NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

SCHEME OF INSTRUCTION AND SYLLABI

for M.Tech. Materials Technology Program

(Effective from 2021-22)

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

Vision and Mission of the Institute
National Institute of Technology Warangal

VISION

"Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society"

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

Vision and Mission of the Department
Department of Metallurgical and Materials Engineering

VISION

Attain global recognition in research and training to meet challenging needs of Metallurgical and Materials Engineering with ethical and moral responsibility towards society

MISSION

- Provide outstanding technical education for analysis, design and operation of metallurgical and materials systems.
- Keep abreast with rapid strides of technology and improve academic standards through innovative teaching and learning processes.
- Engage in quality research in metallurgical, materials and allied engineering areas.
- Develop academic linkages with leading industries for mutual benefit.

Department of Metallurgical and Materials Engineering:

Brief about the Department:

The Department of Metallurgical and Materials Engineering (formerly known as Department of Metallurgical Engineering) was established in the year 1965 with an intake of 30 students. A post-graduate programme in Industrial Metallurgy was introduced in the year 1983 with an intake of 10 students. The Department is also offering a Ph. D. programme since 1983. Department has also introduced another M.Tech. programme in Materials Technology from the academic year 2011-2012.

The main areas of study in Metallurgical and Materials Engineering include Physical Metallurgy, Extractive Metallurgy (Iron, Steel and Non-ferrous Metal extraction), Mineral Processing, Heat Treatment of Steels, Manufacturing Technologies (Metal Casting, Metal Forming, Powder Metallurgy and Welding), Mechanical Metallurgy (includes Material Testing – Destructive and Non-Destructive), Corrosion Engineering, and Materials Characterization Techniques etc. In view of the increasing demand in materials development, the department has introduced new subjects in its curriculum with materials background in the year 2004. Accordingly the scheme of instruction has been enriched with subjects on advanced materials like Composite Materials, Ceramics, Polymers, Nanomaterials, Computer Applications in Metallurgical and Materials Engineering etc. in addition to the above main areas. The laboratories of the Department are well equipped with the state-of-the-art equipment.

Brief about the Programme:

A post-graduate programme in Materials Technology was introduced in the year 2011 with an intake of 20 students. This programme offers in-depth knowledge about Physical Metallurgy, Manufacturing Technologies (Metal Casting, Metal Forming, Powder Metallurgy and Welding), Mechanical Metallurgy (includes Material Testing – Destructive and Non-Destructive), Corrosion Engineering, Biomaterials, Functional Materials, Smart Materials, Electronic and Magnetic Materials and Materials Characterization Techniques, etc. The students are exposed to the core and advanced areas in the first two semesters. Dissertation work is being carried out in the third and fourth semesters. The M.Tech, Materials Technology, graduates will be able to i) Evaluate the performance of material systems using the relationship between structure, properties and processing ii) Characterize materials and carry out research on advanced materials iii) Design and develop effective and eco-friendly materials for generic and strategic applications and iv) Pursue life-long learning by enhancing knowledge and skills for professional advancement. The graduates find employment in major manufacturing and research organizations. Graduates also further their research careers by pursuing PhD in national and international universities

List of Programs offered by the Department:

Program	**Title of the program**
B.Tech	Metallurgical and Materials Engineering
M.Tech	Industrial Metallurgy
	Materials Technology
Ph.D	

Note: **Refer to the following weblink for Rules and Regulations of M.Tech. program:**
https://www.nitw.ac.in/main/MTechProgram/rulesandregulations/

MTech- Materials Technology

Program Educational Objectives

PEO1	Evaluate the performance of materials through processing and structure - property correlations.
PEO2	Design and develop eco-friendly materials for generic and strategic applications.
PEO3	Analyse materials related problems and provide solutions using suitable research methodologies.
PEO4	Pursue life-long learning by enhancing knowledge and skills for professional advancement.

Program Articulation Matrix

PEO / Mission Statements	PEO1	PEO2	PEO3	PEO4
Provide outstanding technical education for analysis, design and operation of metallurgical and materials systems.	3	3	2	2
Keep abreast with rapid strides of technology and improve academic standards through innovative teaching and learning processes.	3	3	2	3
Engage in quality research in metallurgical, materials and allied engineering areas.	3	3	3	3
Develop academic linkages with leading industries for mutual benefit.	3	3	3	3

1:Slightly 2:Moderately3:Substantially

MTech Materials Technology:

Program Outcomes (POs)

At the end of the program, the student will be able to

PO1	Perform independent research to provide cost effective solutions to scientific and industrial problems.
PO2	Write and present professional and technical reports efficiently.
PO3	Demonstrate mastery skills in the development of materials for multidisciplinary applications related to materials technology.
PO4	Design and process advanced materials for societal needs with an emphasis on environment.
PO5	Employ skills related to materials' properties, their life assessment and enhancement in various environments.
PO6	Practice professional ethics and project management skills.

SCHEMEOFINSTRUCTION

M. Tech. (MATERIALS TECHNOLOGY) Course Structure

IYear–ISemester

S.No	Course code	Coursetitle	L	T	P	Credits	Cat. code
1	MM5201	Phase Transformations in Materials	3	0	0	3	PCC
2	MM5202	Strengthening Mechanisms	3	0	0	3	PCC
3	MM5102	Advanced Powder Processing	3	0	0	3	PCC
4		Elective I	3	0	0	3	PEC
5		Elective II	3	0	0	3	PEC
6		Elective III	3	0	0	3	PEC
7	MM5203	Phase Transformations in Materials Laboratory	0	1	2	2	PCC
8	MM5105	Advanced Powder Processing Laboratory	0	1	2	2	PCC
9	MM5248	Seminar I	0	0	2	1	SEM
		Total	**18**	**2**	**6**	**23**	

IYear - II Semester

S.No	Course code	Coursetitle	L	T	P	credits	Cat. code
1	MM5251	Materials Characterization Techniques	3	0	0	3	PCC
2	MM5252	Mechanical Behavior of Materials	3	0	0	3	PCC
3	MM5153	Additive Manufacturing	3	0	0	3	PCC
4		Elective IV	3	0	0	3	PEC
5		Elective V	3	0	0	3	PEC
6		Elective VI	3	0	0	3	PEC
7	MM5253	Materials Characterization Technique Laboratory	0	1	2	2	PCC
8	MM5254	Mechanical Behavior of Materials Laboratory	0	1	2	2	PCC
9	MM5298	Seminar II	0	0	2	1	SEM
		Total	**18**	**2**	**6**	**23**	

IIYear–ISemester

S.No	Course code	Coursetitle	L	T	P	Credits	Cat. code
1	MM6247	Comprehensive Viva Voce				2	CVV
2	MM6249	Dissertation Part A				12	DW
		Total				**14**	

IIYear –IISemester

S.No	Course code	Coursetitle	L	T	P	credits	Cat. code
1	MM6299	Dissertation Part B				20	DW
		Total				**20**	

Note: PCC – Professional Core Courses
PEC – Professional Elective Courses
SEM – Seminar
CVV – Comprehensive Viva Voce
DW – Dissertation Work

Creditsin Each Semester					
Category Code	Sem-I	Sem-II	Sem-III	Sem-IV	Total
PCC	13	13	-	-	26
PEC	9	9	-	-	18
SEM	1	1	-	-	2
CVV	-	-	2	-	2
DW	-	-	12	20	32
Total	23	23	14	20	80

Program Elective Courses

Elective – I, II, III (I Year, I Semester)		
S. No.	**Course Code**	**Course Title**
1	MM5211	AerospaceMaterials
2	MM5212	LightMetalsandAlloys
3	MM5113	TextureofMaterials
4	MM5213	EnvironmentalDegradationofMaterials
5	MM5214	AutomotiveMaterials
6	MM5215	CeramicPolymersandComposites
7	MM5117	Nanotechnology
8	MM5118	Computational Approaches in Materials Engineering
9	MM5216	NuclearMaterials
Elective – IV, V, VI (I Year, II Semester)		
S. No.	**Course Code**	**Course Title**
1	MM5161	SurfaceEngineeringandCoatingTechnology
2	MM5261	Biomaterials
3	MM5262	FunctionalMaterials
4	MM5263	ElectronicandMagneticMaterials
5	MM5264	SmartMaterials
6	MM5265	EnergyMaterials
7	MM5266	HighTemperatureMaterials
8	MM5267	MaterialsSelectionandDesign
9	MM5268	Creep,FatigueandFracture

DETAILED SYLLABUS

M.Tech. - Materials Technology

Department of Metallurgical and Materials Engineering

Course Code: MM5201	PHASE TRANSFORMATIONS IN MATERIALS	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:
At the end of the course, the student will be able to

CO1	Apply the thermodynamic principles to study the phase diagrams of materials
CO2	Describe liquid to solid and solid to solid-state transformations
CO3	Discuss the phase transformations during non-equilibrium processing of materials
CO4	Apply the science of phase transformations to develop advanced and novel materials

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2		3	3		2
CO2	2		3	2		2
CO3	2		3	2		2
CO4	2	2	3	2	1	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction

Crystal geometry, crystal structures, Construction of phase diagrams, Gibbs free energy, Chemical potential, Diffusion, Thermodynamics of phase transformations, free energy vs composition diagrams applied to the phase diagrams. Classification of phase transformations, Theory of nucleation in liquid and solid states

Liquid-to-Solid Transformations

Solidification of pure metals and alloys - thermal and constitutional super-cooling. Solute redistribution and coring, Eutectic solidification and eutectic structures, Peritectic and Monotectic solidification

Solid-to-Solid Transformations

Diffusional and non-diffusional solid-state transformations in ferrous and non-ferrous systems: nucleation and growth of phases, Decomposition of solid solutions; Ordering reactions; Spinodal decomposition; Pearlitic, bainitic, and martensitic transformations; hardenability; tempering; Theory of transformation kinetics and the origin of transformation diagrams.

