Specialization:

1. Surface Engineering
2. Iron and Steel Technology

FIRST SEMESTER

Sl. No	Paper	Credit
1	Paper-I (Dep. Core)	3
2	Paper-II (Dep. Core)	3
3	Paper-III (Dep. Core)	3
4	Paper-IV (Dep. Elec/ Open Elec.)	3
5	Paper-V (Dep. Elec/ Open Elec.)	3
	Theory Subtotal	**15**
6	Lab - I/ Mini Project - I	2
7	Lab - II/Mini Project - II	2
8	Lab - III/Mini Project - III	2
	Practical Subtotal	**7**
	Total Credit	**21**

Note:

1. Paper – I, II and III are compulsory subjects for the particular specialization.
2. Paper – IV, V are elective subjects, which are to be selected from the table below. A student may also opt for open electives offered by other departments for first semester M. Tech Students (subject to availability).
3. Lab – I, II, III are typically related to Paper – I, II and III. However, in some cases, if the Department feels, these may be related to Paper – IV and V also (for departmental electives only). In cases, where lab facility is not available, mini projects related to Paper – I/II/III may be offered.
4. The credits mentioned above are indicative and are as such to be followed. However, in cases, where it is essential to include a Tutorial or to increase the lab hours, credits may be increased to 4 (Theory)/3(Practical). In such cases, the total credit should not exceed 24.

a) Departmental Core Papers for the specialization (Paper – I, II, III)

Specialization: 1. Surface Engineering, and 2. Iron and Steel Technology

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	**MM5101**	**Materials Technology**	3	0	0	40	3	100
2	**MM5102**	**Advanced Characterization of Materials**	3	0	0	40	3	100
3	**MM5103**	**Advanced Thermodynamics and Kinetics**	3	0	0	40	3	100

b) *Departmental Elective* Papers for the specialization (Paper – IV)

Specialization: 1. *Surface Engineering*

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	**MM5121**	**Surface Treatment and Modification**	3	0	0	38	3	100
2	**MM5122**	**Mechanical Behaviour of Thin Films**	3	0	0	42	3	100

Specialization: 2. *Iron and Steel Technology*

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	MM5123	Advanced Iron and Steel Making	3	0	0	42	3	100
2	MM5124	Crystallographic Texture of Materials	3	0	0	40	3	100

b) *Open (non-departmental) Elective* Papers (Paper – V) offered by the Department of Metallurgy and Materials Engineering

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	MM5161	Mechanical Behaviour of Engineering Materials	3	0	0	42	3	100
2	MM5162	Multiscale Modelling	3	0	0	40	3	100
3	MM5163	Microstructure Modelling	3	0	0	40	3	100

c) Departmental Labs for the specialization (Lab – I, II, III)

Specialization: 1. Surface Engineering, and 2. Iron and Steel Technology

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	MM5171	Materials Technology Lab.	0	0	3	33	2	100
2	MM5172	Advanced Characterization of Materials Lab.	0	0	3	30	2	100

d) Departmental Mini Projects for the specialization

Specialization: 1. Surface Engineering, and 2. Iron and Steel Technology

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	MM5173	Mini Project on Materials Technology	0	0	3	30	2	100
	MM5174	Mini Project on Advanced Characterization of Materials	0	0	3	30	2	100
	MM5175	Mini Project on Advanced Thermodynamics and Kinetics	0	0	3	30	2	100

Note: In cases, where Mini Project if offered, the related Paper (Paper – I, II or III) should be mentioned.

SECOND SEMESTER

Sl. No	Paper	Credit
1	Paper - VI (Dep. Core)	3
2	Paper - VII (Dep. Core)	3
3	Paper - VIII (Dep. Core)	3
4	Paper-IX (Dep. Elec/ Open Elec.)	3
5	Paper-X (Dep. Elec/ Open Elec.)	3
	Theory Subtotal	**15**
6	M. Tech Project Part - I (Term Paper)	4
7	Term Paper Seminar & Viva-voce	2
8	**Practical Subtotal**	**6**
	Total Credit	**21**

Note:

1. Paper – VI, VII and VIII are compulsory subjects for the particular specialization.
2. Paper – IX, X are elective subjects, which are to be selected from the table below. A student may also opt for open electives offered by other departments for second semester M. Tech Students (subject to availability).
3. For M. Tech Thesis Part - I (Term Paper), the student will work under the guidance of the Supervisor(s) from the beginning of the second semester, and submit the Term Paper (literature review and objective and scope of the broad area of M. Tech thesis work). Submission will be followed by a seminar and viva-voce.
4. The credits mentioned above are indicative and are as such to be followed. However, in cases, where it is essential to include a Tutorial credits may be increased to 4 (Theory). In such cases, the total credit should not exceed 23.

