineering – An Introduction to microstructure evolution*, Academic Press, 2007
4. Gaskell David R., *Introduction to the Thermodynamics of Materials*, 6th ed., Taylor & Francis Publishers, 2018.

MEE6525D CHARACTERIZATION OF MATERIALS

Pre-requisite: Nil

Total Hours: 39

L	T	P	C
3	0	0	3

Module 1 (12 hours)

X- ray diffraction: Bragg's condition, Laue treatment, reciprocal lattice, intensity of diffracted beam, crystal structure determination, atomic scattering factor, geometrical structure factor for S.C,F.C.C, and B.C.C. structures, experimental methods, Laue, rotating crystal and powder photograph methods, estimation of stress, texture and other defects , electron diffraction, neutron diffraction.

Module 2 (15 hours)

Macro and micro examination of metals: specimen preparation, qualitative and quantitative examination: optical microscopy, transmission and scanning electron microscopy, atomic force microscopy, thermal characterisation techniques.

Atomic absorption spectroscopy, Activation technique, Mossbauer Effect , resonance fluorescence, Temperature dependence, applications of Mossbauer effect, isomer shift, quadrupole splitting, hyperfine splitting.

Module 3 (12 hours)

Magnetic resonance: NMR, analysis of the phenomenon, experimental method, NMR spectra, applications, NQR: analysis of the phenomenon, NQR spectra, applications to study of deformed metals and crystalline electric field, ESR: phenomenon, experimental study, ESR spectra, applications.

References:

1. S.O Pillai, *Solid State Physics*, New Age International, 7thedn, 2006
2. Straughan and Walker, *Spectroscopy – Vols. I & II*, Chapman & Hall
3. R L Singhal, *Solid State Physics*, Kedar Nath Ram Nath & Co., Meerut, 7th edn, 2001.
4. Srivastava and Srinivasan, *Science of Engineering Materials* by Wiley Eastern Ltd., 1991.
5. Agrawal, *Introduction to Engineering Materials*, Tata McGraw -- Hill, 1988.