Phase Transformations during Non-equilibrium Processing of Materials

Mechanical milling, Rapid solidification processing, Vapor deposition, Formation of metastable phases, Formation of metallic glasses, Crystallization of metallic glasses, Phase transformations in high entropy alloys, and nanomaterials systems

Text Books:

1. D.A. Porter, K.E. Easterling: Phase Transformations in Metals and Alloys, Van Nostrand Reinhold (International), 1989.
2. A.K. Jena, M.C. Chaturvedi: Phase Transformations in Materials, Prentice Hall,1992.
3. S.P. Gupta: Solid State Phase Transformations, Allied Publishers, New Delhi, 2004.

Reference Books:

1. P.G. Shewmon: Transformations in Metals, McGraw Hill Book Company, 1980.

2. R.E. Reed-Hill and R. Abbaschian: Physical Metallurgy Principles, 1992.

3. M.F. Ashby and D.R.H. Jones, Engineering Materials 1–An Introduction to Properties, Applications and Design, 4th ed. (2011), Butterworth-Heinemann Publishers, Massachusetts, USA (ISBN: 978-0080966656)

Online Resources:

1. NPTEL lectures: https://www.youtube.com/watch?v=vyR82mXAmxw&t=28s

Course Code: MM5202	STRENGTHENING MECHANISMS	Credits 3-0-0: 3

Pre-Requisites:

Course Outcomes:

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

CO1	Identify strengthening mechanisms in steels and advanced materials
CO2	Explain themechanisms of strengthening in metals and alloys
CO3	Design thermo-mechanical treatments for high strength steels and alloys
CO4	Design new materials/heat treatments based on strengthening mechanisms

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			3	2	1	
CO2			3	2	1	
CO3			3	2	1	
CO4			3	2	1	

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Different methods of strengthening solids; Thermal activation processes; Theories and mechanisms of strain hardening; Solid solution strengthening and Order-disorder transformations; Precipitation hardening; Theories of strengthening and over ageing; Dispersion hardening and theories; Martensitic and bainitic transformations; Special thermo-mechanical treatments for steels; Grain refinement; super plasticity; Fibre-strengthening.

Text Books:

1. Strengthening mechanisms, B. Geddes, H. Leon and X. Huang, ASM International
2. Introduction to Strengthening mechanisms, D. K. Felbeck, Prentice Hall, London, 1968; Published online by Cambridge University Press: 04 July 2016.
3. Introduction to Dislocations, D. Hull and D.J. Bacon, Butterworth Heinemann, 1984,5th edition.

Reference Books:

1. Materials Science and Engineering – An introduction,William D. Callister, Jr, John Wiley & Sons, Inc. 2004, sixth edition.
2. Physics of solids, C.A. Wert and R. M. Thomson, McGraw-Hill Publishers, 1964

Online Resources:

1. https://nptel.ac.in/courses/112/108/112108150/
2. https://www.youtube.com/watch?v=j9zwMixklTg
3. https://www.youtube.com/watch?v=FD557dzqz28
4. https://www.youtube.com/watch?v=7BBldSkL_k8
5. https://www.ias.ac.in/public/Volumes/sadh/003/04/0275-0296.pdf

Course Code: MM5102	ADVANCED POWDER PROCESSING	Credits 3-0-0: 3

Course Outcomes:

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

CO1	Explain various powder production, and characterization techniques
CO2	Compare and appraise powder processing techniques
CO3	Appraise the need for powder processing in the fabrication of special engineering components
CO4	Evaluate the fabrication processes of special engineering components by powder metallurgy

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		1	1	1	
CO2		1	2			
CO3	1		3	1		1
CO4	1		3	1	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Basic steps of powder metallurgy, SWOT analysis of powder metallurgy, Synthesis of Nanocrystalline powder through Chemical Synthesis & Mechanical Alloying, chemical synthesis and atomization of powder, characterization of powder, powder compaction, conventional and Modern Sintering Technique (HIP, SPS, Laser Sintering, Microwave Sintering), sintering of production of filters, self-lubricating bearings, gears, friction parts, electrical materials, carbide tools, fabrication difficulty of tungsten filament, bioceramics, powder metallurgy of superalloys and stainless steel, dispersion strengthened materials, application of powder metallurgy in Indian industries.

Text Books:

1. G. S. Upadhyaya, Powder Metallurgy Technology, Cambridge International Science Publishing, 1998.
2. ASM Handbook, Vol-7, Powder Metallurgy, ASM International, 2010.
3. P. C. Angelo and R. Subramaniam, Powder Metallurgy - Science, Technology and Application, PHI, New Delhi, 2008.
4. R. M. German, Powder Metallurgy- Principles and Applications, MPIF, Princeton, 1994.
5. A. K. Sinha, Powder Metallurgy, Dhanpat Rai Publications, New Delhi, 2009.

Course Code: MM5203	PHASE TRANSFORMATIONS IN MATERIALS LABORATORY	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

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

CO1	Evaluate microstructural parameters to correlate to the mechanical properties
CO2	Analyze the microstructure of ferrous, nonferrous, and composite materials
CO3	Apply heat treatment methods to modify material properties
CO4	Demonstrate materials characterization techniques to evaluate the phase transformations

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3			2
CO2	2	3	2			1
CO3	3	3	3			2
CO4	2	3	3			2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Application of phase rule for calculation of weight fraction of phases, Grain size measurement by linear intercept method, Microstructure of ferrous, nonferrous, bulk metallic glasses and composites, Microstructure of annealed, normalized, hardened and tempered samples, Jominy end-quench test, and Scanning electron microscopy (SEM) and x-ray diffraction study

Text Books:

1. PTM Lab Manual
2. D.A. Porter, K.E. Easterling: Phase Transformations in Metals and Alloys, Van Nostrand Reinhold (International), 1989.
3. S. H. Avner : Introduction of Physical Metallurgy, Mc Graw Hill, 2017
4. A.K. Jena, M.C. Chaturvedi: Phase Transformations in Materials, Prentice Hall,1992.
5. P.G. Shewmon: Transformations in Metals, McGraw Hill Book Company, 1980.

Reference Books:

1. S.P. Gupta: Solid State Phase Transformations, Allied Publishers, New Delhi, 2004.
2. R.E. Reed-Hill and R. Abbaschian: Physical Metallurgy Principles, 1992.

Course Code: MM5105	ADVANCED POWDER PROCESSING LABORATORY	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:

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

CO1	Apply different powder production techniques such as ball milling, wet-chemical technique, reactive synthesis
CO2	Demonstrate the effect of compaction pressure, particle geometry, binders and lubricant on the green strength
CO3	Demonstrate the effect of sintering time, temperature and environment on sintered properties.
CO4	Evaluate microstructures of synthesized powders and sintered components.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	3	3		
CO2	1	2	2	2		1
CO3	1	2	2	2		1
CO4	1	2	3	3		1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Powder Metallurgy- Ball milling of powders, Chemical synthesis of powders, Electrolytic synthesis of iron powder, Cementation of powders, Determination of size and size distribution of metal powders, Determination of apparent density, tap density, flow rate of metal powders, Determination of surface area, Compaction of metal powders and determination of green density, Sintering of metal powders and determination of sintered density.

Text Books:

1. Powder Metallurgy, Cambridge International Science Publishing, 2002, G.S. Upadhyaya
2. Powder Metallurgy: Science, Technology and Applications, PHI Learning Private Limited, 2008 – P.C. Angelo, R. Subramanian.
3. Sintering: Densification, Grain Growth and Microstructure, Elsevier publishers, 2005 – Suk-Joong L. Kang

Course Code: MM5248	SEMINAR I	Credits 0-0-2: 1

Pre-Requisites: None

Course Outcomes:
At the end of the course, the student will be able to

CO1	Identify the technological trends in materials development
CO2	Analyze the available literature in the chosen topic
CO3	Formulate a comprehensive report in a logical and coherent manner
CO4	Present a professional technical review using ICT tools

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3					
CO2	3					
CO3	1	3				3
CO4	2	3				3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:
Any topic of relevance to materials technology and allied areas.
Leading journals and conferences, paper referencing and critiquing, ethics and plagiarism, improving presentation and communication skills, technical paper and report writing

Course Code: MM5251	MATERIALS CHARACTERIZATION TECHNIQUES	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Classify materials characterization techniques
CO2	Compare the principle and operation of different characterization tools
CO3	Explain the operation variables on the formation of quality images/results
CO4	Analyze the results obtained by characterization equipment
CO5	Select suitable characterization tools based on the need of the analysis

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	2	1		
CO2	3	2	2	1		
CO3	3	2	2	1		
CO4	3	2	2	1		
CO5	3	2	2	1		

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Optical Microscopy - Introduction, Optical principles, Instrumentation, Specimen preparation-metallographic principles, Imaging Modes, Applications, Limitations.Introduction to stereomicroscopy and its applications.