a) Departmental Core Papers for the specialization (Paper – VI, VII, VIII)

Specialization: 1. Surface Engineering, and 2. Iron and Steel Technology

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	**MM5201**	**Manufacturing Processes**	3	0	0	40	3	100
2	**MM5202**	**Design and Selection of Materials**	3	0	0	40	3	100
3	**MM5203**	**Defects in Materials**	3	0	0	40	3	100

b) Departmental Elective Papers for the specialization (Paper – IX)

Specialization: 1. *Surface Engineering*

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	**MM5221**	**Surface Degradation and Protection**	3	0	0	40	3	100
2	**MM5222**	**Engineering Tribology**	3	0	0	44	3	100

Specialization: 2. *Iron and Steel Technology*

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	MM5222	Engineering Tribology	3	0	0	44	3	100
2	MM5223	Advanced Ferrous Materials	3	0	0	45	3	100
3	MM5224	Advanced Joining Techniques	3	0	0	42	3	100

b) *Open (non-departmental)* *Elective* Papers (Paper – X) offered by the Department of Metallurgy and Materials Engineering

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	MM5261	Nanostructures and Nanomaterials	3	0	0	38	3	100
2	MM5262	Microelectromechanical Systems: Materials and Processes	3	0	0	44	3	100
3	MM5263	Biomedical Materials and Devices	3	0	0	38	3	100
4	MM5264	Non-destructive Testing	3	0	0	45	3	100

c) M. Tech Project Part - I

Sl. No	Subject code	Subject Name	Total load (h)	Credit	Marks
1	MM5291	M. Tech thesis Part - I (Term Paper)	8	4	200
2	MM5292	Term Paper Seminar & Viva-voce		2	100

THIRD SEMESTER

Sl. No	Paper	Credit
1	M. Tech Thesis Part - II (Progress Report)	12
2	Progress Report Seminar & Viva-voce	6
	Total Credit	**18**

Note:

1. *For M. Tech Thesis Part - II (Progress Report), the student will submit the details of work done for the M. tech Thesis during the third semester, and findings (if any). Submission will be followed by a seminar and viva-voce.*

M. Tech Project Part - II

Sl. No	Subject code	Subject Name	Total load (h)	Credit	Marks
1	**MM6191**	**M. Tech Thesis Part - II *(Progress Report)***	24	12	300
2	**MM6192**	**Progress Report Seminar & Viva-voce**		6	100

FOURTH SEMESTER

Sl. No	Paper	Credit
1	**M. Tech Final thesis**	**22**
2	**Thesis Seminar & Viva-voce**	**8**
	Total Credit	**30**

Note:

1. *For M. Tech Final thesis, the student will compile the entire work done for the M. Tech Project, along with the findings, in the form of a Thesis and submit at the end of the semester. Thesis submission will be followed by a Thesis seminar and viva-voce.*

M. Tech Project Part – III

Sl. No	Subject code	Subject Name	Total load (h)	Credit	Marks
1	**MM6291**	**M. Tech Final thesis**	**30**	**22**	**400**
2	**MM6292**	**Thesis Seminar& Viva-voce**		**8**	**200**

Total Credit: 21 + 21 + 18 + 30 = 90

Note on Subject Code:

XX: Department Code (AE, CE, ME, etc.); YY: Year(Y)-Semester(Y) (51, 52, 61, 62, etc.);
ZZ: Subject Code (01 to 49 for Theory subjects, 50-99 for practical subjects.
Example: AE5124 [Aerospace Engineering, Fifth Year (PG), First Semester, 24 subject code)

Course Code	MM5101	Course Name	Materials Technology	Course Category	Core	L	T	P
						3	0	0
Course Offering Department		Metallurgy and Materials Engineering		Pre-requisite Courses		NIL		