Scanning Electron Microscopy (SEM) - Introduction, Instrumentation, Contrast formation, Operational variables, Specimen preparation, imaging modes, Applications, Limitations.

Transmission Electron Microscopy (TEM) - Introduction, Instrumentation, Specimen preparation-pre thinning, final thinning, Image modes- mass density contrast, diffraction contrast, phase contrast, Applications, Limitations.

X- Ray Diffraction (XRD) - Introduction, Basic principles of diffraction, Instrumentation, Types of analysis, Data collection for analysis, Applications, Limitations.Introduction to STEM.

Thermal Analysis - Introduction, Common characteristics- Instrumentation, experimental parameters, Different types used for analysis, Thermogravimetry, Differential Scanning Calorimetry, Differential Thermal Analysis, Thermo-Mechanical Analysis, Dynamic Mechanical Analysis, Dilatometry - Working principles, Instrumentation, Applications, Limitations.

Scanning Probe Microscopy (SPM) & Atomic Force Microscopy (AFM)- Introduction, Instrumentation, Scanning Tunneling Microscopy-Basics, probe tips, working environment, operational modes, Applications, Limitations.

Atomic Force Microscopy (AFM) - basic principles, instrumentation, operational modes, Applications, Limitations.

Electron Probe Micro Analyzer (EPMA) - Introduction, Sample preparation, Working procedure, Applications, Limitations.

X- Ray Spectroscopy for Elemental Analysis - Introduction, Characteristics of X-rays, X- ray Fluorescence Spectrometry, Wavelength Dispersive Spectroscopy-Instrumentation, Working procedure, Applications, Limitations, Energy Dispersive Spectroscopy - Instrumentation, Working procedure, Applications, Limitations.

Text Books:

1. Materials Characterization-Introduction to Microscopic and Spectroscopic Methods, Yang Leng, John Wiley & Sons (Asia) Pte Ltd, 2008
2. Thermal Analysis of Materials, Robert F. Speyer, Marcel Dekker Inc., New York, 1994.
3. Experimental Techniques in Physical Metallurgy, V. T. Cherapin and A. K. Mallik, Asia Publishing House, 1967.
4. Electron Microprobe Analysis, S.J.B. Reed, Cambridge University Press, London, 1975.

Reference Books:

1. Materials Characterization, ASM Handbook, ASM International, 2008.

Course Code: MM5252	MECHANICAL BEHAVIOUR OF MATERIALS	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Interpret the relationship between structure of a material and its mechanical properties
CO2	Apply plastic deformation theories for efficient metal working operations
CO3	Apply the fracture mechanics principles to determine the fracture toughness of brittle and ductile materials
CO4	Apply fatigue, creep and superplasticity phenomena to design the components for engineering applications

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3	1	1	
CO2			2	1		
CO3			1	1	3	
CO4			2	3	3	

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Concept of stresses and strains, engineering stresses and strains, Different types of loading and temperature encountered in applications, Tensile Test - stress-strain response for metal, ceramic and polymer, elastic region, yield point, plastic deformation, necking and fracture, Bonding and Material Behaviour, theoretical estimates of yield strength, Physical origin of elastic moduli, Generalized Hooke's law and its application to crystals, Designing for modulus and Composites.

Yielding and Plastic Deformation: Hydrostatic and Deviatoric stress, Octahedral stress, yield criteria and yield surface, texture and distortion of yield surface, Limitation of engineering strain at large deformation, true stress and true strain, Necking and Considere's Criterion, effective stress, effective strain, flow rules, strain hardening, stress-strain relation in plasticity.

Fracture: Fracture, Fracture Mechanics, Griffith Fracture Theory, LEFM -K_{IC}, EPFM - J_{IC}, CTOD; Fatigue: HCF and LCF, Fatigue crack inhibition, Fatigue crack growth, Paris law; Creep: Time-dependent deformation - creep, different stages of creep, creep and stress rupture, creep mechanisms.

Text Books:

1. R. W. Hertzberg: Deformation and Fracture Mechanics of Engineering Materials, 4th Edition, John Wiley & Sons Inc., 2012.
2. M.A. Meyers and K.K. Chawla: Mechanical Behavior of Materials, Prentice Hall Inc., New Delhi, 1999.
3. T. L. Anderson: Fracture Mechanics- Fundamentals and Applications, 3rd Edition, CRC Press, 2011.
4. G. E. Dieter: Mechanical Metallurgy, McGraw-Hill, 2002

Course Code: MM5153	ADDITIVE MANUFACTURING	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Explain the basic concepts and importance of additive manufacturing
CO2	Describe the principles, processes and advantages of additive manufacturing systems
CO3	Apply the knowledge of additive manufacturing for various real-life applications
CO4	Suggest mitigation techniques for additive manufacturing defects

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			3	1		
CO2		1	3	1		
CO3	1		3	3	2	1
CO4			2		2	

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Overview, basic principles and advantages of additive manufacturing, procedure of product development in additive manufacturing, classification of additive manufacturing processes, materials used in additive manufacturing, challenges in additive manufacturing.

Generic AM process: CAD, conversion of STL, transfer to AM machine and STL file manipulation, machine setup, build, removal, distinction between AM and CNC machining, reverse engineering

Additive Manufacturing Processes: Z-Corporation 3D-printing, Stereolithography apparatus (SLA), Fused deposition modeling (FDM), Laminated Object Manufacturing (LOM), Selective deposition lamination (SDL), Ultrasonic consolidation, Material Jetting, Binder jetting

Powder bed fusion processes: Selective laser sintering (SLS), Laser engineered net shaping (LENS), Selective laser melting (SLM), Electron beam melting (EBM), materials, powder fusion mechanisms (Solid-state sintering, chemically induced sintering, liquid phase sintering, Full melting), powder handling challenges, powder recycling, defects

Direct energy deposition processes: DED process description, powder feeding, wire feeding, laser and electron-based deposition processes

Post-Processing in Additive Manufacturing: Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques, brief information on characterization techniques used in additive manufacturing, applications of additive manufacturing in rapid prototyping, rapid manufacturing, rapid tooling, repairing and coating.

Future scope in Additive Manufacturing: Evaluation of additive manufactured structures/ components,scope of AM in various fields. Its importance and applications.

Text Books:

1. C.K. Chua, K.F. Leong, C.S. Lim: Rapid prototyping- Principles and applications, 3rd Ed., World Scientific Publishers, 2010.
2. Gibson, I, Rosen D W., and Stucker B., Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010
3. Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014

4. A. Gebhardt: Rapid prototyping, Hanser Gardener Publications, 2003.
5. L.W. Liou, F.W. Liou: Rapid Prototyping and Engineering applications: A toolbox for prototype development, CRC Press, 2007.
6. A.K. Kamrani, E.A. Nasr: Rapid Prototyping- Theory and Practice, Springer, 2006.
7. P.D. Hilton, P.F. Jacobs: Rapid Tooling- Technologies and Industrial Applications, CRC Press, 2000.
8. Ian Gibson, David W Rosen, Brent Stucker: Additive Manufacturing Technologies- Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010
9. D.T. Pham, S.S. Dimov: Rapid Manufacturing- The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer, 2001.C.K. Chua, K.F. Leong, C.S. Lim: Rapid prototyping- Principles and applications, 3rd Ed., World Scientific Publishers, 2010.

Reference Books:

1. Additive Manufacturing Processes, Editor: David L. Bourell, William Frazier, Howard Kuhn, and Mohsen Seifi, ASM Hand Book, Volume 24, ASM International, 2020Title of the Text Book, Author(s), Publisher, Year and Edition

Online Resources:

1. https://additivemanufacturing.com/basics/
2. https://www.additivemanufacturing.media/

Course Code: MM5253	MATERIALS CHARACTERIZATION TECHNIQUES LABORATORY	Credits 0-1-2: 2

Pre-Requisites:MM5251 - Materials Characterization Techniques

Course Outcomes:

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

CO1	Prepare specimens for characterization
CO2	Apply microscopic techniques for microstructural, chemical and fracture analysis
CO3	Analyze X-ray diffraction data for determining crystallographic parameters
CO4	Apply thermal analysis techniques to study the stability and transformation behaviour of materials

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1				2	
CO2	1	2			3	
CO3	1	2		1	3	
CO4	1	2		1	3	

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

1. Study of optical and scanning electron microscopes
2. Study of specimen cutting machine, specimen mounting method, grinding and polishing technique and etching techniques for Metallographic Examination
3. Quantitative image analysis of phase fraction, grain size, nodularity and nodule count.
4. Calculation of structure factor for different crystal structures.
5. Determination of crystal structure by X-ray Diffraction (XRD)
6. Determination of lattice parameter by XRD
7. Determination of crystallite size by XRD
8. Fractography analysis using Scanning electron microscopy (SEM)
9. Determination of inter-lamellar spacing of pearlite using SEM
10. Chemical analysis using energy dispersive X-ray analysis in SEM (spot and line analysis).
11. Determination of glass transition temperature and a melting point of a given polymer
12. Study of TGA, DSC, and DMA

Text Books:

1. Yang Leng: Materials Characterization-Introduction to Microscopic and Spectroscopic Methods - John Wiley & Sons (Asia) Pte Ltd, 2008
2. ASM Handbook: Materials Characterization, ASM International, 2008.