Module	Syllabus	Duration (h)
Module-I	Classification of engineering materials; Elements of crystallography, Bravais lattice & Miller indices, Atomic packing; Crystal imperfections	06
Module-II	Phase rule, Types and construction of phase diagrams, Free energy-composition diagrams, Lever Rule, Introduction to ternary system	06
Module - III	Fe-C system, steel and cast iron microstructures with phase relations	06
Module -1V	*Solidification*: Homogeneous & Heterogeneous nucleation, Growth; Dendritic solidification; Segregation	06
Module-V	*Diffusion:* Diffusion laws, Kirkendall effect, activation energy, uphill diffusion *etc.*	04
Module -VI	*Solid-state phase transformation:* Nucleation and Growth kinetics, T-T-T and C-C-T diagrams	02
Module - VII	*Diffusional and diffusion less phase transformation processes:* polymorphic transformation, pearlite, bainite and martensite transformations, massive transformation, order-disorder transformation, precipitation, recrystallization	08
	Total contact hours	**40**

Learning Resources	
	Materials Science and Engineering: W.F. Smith, J. Hashemi and R Prakash, McGraw Hill
	The Science and Engineering of Materials, D.R. Asheland, Springer Science
	Fundamentals of Materials Science and Engineering : W.D. Callister, Jr, John Wiley & Sons, Inc.
	Science and Engineering - A First Course, V. Raghavan, PHI

Course Code	MM5102	*Course Name*	Advanced Characterization of Materials	*Course Category*	Core	L	T	P
						3	0	0
Course Offering Department		Metallurgy and Materials Engineering		*Pre-requisite Courses*		*NIL*		

Module	Syllabus	Duration (h)
Module-I	Introduction to Advanced material characterization techniques	01
Module-II	x-ray diffraction pattern analysis: Determination of crystal structure, crystal size, lattice parameter, quantitative phase analysis and defect analysis.	08
Module - III	Advanced optical Microscopy: Interference, Phase contrast, polarized light and near field scanning optical microscopy	04
Module -1V	Electron Microscopes: Scanning Electron Microscopes and Transmission Electron microscopes, Electron diffraction and diffraction pattern analysis	10
Module-V	Scanning probe Microscope : Scanning tunneling microscope,Atomic force microscope, Magnetic force microscope	05
Module VI	Spectroscopy: Principle and application of Energy dispersive spectroscopy, Auger electron spectroscopy, X ray photo electron spectroscopy, x-ray fluorescence spectroscopy, Raman spectroscopy. Fourirer transform Infrared spectroscopy	08
Module-VII	Thermal Characterization techniques: DSC, DTA-TGA, principles and applications	04
	Total contact hours	**40**

Learning Resources	B.D Cullity: **Elements of x- ray diffraction** Yang Leng: **Materials Characterization: Introduction to Microscopic and Spectroscopic Methods** David B Williams, C. Barry Carter: **Transmission Electron Microscopy**

Course Code	MM5103	*Course Name*	Advanced Thermodynamics and Kinetics	*Course Category*	Core	L	T	P
						3	0	0
Course Offering Department		Metallurgy and Materials Engineering		*Pre-requisite Courses*		*NIL*		

Module	Syllabus	Duration (h)
Module-I	Basics of statistical thermodynamics and derivation of thermodynamics quantities	05
Module-II	Laws of thermodynamics, activity, equilibrium constant, application to metallurgical systems.	08
Module-III	Thermodynamics of solutions and phase equilibria.	10
Module-IV	Thermodynamics of electrochemical cells and degradation phenomena.	04
Module-V	Thermodynamics of surfaces, interphases and defects.	04
Module-VI	Basic kinetic laws, rate constants and rate limiting steps.	04
Module-VII	Experimental and theoretical techniques in thermodynamics of materials.	05
	Total contact hours	**40**

Learning Resources	
	Statistical mechanics: A survival guide, A. M. Glazer and J. S. Wark, Oxford University Press.
	Textbook of Materials and Metallurgical Thermodynamics, Ahindra Ghosh, PHI Eastern Economy edition.
	Introduction to the Thermodynamics of Materials, David R. Gaskell, Taylor and Francis.
	A Textbook of Metallurgical Kinetics, Sudipto Ghosh and Ahindra Ghosh, PHI Eastern Economy edition.