Reference Books:

1. Robert F. Speyer: Thermal Analysis of Materials, Marcel Dekker Inc., New York, 1994.
2. V. T. Cherapin and A. K. Mallik: Experimental Techniques in Physical Metallurgy, Asia Publishing House, 1967.
3. S.J.B. Reed: Electron Microprobe Analysis, Cambridge University Press, London, 1975.
4. B.D. Cullity, S.R. Stock, “Elements of X-Ray Diffraction”, Pearson; 3 Ed., 2001

Course Code: MM5254	MECHANICAL BEHAVIOUR OF MATERIALS LABORATORY	Credits 0-1-2: 2

Pre-Requisites: None

Course Outcomes:
At the end of the course, the student will be able to

CO1	Operate mechanical testing equipment for measuring materials properties
CO2	Analyze the data obtained from mechanical testing.
CO3	Determine the fracture toughness of materials
CO4	Assess high-temperature mechanical properties of alloys

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1		2	2		3	
CO2		2	2		3	
CO3		2	2		3	
CO4		2	2		3	

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:
Hardness test, Tensile test, Compression test, Impact test, Wear and erosion test, Microhardness and indentation fracture toughness test, Fracture toughness test, Fatigue testing, Creep and stress rupture tests. NDT techniques- Ultrasonic, magnetic particle, die penetrant test.

Text Books:

1. R. W. Hertzberg: Deformation and Fracture Mechanics of Engineering Materials, 4th Edition, John Wiley & Sons Inc., 2012.
2. 2. M.A. Meyers and K.K. Chawla: Mechanical Behavior of Materials, Prentice Hall Inc., New Delhi, 1999.
3. 3. T. L. Anderson: Fracture Mechanics- Fundamentals and Applications, 3rd Edition, CRC Press, 2011.
4. 4. G. E. Dieter: Mechanical Metallurgy, McGraw-Hill, 2002
5. 5. Laboratory Manual

Course Code: MM 5298	SEMINAR II	Credits 0-0-2: 1

Pre-Requisites: None

Course Outcomes:
At the end of the course, the student will be able to

CO1	Identify advanced technological problems in materials research
CO2	Evaluate the available literature and technical reports
CO3	Formulate a comprehensive report in a logical and coherent manner
CO4	Discuss the case studies with peers using ICT tools

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3		1			1
CO2	3		1			1
CO3	1	3	1			3
CO4	2	3	1			3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:
Any topic of relevance to materials technology and allied areas.
Leading journals and conferences, paper referencing and critiquing, ethics and plagiarism, improving presentation and communication skills, technical paper and report writing

Course Code: MM5211	AEROSPACE MATERIALS	Credits 3-0-0: 3

Pre-requisites: None

Course Outcomes:

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

CO1	Outline the material selection criteria for aerospace applications
CO2	Identify components and materials in aeroplanes and space vehicles
CO3	Provide solutions for materials selection, processing, testing and performance evaluation.
CO4	Discuss the creep, fatigue and high-temperature degradation phenomena with respect to aerospace and gas turbine engine components
CO5	Suggest advanced materials for the aerospace applications

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3	2		
CO2			3	2		
CO3			3	2		
CO4			3	2		
CO5			3	2		

1: Slightly 2: Moderately 3: Substantially

Syllabus:

Requirements of space and aerospace materials, land base and aerospace materials, identification of components of aeroplanes and space vehicles, materials usage in each section and criticality of the components and their materials selection, gas turbine, and aero engines; creep, fatigue and corrosion; Nickel and Cobalt based super alloys, special steels, aluminium alloys, titanium alloys, intermetallics, ceramics and their composites, Carbon-Carbon composites, new high strength and advanced materials in aerospace structural components.

Text Books:

1. Aerospace Materials and Material Technologies-Aerospace Materials (Vol. 1) and Aerospace Material Technologies (Vol. 2), N. Eswara Prasad, R.J.H. Wanhill, Indian Institute of Metals Series, Springer, 2017.
2. Materials Selection in Mechanical Design, Michael F. Ashby, Butterworth-Heinemann, 2005
3. Aircraft Materials and Processes, George F. Titterton, Himalayan Books, New Delhi, 1998
4. Manufacturing Technology for Aerospace Structural Materials, F. C. Campbell, Elsevier, UK, 2006
5. Aerospace Materials with Materials Technology for Engineers, Vol. 1-4, Balram Gupta, S. Chand & Co., New Delhi, 1996 and 2002.

Reference Books:

1. Light Alloys: From Traditional Alloys to Nanocrystals, Polmear, I. J., Elsevier, 2005, 4th ed.
2. The Superalloys: Fundamentals and Applications, Reed, R. C., Cambridge Univ. Press, 2006.
3. Aerospace Materials, Cantor, B., Assender, H., and Grant, P. (Eds.), CRC Press, 2001.

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Course Code: MM5212	LIGHT METALS AND ALLOYS	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Understand the relationship between Processing, Microstructure and Properties
CO2	Design Al - alloys for automotive and aerospace applications
CO3	Apply the concepts of microstructure design for high strength Mg- alloy development
CO4	Design processes to tailor the properties of Ti- alloys

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3	2	2	
CO2			3	2	2	
CO3			3	2	2	
CO4			3	2	2	

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

General introduction - strengthening by solid solution, precipitation, dispersion of second phase particles, grain refinement and work hardening.

Aluminum and its alloys: Production of Aluminum, Designation, temper and characteristics of cast and wrought alloys. Heat treatment of Aluminum alloys – Al-Si, Al-Cu, Al-Mg, Al-Zn-Mg&Al-Cu-Zn-Mg systems. Development of high strength Aluminum alloys by non-equilibrium processing routes such as rapid solidification and powder metallurgy. Applications in consumer, automotive and aerospace industry.

Magnesium and its alloys: Production of Magnesium, Designation, temper and characteristics. Heat treatment of Magnesium alloys – Mg-Sn, Mg-Zn, Mg-Gd, Mg-Li& Mg-Al-Zn systems. Development of high strength magnesium alloys. Applications in consumer, automotive and aerospace industry.

Titanium and its alloys: Production of titanium. Heat treatment of Titanium and its alloys - alpha alloys, alpha - beta alloys, beta alloys. Applications in sports, automotive, aerospace and strategic industries.

Text Books:

1. Light Alloys - From Traditional alloys to nanocrystals, I.J.Polmear, Butterworth Heinemann, 2005, Fourth Edition
2. Principles of Metal Casting, R.W.Heine, C.R.Loper, P.C.Rosenthal, Tata McGraw Hill, 1976.
3. Semisolid Processing of Alloys, D.H. Kirkwood, M. Surey, P. Kapranos, H.V. Atkinson, K.P. Young, Springer Series in materials Science, 2010.
4. Magnesium, Magnesium Alloys, and Magnesium Composites, M. Gupta, N.M.L. Sharon, Wiley, 2011
5. Titanium, G. Lutjering, J.C. Williams, Springer, 2007
6. An introduction to metal-matrix composites, T.W. Clyne, P.J. Withers, Cambridge University Press, 1993.

Course Code: MM5113	TEXTURE OF MATERIALS	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:
At the end of the course, the student will be able to

CO1	Describe texture in polycrystalline materials and methods available for texture analysis
CO2	Explain the effect of processing parameters on texture
CO3	Interpret texture measured by X-ray and electron diffraction techniques
CO4	Evaluate the macro and micro texture
CO5	Choose the right processing route to get right texture

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			2	2	1	
CO2			2	2	1	
CO3			1	2	1	
CO4		1	1	2	1	
CO5	3				5	

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:
Introduction to Crystallographic texture ,Concepts of texture in materials, representation of texture by pole figure and orientation distribution functions, measurement of Texture - X-ray diffraction, neutron diffraction, synchrotron X-rays, materials processing effect on texture , texture in FCC, BCC and HCP metals and alloys, models for polycrystalline deformation and texture evolution, Texture developments during solidification, deformation, annealing, coatings and thin film deposition, correlation between texture and properties, micro texture analysis, Kikuchi diffraction pattern, quantitative evaluation of kikuchi pattern, SEM based techniques-EBSD, TEM based techniques, evaluation and representation of microtexture data. Concepts of grain boundary engineering, special boundaries, applications of Texture and microtextures.

Text Books:

1. Texture Analysis in Materials Science, Bunge, H.-J, Butterworth, London, 1983.
2. Introduction to Texture Analysis: Macrotexture, Microtexture and orientation mapping, V. Randle and O. Engler, CRC Press, 2009,2nd edition.
3. Crystallographic Texture of Materials,Satyam Suwas,Ranjit Kumar Ray,Springer Nature Switzerland AG,2014
4. Texture and Anisotropy, U.F. Cocks, C.N. Tome and H.-R. Wenk, Cambridge University Press, 2000.
5. Electron Backscatter Diffraction in Materials Science,Adam J. Schwartz, Mukul Kumar, Brent L. Adams, David P: Springer, 2000.

Reference Books:

1. Recrystallisation and Related Phenomenon,F.J. Humphreys and M. Hatherly, Pergamon
2. Press, 2004.

Online Resources:
1. https://mme.iitm.ac.in/vsarma/mm5020/Texture_Intro.pdf
2. https://nptel.ac.in/courses/113/108/113108054/
3. http://www.dierk-raabe.com/textures-of-steels/
4. http://www.texture.de/

Course Code: MM5213	ENVIRONMENTAL DEGRADATION OF MATERIALS	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:
At the end of the course, the student will be able to

CO1	Describe degradation of alloys, polymers, ceramics and composites
CO2	Explain the thermodynamic basis of degradation
CO3	Select suitable techniques to assess materials degradation
CO4	Suggest methods to mitigate degradation of materials

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1				3	2	
CO2				3	2	
CO3				3	3	
CO4				3	3	

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:
Degradation economics, types of degradation: electrochemical, high-temperature corrosion and oxidation, chemical and physical ageing of plastics, degradation of reinforced concrete, biofouling, biodegradation, erosion corrosion – environmental variables, cavitation, fretting corrosion, erosive and corrosive wear, corrosion of ceramics, laboratory assessment of corrosion: linear polarisation techniques, Tafelextrapolation, oxidation,free energy- temperature diagrams, corrosion control: materials selection and design, protective coatings, inhibitors, passivators, electrical methods.

Text Books:

1. Myer Kutz, Handbook of Environmental Degradation of Materials, William Andrew Publishing, 2005
2. Denny A Jones, Principles and Prevention of Corrosion 2Ed., Pearson, 2014
3. R. D. Angel, Principles and Prevention of Corrosion, Narosa, 2010
4. Mars Guy Fontana: Corrosion Engineering, Tata McGraw-Hill Education, New York, 2005.
5. H.H. Uhlig, R. Winston Revie: An Introduction to Corrosion and Corrosion Engineering, 4th Ed, John Wiley & Sons, 2008.

Course Code: MM5214	AUTOMOTIVE MATERIALS	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Describe the properties of the material required for automotive applications
CO2	Classify advanced metallic and non-metallic materials used in automotive applications
CO3	Analyze the structure, property and processing relationship for metallic and non-metallic materials for automotive applications.
CO4	Suggest materials for automobile structural and functional components.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			3			
CO2			3			
CO3			3	3	2	
CO4			3		3	

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Automotive Components & Material Selection, Selection of materials for different components of automobiles. Classes of materials and their properties: metals, alloys, polymers, ceramics, composites, body materials: aluminium alloys, steels, special steels, magnesium, sandwich materials, engine materials: cylinder, piston, camshaft, valve materials, plastic materials, functional materials, electronic materials, smart materials advanced materials, light-weighting automobiles, future vehicles and materials, materials for electric vehicles, materials selection in design.

Text Books:

1. Jason Rowe (Ed): Advanced Materials in Automotive Engineering, Woodhead Publishing Limited, 2012.
2. Geoffrey Davies: Materials for Automobile Bodies, Elsevier, 2012.
3. Brian Cantor, P. Grant, C. Johnston (Eds): Automotive Engineering- Lightweight, Functional, and Novel Materials, CRC Press, 2007.
4. Hiroshi Yamagata: The Science and Technology of Materials in Automotive Engines, Woodhead Publishing Limited, 2005.
5. W.D. Callister: Material Science and Engineering -An Introduction, Wiley – Eastern, 2006.
6. Kenneth G. Budinski, Michael K. Budinski Engineering Materials, Prentice-Hall, 9th Ed., 2009.

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Course Code: MM5215	CERAMICS, POLYMERS AND COMPOSITES	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Differentiate the properties of metals, ceramics, polymers and composite materials
CO2	Describe processing routes for ceramics, polymers and composites
CO3	Explain the failure mechanism of polymers, composite materials and ceramics
CO4	Select the suitable materials for engineering applications

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3	2		
CO2			3	2		
CO3			3	2		
CO4	2		3	3		

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Ceramics: Introduction to ceramics, properties of ceramics, crystal structure, defects in ceramics, classification of ceramics, Processing of ceramics-powder preparation, consolidation and shaping of ceramics, sintering , super plasticity in ceramics, Bio ceramics, ceramic coating, Toughening mechanism in ceramics, engineering applications of ceramics.

Polymers: Introduction to Polymers, structure and properties of polymers, degradation of polymers, high temperature polymers, processing of polymers, applications of polymers.

Composites: Introduction to Composites, properties, rule of mixtures, classification of composites, various routes of processing of composites, applications of composites, fracture in composites, Case studies.

Text Books:

1. Introduction to Ceramics, W. David Kingery, H. K. Bowen and Donald R. Uhlmann, John Wiley & Sons,2004, 2nd Edition.
2. B. Raymond, Seymour and Charles E. CarraherJr, Polymer Chemistry, An Introduction, 2nd Edition, Marcel Dekkar, Inc. New York, 1987
3. Composite Materials: Science and Applications, Deborah D. L. Chung, Springer,2009, SecondEdition.
4. Composite Materials: Engineering and Science,F.L. Matthews and R.D. Rawlings, CRC Press,1999.
5. Composite Materials- Science and Engineering, Krishan Kumar Chawla,Springer,2012.

Reference Books:

1. Handbook of Advanced Ceramics, Parts 1 and 2, S. Somiya, Academic Press, 2006
2. Chemistry,AnIntroduction, B.Raymond,SeymourandCharlesE.CarraherJr,PolymerMarcel Dekkar, Inc. New York, 1987, 2ndEdition.
3. An Introduction to Composite Materials, D Hull, TW Clyne Cambridge University, Press, New York, 1996, 2nd edition
4. Fundamentals of Ceramics (Series in Materials Science and Engineering) Michel Barsoum and M.W Barsoum, 2002

Online Resources:

1. https://nptel.ac.in/content/storage2/courses/101104010/downloads/Lecture4.pdf
2. https://www.youtube.com/watch?v=7Be7hGvqoAg

3. https://youtu.be/0kB0G6WKhKE?list=PLSGws_74K01-bdEEUElQ9-obrujIKGEhg
4. https://nptel.ac.in/courses/113/105/113105015/
5. https://www.youtube.com/watch?v=c1ZbiBIY6Sc

Course Code: MM5117	NANOTECHNOLOGY	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Discuss the significance, properties and applications of nanomaterials
CO2	Distinguish various synthesis techniques for the preparation of nanomaterials
CO3	Appraise the effect of size reduction on functional properties of materials
CO4	Select suitable nanomaterials for advanced applications

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			3	3		
CO2			2	3		
CO3			2	2		
CO4			3	3	2	

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Significance, properties and applications nanomaterials, carbon nano structures, nano indentation, super plastic behaviour of nanomaterials, Ceramic nanosystems, quantum confinement, effect of size reduction on optical, electrical, electronic, mechanical, magnetic and thermal properties of materials, nano electronics, Nano fluidics, NEMS, photonic crystals, biomimetic nano structures.

Text Books:

1. B S Murty et. al.: Textbook of Nanoscience and Nanotechnology, Universities Press (India) Private
2. Limited 2013.
3. Sulabha K. Kulkarni: Nanotechnology Principles and Practices, Capital Publishing Company, 2007.
4. H. Hosono, Y. Mishima, H. Takezoe, K.J.D Mackenzie: Nanomaterials- From Research to Applications, Elsevier, 2008.
5. Massimilano Di Ventra, S. Evoy, James R. Heflin Jr: Introduction to Nanoscale Science and Technology, Springer, 2009.
6. Charles P. Poole Jr., Frank J. Owens: Introduction to Nanotechnology, Wiley India, New Delhi, 2010.
7. Jack Uldrich, Deb Newberry: Next Big Thing Is Really Small: How Nanotechnology Will Change the Future of Your Business.

Course Code: MM5118	COMPUTATIONAL APPROACHES IN MATERIALS ENGINEERING	Credits 3-0-0: 3

Pre-Requisites: Engineering Mathematics

Course Outcomes:

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

CO1	Apply thermodynamic modelling for alloy design.
CO2	Apply FEA techniques for simulating material problems.
CO3	Make use of mesoscale modelling techniques to solve material problems.
CO4	Select an appropriate method for simulation considering length and time scale

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		2	3		
CO2	1		2	2	2	
CO3			2	2		
CO4		1	2	2	1	

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Basics of computer programming, introduction to open-source tools in programming. Introduction to computation, numerical methods, physical modelling of material problems.Scales in materials structure, length and time scales in modelling. Monte-Carlo Methods: basics and applications, molecular modelling: interatomic potential, requirements for molecular dynamics simulation, Verlet algorithm.Introduction to FEA and crystal Plasticity: basics, solving 1D and 2D problems, microstructure modelling.Thermodynamic modelling: CALPHAD, ThermoCalc, alloy design, integrated computational materials engineering. Materials selection and design.Basics and applications of statistics, neural network, artificial neural network, genetic algorithm and fuzzy logic in materials engineering.