Course Code	MM5121	Course Name	Surface Treatment and Modification	Course Category	Departmental Elective	L	T	P
						3	0	0
Course Offering Department		Metallurgy and Materials Engineering		Pre-requisite Courses		NIL		

Module	Syllabus	Duration (h)
Module-I	**Introduction** Conventional Surface Engineering, Types of Surface Modifications, Physical Modifications, Chemical Modifications, Applications of Surface Engineering towards Nanomaterials, Structure, Defects in solids, Bonds and Bands in Materials, Thermodynamics of Materials, Kinetics, Nucleation	04
Module-II	**Vacuum Science and Technology** Kinetic Theory of Gases, Gas Transport and Pumping, Vacuum Technology	06
Module -1II	**Thin-film Evaporation Processes** Physics and Chemistry of Evaporation, Film Thickness Uniformity, Evaporation Processes and Applications	10
Module-IV	**Discharges, Plasma, and Ion-Surface Interactions** Plasma Discharges and Arcs, Fundamentals of Plasma Physics, Reactions in Plasmas, Physics of Sputtering, Ion bombardment modification of growing films	05
Module-V	**Chemical Vapor Deposition** Reaction types, Thermodynamics of CVD, Gas transport, Film growth kinetics, Thermal CVD, Plasma-enhanced CVD	05
Module-VI	**Substrate Surface and Thin-film Nucleation** Atomic view of substrate surface, Thermodynamic aspects of nucleation, Kinetic processes in nucleation and growth	08
	Total contact hours	**38**

Learning Resources	Materials Science of Thin Films by Milton Ohring

Course Code	MM5122	*Course Name*	Mechanical Behaviour of Thin Films	*Course Category*	Departmental Elective	L	T	P
						3	0	0
Course Offering Department		Metallurgy and Materials Engineering		*Pre-requisite Courses*			*NIL*	

Module	Syllabus	Duration (h)
Module-I	Introduction to thin films	1
Module-II	Description of common thin film deposition techniques;	6
Module-III	Film stress and substrate curvature; Stress in anisotropic and patterned films	10
Module- IV	Delamination and fracture; Film buckling bulging and peeling	10
Module-V	Dislocation interactions and strain relaxation	10
Module-VI	Mechanical testing of thin films, including nanoindentation.	5
	Total contact hours	**42**

Learning Resources	M. Ohring, "**Materials Science of Thin Films**" Academic Press, Second Edition. L.B. Freund, and S. Suresh, "**Thin film materials: stress, defect formation and surface evolution**", Cambridge University Press.

Course Code	MM5123	*Course Name*	Advanced Iron and Steel Making	*Course Category*	Departmental Elective	L	T	P
						3	0	0
Course Offering Department		Metallurgy and Materials Engineering		*Pre-requisite Courses*		*NIL*		

Module	Syllabus	Duration (h)
Module-I	Up gradation of raw materials: Washing of Ore & Coal; Advances in Agglomeration of Iron Ores – process control and current innovations. Characteristics of suitable Raw Materials.	03
Module-II	Blast furnace (BF) Iron Making- Design Features of BF and supporting units, viz. Coke Ovens, Stoves, Gas Cleaning Systems. Recent Trends in Iron Making; Gas – Solid and Slag Metal Reactions; Sponge Iron Making.	04
Module-III	Reduction Mechanism and Equilibrium in Carbon-Oxygen System; Slag formation - Chemistry and Characteristics; Reserve Zones, Cohesive Zone and their Importance.	05
Module- IV	Modern trends to Minimize Coke Rate and Emissions; Injection techniques; Blast furnace (BF) Irregularities and Remedies. Treatment of Slag and Outgoing Gas.	04
Module-V	Alternate routes of Iron making - Direct reduced iron (DRI); Gas based and Coal-Based DRI; Hot Briquetted Iron (HBI); Problems and prospects of DRI in India.	04
Module-VI	Steel making: Principles of Refining, Steel making in Basic Oxygen Blown Converters, Kinetics of Reactions and Lance Design.	04
Module-VII	Arc furnace Steel Making - Production of Alloy Steels; Induction Furnace Steel Making: Use of DRI in Steel Making.	03
Module-VIII	Secondary Steel Making - Quality, Continuous Steel Making; Continuous Casting; Vacuum Degassing and Electro Slag Re-melting de-oxidation and de-sulphurization; Vacuum techniques – Re-melting and Refining; Injection Metallurgy.	05
Module-IX	Inclusion removal and its modification. Casting of ingots and Continuous Casting. Defects and Remedies.	04
Module-X	Energy and Environmental aspects in Steel Making, concept of Zero CO_2 Emission.	02
Module-XI	Latest Developments in Iron and Steel Making Processes.	04
	Total contact hours	**42**

Learning Resources	
	An Introduction to Modern Iron Making - R. H. Tupkary
	An Introduction to Modern Steel Making - R. H. Tupkary
	Principles of Blast Furnace Ironmaking: Theory and Practice - A. K. Biswas
	Ironmking and Steelmaking: Theory and Practice - Ahindra Ghosh and Amit Chatterjee