Text Books:

1. Richard Laser, Introduction to Computational Materials Science, Cambridge University Press, 2013.
2. Zoe Barber, Introduction to Materials Modelling, Maney Publishing, 2005.
3. June Gunn Lee, Computational Materials Science 2ed., CRC Press, 2016

Reference Books:

1. R J Arsenault, J R Beeler Jr, D M Easterling (Eds): Computer Simulation in Materials Science, ASM International, 1986.
2. B.S. Grewal, Numerical Methods in Engineering and Science, Mercury Learning and Information, 2018

Online Resources:

1. https://nptel.ac.in/courses/115/103/115103114/
2. https://ocw.mit.edu/courses/materials-science-and-engineering/3-320-atomistic-computer-modeling-of-materials-sma-5107-spring-2005/index.htm
3. https://ocw.mit.edu/courses/materials-science-and-engineering/3-021j-introduction-to-modeling-and-simulation-spring-2012/

Course Code: MM5216	NUCLEAR MATERIALS	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Discuss nuclear reactor components and their materials
CO2	Explain processing of nuclear reactor grade materials.
CO3	Describe nuclear reactive fuels and their processing.
CO4	Appraise the techniques for disposal of radioactive waste.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3	2		
CO2			3	3		
CO3	2	3	3	3		
CO4			3	3		

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Nuclear Engineering: Concepts of nuclear reactors, Structure of the nucleus, binding energy, fission reactions, neutron cross sections, moderation of neutrons, multiplication factor. Fission reactions, Nuclear Power.

Nuclear Reactor Components: Reactors, Classification of nuclear reactors. Materials for nuclear reactors viz., fuels, moderators, control rods, coolants, reflectors and structural materials. Fabrication of fuel and cladding materials.

Processing of Nuclear Materials: Production of Nuclear Grade Materials, general methods of nuclear minerals processing, Production metallurgy of nuclear grade uranium, thorium, beryllium and zirconium, Production of enriched uranium, Processing of spent fuel and extraction of plutonium.

Radiation and Nuclear Waste Disposal: History of Radiation Effects, Radiation Units, Radiation Effects, Biological Effects of Radiation, Radiation Doses and hazard Assessment, Interaction of radiation with materials, Radiation safety and shielding, Disposal of nuclear waste.

Indian Nuclear Power Programme: Indian Reactors and Nuclear Energy Programme in India, Medical Applications of Nuclear Technology.

Text Books:

1. K. Linga Murty and Indrajit Charit: An Introduction to Nuclear Materials, Wiley, 2013.
2. J. Kenneth Shultis, Richard E. Faw: Fundamentals of Nuclear Science and Engineering, Marcel Dekkar, 2002.
3. John R. Lamarash: Introduction to Nuclear Engineering, 2 ed., Addison Wesley, 1983.
4. S. Glasstone, A. Sesnoke: Nuclear Reactor Engineering, CBS Publishers, 2003.
5. Bodansky: Nuclear Energy- Practices and Projects, Springer, 2004.
6. Gary S. Was: Fundamentals of Radiation Materials Science: Metals and Alloys, 2ed. Springer, 2017

Course Code: MM5161	SURFACE ENGINEERING AND COATING TECHNOLOGY	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Differentiate diffusion and overlay coatings
CO2	Explain the principles of thermo-chemical surface engineering techniques and thin film coatings
CO3	Evaluate thermal modification processes applicable to surface modification of industrial components
CO4	Evaluate the performance of coatings

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			3	1		
CO2			3			
CO3			3			
CO4	1		3		3	

1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Introduction - Importance and need of surface engineering, Past, present and future statusof surface engineering, Classification of surface engineering processes, Substrates and their pre-treatments, Difference between diffusion coatings and overlay coatings, Coating characteristics: Coating thickness, continuity, hardness, adhesion, porosity, bond strength;

Overlay coatings: Process fundamentals, advantages, limitations, and applications of (a) Thermally sprayed coatings, Thermal barrier coatings, Powders for thermal spraying and Factors influencing thermal spray coatings, Applications of thermal spraying, Recent developments in thermal spraying, (b) Electrochemical coatings-Electroplating (Cu, Ni, Cr, Zn), Electro-less nickel plating and anodizing, Coating on plastics; (c) Micro arc oxidation- Basics, technology and fundamentals of micro-arc oxidation, Advantages, shortcomings and applications of micro-arc oxidation; (d) Electro-spark coating-process-Fundamentals, mechanism of coating formation, advantages and limitations, applications, Case studies;

Diffusion coatings: Process fundamentals, advantages, limitations and applications of Carburising Overview of pack, liquid, and gas carburizing; Nitriding Overview of gas and liqud nitriding; Carbonitriding and Nitrocarburising; Boronizing, Aluminized coatings, Chromized and Siliconized coatings; Plasma processes - Plasma carburizing and Plasma nitriding; Plasma immersed ion implantation, Plasma enhanced chemical vapour deposition;Plasma enhanced physical vapour deposition;

Thermal modification processes: Different types of lasers and their applications, Laser-assisted surface modification processes-Laser surface cleaning, Laser surface hardening, Laser surface cladding, Laser surface alloying; Flame hardening and Induction hardening;

Thin film coating technology: Chemical vapour deposition (CVD), Physical vapour deposition (PVD), Electron beam evaporation, Magnetron sputtering; Diamond-like carbon coating technology; Sol-gel coating technologies;

Evaluation of coatings: Thickness, bond strength and porosity measurement, Hardness, wear and corrosion resistance.

Text Books:

1. Tadeusz Burakowski and Tadeusz Wierzchon, Surface Engineering of Metals: Principles, Equipment, Technologies, CRC Press LLC, 1999
2. K. G. Budinski, Surface Engineering for Wear Resistance, Prentice-Hall, New Jersey, 1998.
3. J. R. Davis, Surface Engineering for Corrosion and Wear resistance, ASM International, 2001
4. Howard E. Boyer, Case Hardening of Steel, ASM International, Metals Park, OH 44073.
5. ASM Hand Book, Surface Engineering, Volume 5, ASM Metals Park. Ohio. USA. 1994

Course Code: MM5261	BIOMATERIALS	Credits 3-0-0: 3

Pre-Requisites:

Course Outcomes:

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

CO1	Discuss the materials science principles for bio-applications
CO2	Design the processing methods for biomaterials
CO3	Apply different characterization techniques to assess biomaterials properties
CO4	Select materials for different bio-applications

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		1	2	2	
CO2	1		1	2	2	
CO3	1		2	2	3	
CO4	1		1	2	3	

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Overview: Historical development;Materials in Medical Applications; Materials Properties for Bio-applications

Biomaterials Classification and Processing: Metallic materials;Ceramic and glass implant materials;Polymeric implant materials;Collagen; Thin films; Grafts and coatings;Biologicalfunctional materials

Cell Structure: Bone structure; Bone properties; Proteins; Bacteria structure; Antibacterial assay

Cell-material Interaction: In vivo testing; Cell-material interaction; Cell-signalling; in vitro testing;Cytotoxicity; Clinical trials

Tissue Engineering: Scaffolds, cellular materials, stem cells, regeneration engineering

Text Books:

1. B. Basu, D. Katti and Ashok Kumar; Advanced Biomaterials: Fundamentals, Processing and Applications; John Wiley & Sons, Inc., USA, 2009.
2. B. Basu; Biomaterials Science and Tissue Engineering: Principles and Methods, Cambridge IISc Press, 2017.
3. S. V. Bhat, Biomaterials; 2nd Ed., Narosa Publishing House, 2006.
4. J. Park, R.S. Lakes, Biomaterials an introduction; 3rd Ed., Springer, 2007

Reference Books:

1. Buddy D. Ratner: Bio Material Science- An introduction to Materials in Medicine, Elsevier, 2013.

Online Resources:

1. https://nptel.ac.in/courses/113/108/113108071/

Course Code: MM5262	FUNCTIONAL MATERIALS	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Classify functional materials
CO2	Explain structure-property correlation in functional materials
CO3	Discuss processing methods for functional materials
CO4	Select materials for advanced functional applications

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			1	2	1	
CO2			2	3	1	
CO3	1		1	3	3	
CO4	1		2	3	3	

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

The Origin of Functional Materials (FMs), Potential Applications of FMs, Classification of FMs, Processing Techniques: Powder Metallurgy Route, Melt-processing Route, Vacuum arc melting, Vacuum induction melting, Vapor deposition and types

Specific properties of functional materials: Magnetic materials, Electronic Materials and Sensors, Electric Contact Materials, Conducting Thermoplastics and polymer composites, Surface coatings for functional applications, Biomaterials and Shape memory metals, Invar alloys

Batteries and fuel cells, solar energy harvesting, Reflective and anti-reflective layers, Waste heat recovery materials

Microstructure-property correlations, characteristic dimensions and spatial variations, volume fraction, rule of mixtures and effective field parameters; characterization of FMs, macrostructural thermomechanical properties, material properties of ceramic-metal FMs, basic mathematical modeling.

Text Books:

1. Engineering Materials for Technological Needs, Vol. 2- Functional Materials: Electrical, Dielectric, Electromagnetic, Optical and Magnetic Applications, D.D.L. Chung, World Scientific Publishing,2010.
2. Composite Materials- Functional Materials for Modern Technologies, D.D.L. Chung, Springer, 2002.
3. Functionally Graded Materials- Design, Processing and Applications, Y. Miyamoto, W.A. Kaysser, B.H. Rabin, A. Kawasaki, R.G. Ford (Eds), Springer,1999.

Reference Books:

1. Functionally Graded Materials - Nonlinear Analysis of Plates and Shells, Hui-Shen Shen, CRC Press,2009.

Online Resources:

1. https://nptel.ac.in/courses/113/105/113105081/
2. https://www.researchgate.net/publication/227194436_Functional_Materials_Properties_Processing_and_Applications
3. https://www.intechopen.com/books/7554

Course Code: MM5263	ELECTRONIC AND MAGNETIC MATERIALS	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Design novel microstructures to modify magnetic properties of materials
CO2	Describe the processing and structure of semiconducting materials
CO3	Discuss the structure and fabrication of superconducting materials
CO4	Describe vacuum technologies necessary while manufacturing and characterizing the electronic and magnetic materials

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3		2
CO2	1	2	2	2		2
CO3	1	1	1	2		2
CO4	1	1	1	2		2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Magnetic Materials:

Brief introduction: Origin of magnetism, Permanent magnetic moments of atoms, Magnetic domains, Super-paramagnetism, Types of magnetic materials, Soft and hard magnetic materials; Ferrites-classification and crystal structure, Nanocrystalline soft magnetic materials, Melt-quenching method for soft magnetic ribbons and metallic glasses; Permanent magnets - properties and preparation of sintered magnets, High performance rare-earth permanent magnets (SmCo & NdFeB), Grain boundary diffusion process of Nd-Fe-B magnets

Principles and Processing of Semiconducting Materials:

Brief introduction to semiconductor principles: band diagrams, doping, carrier concentration, I-V characteristics

Manufacturing of metallurgical grade silicon, Siemens process to obtain electronic grade Si, Growth of single crystals by Czochralski technique, Silicon wafer preparation for electronic devices. Techniques involved in the preparation of electronic chip: Lithography, physical and chemical vapour deposition.
Solar cells: Photovoltaic effect, Types of silicon solar cells (amorphous, poly & single crystal), Fabrication and functioning of silicon solar cells, Multi-junction solar cells

Superconducting Materials:

Temperature dependence of resistance, BCS Theory, Type I and II superconductors, Meissner-Effect, High-temperature Superconductors, YBCO & Bi-2212 – Crystal structure, Applications, Persistent current, Levitation; Fabrication of YBCO superconductors

High Vacuum Techniques

Introduction to vacuum devices, Rotary pump, Diffusion pump, turbo-molecular pump, Ion-pump, Basic vacuum system assembly and sequence of operation to create high vacuum.

Text Books:

1. B. D. Cullity, C.D. Graham, 2nd Ed., Introduction to Magnetic Materials, Wiley and IEEE, 2009
2. J D Patterson, Solid State Physics, 2nd Edition, Springer, 2011.
3. D.M. Hoffman, B. Singh, J.H. Thomas, Handbook of Vacuum Science and Technology, Academic Press 1998.

4. David Jiles, Introduction to Magnetism & Magnetic materials, London: Chapman & Hall, 1998.
5. Milton Ohring, Materials Science of Thin Films, Academic Press, San Diego, 2002.

Reference Books:

1. John J. Croat, Rapidly Solidified Neodymium-Iron-Boron Permanent Magnets, Woodhead Publishing, 2017
2. G.S. May and C.J. Spanos, Fundamentals of Semiconductor Manufacturing and Process Control, Wiley – IEEE, 2006.
3. Lecture Notes

Online Resources:

1. https://www.youtube.com/watch?v=G41t_0CqPzY&t=15s

Course Code: MM5264	SMART MATERIALS	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Comprehend operational principles of optical fibres, magneto/electro rheological fluids
CO2	Evaluate shape memory behaviour of materials
CO3	Suggest materials for energy harvesting applications
CO4	Select materials for sensor/actuator applications in smart structures

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			2	2		
CO2	1		3	2		
CO3	1	1	3	2		
CO4	1	2	3	2		

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Smart responses from nature, Classification of smart materials, Dependence of structure on material behaviour, Sensing and actuation, Examples and applications.

Piezoelectric and Magnetostrictive Materials: Piezoelectric effect, Structure of piezoelectric ceramics, Polarization, Processing of piezoelectric ceramics, Polymer piezoelectrics, Composites, Electrostrictive materials, Applications, Magnetostrictive materials, Magnetostrictive effects for sensing and actuation, Hybrid sensors, Applications.

Shape memory materials: Shape memory alloys (SMAs), Shape memory effect and phase changes, Phase transformation process for SMAs, Types of SMAs, Superelasticity, SMA properties and Processing, SMA fibers in composites, Applications of SMAs – aerospace, automotive, medical and construction, Challenges in SMAs, Smart memory ceramics, Mechanisms of smart recovery in ceramics.

Magneto/electro rheological fluids and optical fibers: Magneto rheological (MR) fluids, MR vs ferro fluids, Applications of MR fluids – damping and dissipation, Electro rheological (ER) fluids, Giant electro rheological (GER) fluid and its applications, Advantages and disadvantages, Optical fibers, Fiber optic total internal reflection, Fiber optic sensors, Intrinsic and extrinsic fiber optic sensors, Applications and advantages.

Smart Structures: Need for smart structures, Concept of smart structure, Integration of functions, sensor / actuator and control mechanisms, Smart structure classifications, Applications – aerospace, defence, automotive, industrial, medical, civil/construction.

Text Books:

1. Smart Materials and Structures, M.V. Gandhi, B.S. Thompson, Chapman & Hall, 1992.
2. Shape Memory Materials, D.I. Arun, P. Chakravarthy, R. Arockia Kumar, B. Santhosh, CRC Press, 2018.

Reference Books:

1. Smart Materials: Proceedings of the 1st Caesarium, Hoffmann, Karl-Heinz (Ed.), Springer, 1999.
2. Smart Materials – An Industrial Perspective, P. Nikhil Chandra, Mothi Krishna Mohan, Notion Press, 2021.
3. Smart Structures Theory, I Chopra and J. Sirohi, Cambridge University Press, 2013.
4. Smart Material Systems and MEMS:Design and Development Methodologies,V. K. Varadan, K. J. Vinoy, S.Gopalakrishnan, John Wiley and Sons.
5. Dynamics and Control of Structures, L. Meirovitch, John Wiley,1992.

Online Resources:

1. https://nptel.ac.in/courses/112/104/112104251/

2. https://nptel.ac.in/courses/113/105/113105081/

Course Code: MM5265	ENERGY MATERIALS	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Discuss the materials requirements in energy production
CO2	Appraise materials used in fuel cells for energy production
CO3	Describe the effect of irradiation on materials properties
CO4	Evaluate materials for conventional and alternative energy generation technologies

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1		3	3		
CO2	1		3	3		
CO3			3	2		
CO4	1		3	3		

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: World energy consumption. Non-conventional renewable energy sources. Current Energy generation Technologies and their Limitation. Materials related to Thermal power plants, Material requirements for nuclear energy– structural materials, coolants, shielding materials and fuel rods – fabrication requirements

Fuel cell basics: Fuel cell definition, Difference between batteries and fuel cells, fuel cell history, components of fuel cells, principle of working of fuel cells, Fuel cell thermodynamics and its efficiency, Electrochemical kinetics, Types of fuel cells and its chemistries - AFC, PAFC, PEMFC, MCFC and SOFC – merits and demerits. Fuel cells- global research development trends and application of PEMFC in the automobile industry and application SOFC in stationery. Current issues in PEMFC, Direct methanol fuel cells (DMFC) - Electrochemical kinetics methanol oxidation, Hydrogen – production and storage methods for fuel cells. Introduction to catalysis, Noble metal catalysts, oxide catalysts, introduction to membranes, porous membranes, dense membranes

Materials for solar cells: Semi-conductors, Materials for batteries: Li- batteries, metal hydride batteries, Materials for hydrogen technology: Production (electrolysis), Storage (hydrides), fuel cells (solid electrolytes, ion conductors), Materials for supercapacitors

Text Books:

1. J.C. Bryan: Introduction to Nuclear Science, CRC Press, 2009.
2. G.S. Was: Fundamentals of Radiation Materials Science, Springer, 2007.
3. C.O. Smith: Nuclear Reactor Materials, Addison-Wesley, 1967.
4. J.T.A. Roberts: Structural Materials in Nuclear Power Systems, Plenum Press, 2013.
5. Wolf Vielstich, Arnold Lamm, Hubert A. Gasteiger, Harumi Yokokawa: Handbook of Fuel Cells, John Wiley & Sons, 2003.
6. D Roddy (Ed): Advanced Power Plant Materials, Design and Technology, Woodhead Publishing Series in Energy No. 5 and CRC Press, 2010.
7. S Srinivasan, "Fuel Cells: From Fundamentals to Applications", Springer 2006.
8. G. David and C. David, "Fundamentals of Materials for Energy and Environmental Sustainability" Cambridge University Press, 2011

Course Code: MM5266	HIGH TEMPERATURE MATERIALS	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Discuss the oxidation mechanisms of metals and alloys
CO2	Classify materials for high temperature applications
CO3	Explain mechanisms of creep, thermal fatigue, oxidation and hot corrosion
CO4	Select the materials and/or coatings for high temperature applications

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			1	3	1	
CO2			2	3	2	
CO3			2	3	1	
CO4			3	3	2	

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to high temperature Materials, Characteristics of engineering materials at high temperature, oxidation, high temperature corrosion, Creep, thermal fatigue, erosion, aging, structural changes, material damage, crack propagation, damage mechanics, life time analysis.

High temperature materials- Carbon alloy steels, Stainless steels, super alloys and titanium and its alloys, ceramics, composites, Refractory metals, alloys and Structural inter-metallic and high temperature polymers.

Coatings: Thermal barrier coatings, Oxidation resistant coatings.

Text Books:

1. G. W. Meetham and M. H. Van de Voorde, Materials for High Temperature Engineering Applications (Engineering Materials) Springer; 1 edition, 2000.
2. Neil Birks, Gerald H. Meier, and Frederick S. Pettit, Introduction to the High Temperature Oxidation of Metals by Cambridge University Press; 2 edition, 2009.
3. Sudhansu Bose, High Temperature Coatings, Butterworth-Heinemann; 1 edition, 2007.
4. K. L. Mittal, Polyimides and Other High Temperature Polymers: Synthesis, Characterization and Applications, Brill Academic Publications, 2009.
5. R.W. Evans, and B. Wilshire, Creep of metals and alloys, Institute of Metals, London, 1985.
6. Krishan Kumar Chawla, Composite Materials- Science and Engineering, Springer, 2012.
7. B. Raymond, Seymour and Charles E. CarraherJr, Polymer Chemistry, An Introduction, 2nd Edition, MarcelDekkar, Inc. New York, 1987.

Reference Books:

1. J. R. Davis: ASM specialty Hand book: Heat-Resistant materials, ASM, 1997.

Online Resources:

1. https://www.youtube.com/watch?v=7z1KCDq43Zo

Department of Metallurgical and Materials Engineering

Course Code: MM5267	**MATERIALS SELECTION AND DESIGN**	**Credits 3-0-0: 3**

Pre-Requisites: None

Course Outcomes:

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

CO1	Discuss materials selection methodologies
CO2	Apply statistics in materials selection
CO3	Analyze the influence of composition, heat treatment and microstructure on the properties of engineering materials
CO4	Select suitable materials for structural and functional applications

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			1	2		
CO2			1	2		
CO3			3	3	2	
CO4			3	3	2	

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Revision of engineering materials, Classification of materials- metals and alloys, ceramics, polymers and composites, Importance of materials selection and metallurgical design, Properties and applications of plain carbon steels and common non-ferrous alloys.

Criteria for selection of materials, Ashby charts for materials selection, application of statistics in materials, specification of steels, Composition, heat treatment, microstructure and properties of ferrous and non-ferrous alloys, ceramics and polymers for light and heavy structural, corrosion-resistant, high temperature, low-temperature and cryogenic, wear-resistant, magnetic, electrical and electronic applications, pressure vessels and boilers, bearings, tools, medical implants and prostheses application, Composites, shape memory alloys, metallic glasses, nanocrystalline materials.

Text Books:

1. M.F. Ashby: Engineering Materials, 4th Edition, Elsevier, 2005.
2. M.F. Ashby: Materials Selection in Mechanical Design, Butterworth Heinemann, 2005.
3. Pat L. Mangonon: The Principles of Materials Selection and Design, Prentice Hall International, Inc.1999.

Reference Books:

1. ASM Metals Handbook, Vol.20: Materials Selection and Design, ASM, 1997.

Online Resources:

1. https://www.youtube.com/watch?v=9RQkvcsRzbo

Course Code: MM5268	CREEP, FATIGUE AND FRACTURE	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Classify deformation and fracture behaviour of materials at high temperature
CO2	Determine theoretical and experimental fracture strength of materials through EPFM, CTOD and J-integral
CO3	Predict the life of materials under fatigue loading
CO4	Select metals and alloys for high-temperature applications

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1					2	
CO2			2		3	
CO3			2		3	
CO4			2	2	3	

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Analysis of stresses and strains, Principal stresses and strains. Stress / Strain Invariants, Theories of Failure, Various yield criteria, Theoretical cohesive strength of metals, defects and stress concentration, stress due to crack inside a large plate, Energy balance during propagation of crack, concept of critical stress to propagate crack, Griffith theory, Common causes of engineering fracture, Fractography, Microscopic fracture modes, Fractographic observation of cleavage/brittle, Embrittlement, quasi-cleavage and ductile/dimple fracture.

Fracture Mechanics: Concept of fracture, Classification of fracture, Mechanism of ductile and brittle fracture, Strain energy release rate, Modes of fracture, Stress intensity factor, Fracture toughness, Determination of fracture toughness (KIc), Plasticity at the crack tip, Orowan correction, Irwin's modification, Plastic zone shape and size, effect of constraint, plane stress, plane strain, thickness effect, CTOD, J integral.

Fatigue: Fatigue testing and its significance, stress cycles, S-N curve, HCF, LCF, R ratio, Goodman diagram, fatigue limit, Paris law, Miner's rule, mechanism of fatigue failure, effect of stress concentration, size, surface condition and environments on fatigue, effect of metallurgical variables on fatigue properties.

Creep: High temperature materials problem, Temperature dependent mechanical behavior, Creep test, Creep curve, Creep properties of metals, Structural change during creep, Creep mechanisms, Stress-rupture test, Deformation and fracture at elevated temperature, Prediction of long time properties, LMP, Creep resistant materials, Effect of metallurgical variables on creep.

Text Books:

1. R. W. Hertzberg: Deformation and Fracture Mechanics of Engineering Materials, 4th Edition, John Wiley & Sons Inc., 2012.
2. M.A. Meyers and K.K. Chawla: Mechanical Behavior of Materials, Prentice Hall Inc., 1999.
3. T. L. Anderson: Fracture Mechanics- Fundamentals and Applications, 3rd Edition, CRC Press, 2011.
4. G. E. Dieter: Mechanical Metallurgy, 3rd Edition, McGraw-Hill, 2013
5. Michael Kassner: Fundamentals of Creep in Metals and Alloys, 2nd Edition, Elsevier Science, 2009.

Course Code: MM6247	COMPREHENSIVE VIVA-VOCE	Credits 0-0-0: 2

Pre-Requisites: None

Course Outcomes:

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

CO1	Demonstrate an understanding of the materials technology courses studied
CO2	Explain the materials technology principles, phenomena and their applications
CO3	Communicate technical concepts effectively
CO4	Comprehend the materials technology concepts for solving practical issues

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2		3	2		1
CO2	2		3	2	1	1
CO3		3				1
CO4	3		3	3		2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

All the courses of 1 year

Course Code: MM6249	DISSERTATION PART-A	Credits 0-0-0: 12

Pre-Requisites: None

Course Outcomes:

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

CO1	Identify the problem based on literature survey
CO2	Formulate the objectives in line with the identified research problem
CO3	Develop an effective methodology to meet the objectives
CO4	Prepare a technical report
CO5	Demonstrate the progress of dissertation work

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3		3	3		3
CO2	3		3	3	1	3
CO3	3		3	3	2	3
CO4		3	3	3	1	3
CO5		3	3	3		3

1 - Slightly; 2 - Moderately; 3 – Substantially

Course Code: MM6299	DISSERTATION PART-B	Credits 0-0-0: 20

Pre-Requisites: MM6249

Course Outcomes:

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

CO1	Execute the project methodology designed in dissertation part-A
CO2	Analyze the experimental/simulation results
CO3	Deduce conclusions from the results
CO4	Prepare a comprehensive dissertation report by following ethical principles
CO5	Demonstrate the outcome of dissertation work

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3		3	2	1	3
CO2	3		3	2	1	3
CO3	3		3	2	1	3
CO4		3	3			3
CO5		3	3			3

1 - Slightly; 2 - Moderately; 3 – Substantially

NOTE: Refer to the following link for the guidelines to prepare dissertation report:
https://www.nitw.ac.in/main/PGForms/NITW/