Course Code	MM5124	Course Name	Crystallographic Texture of Materials	Course Category	Departmental Elective	L	T	P
						3	0	0
Course Offering Department		Metallurgy and Materials Engineering		Pre-requisite Courses		NIL		

Module	Syllabus	Duration (h)
Module-I	***Introduction:*** Crystallography, Microstructure and Texture, Description of Grain Orientation and Texture, Development of Texture During Processing, Macro- and Microtexture & Industrial Importance of Texture	3
Module-II	***Representation of Texture:*** Stereographic Projection , Pole Figure .and Orientation Distribution Function (ODF) Method, Description of an Orientation,	4
Module-III	***Experimental Determination of Texture:*** Macrotexture Measurement by X-ray Diffraction and using Synchrotron X-rays ***Microtexture Measurement Techniques:*** Scanning Electron Microscopy-Based Electron Backscattered Diffraction (SEM-EBSD) & Transmission Electron Microscopy-Based Orientation Imaging Microscopy (TEM-OIM)	6
Module- IV	Deformation texture (BCC, FCC& HCP Metals and alloys), Recrystallisation texture, Transformation Texture, Theories of Formation of Recrystallization Textures	5
Module-V	***Texture Evolution in Thin Films:*** Representation of Texture in Thin Films, Texture Measurement in Thin Films, Mechanism of Texture Formation in Thin Films Texture Developed During Various Methods of Film Deposition . .	5
Module-VI	***Textures of Non-metals:*** Textures in Ceramics, Alumina, Zirconia, High Tc Superconductors, Texture in Geological Materials.	4
Module-VII	**Texture and Properties:** Texture Dependence of Mechanical and other Properties: Elastic Modulus, Yield Stress,r-Value, Fracture, Magnetic and Electrical properties, Corrosion and oxidation Oxidation	5
Module-VIII	Texture Control in Some Engineering Materials Texture Control in Cold-Rolled and Annealed Low-Carbon and Intestinal free steels Sheet Steels, Grain-Oriented Silicon Steels, Non-oriented Silicon Steels, Aluminum and Aluminum Alloys ,Ni and Ni Alloys andTexture Control in the Coatings of Industrial Galvannealed Steels	8
	Total contact hours	**40**

Learning Resources	Serope Kalpakjian, "**Manufacturing Engineering and Technology**", Fourth Edition, Addison-Wesley Publishing Co., Boston, 2014. Mikell P. Groover, "**Principles of Modern Manufacturing SI Version**", Wiley India, 2018. ParasuramanSwaminathan, "**Semiconductor Materials, Devices and Fabrication**", Wiley India, 2017. Madou.M.J, "**Fundamentals of micro fabrication: The Science of Miniaturization**, Second Edition", CRC Press, USA, 2002. C. S. Lim, K. F. Leong, C. K. Chua, "**Rapid Prototyping: Principles and Applications**" (3rd Edition), World Scientific Publishing Company, 2009. P. D. Hilton, P.F. Jacobs, "**Rapid Tooling: Technologies and Industrial Applications**", ist Ed., Marcel Dekker, Inc., 2010. Steinar WesthrinKilli, "**Additive Manufacturing: Design, Methods, and Processes**", Pan Stanford Pub., 2017. T. DebRoy et al., Review Article – "A**dditive manufacturing of metallic components – Process, structure and properties**", Progress in Materials Science, Volume 92 (2018), 112-224.

Course Code	MM5161	Course Name	Mechanical Behaviour of Engineering Materials	Course Category	Open Elective	L	T	P
						3	0	0
Course Offering Department		Metallurgy and Materials Engineering		Pre-requisite Courses		NIL		

Module	Syllabus	Duration (h)
Module-I	**Introduction to deformation and failure** Concept of stresses and strains; Engineering and true stresses and strains; Different types of loading and temperatures encountered in engineering applications; Mechanical behaviour and failure of of metals, alloys, ceramics, polymer and composites materials	08
Module-II	**Elastic deformation** State of stress and strain; Principal stress and strain; elastic stress-strain relation; Elastic behaviour of engineering materials	06
Module-III	**Plastic deformation** Hydrostatic and deviatoric stress; Octahedral stress; Effective stress and strain; Yield criteria; Mohr circle; Plastic stress-strain relation;	06
Module- IV	**Mechanisms of plastic deformation** Crystal defects; Dislocation; Geometrical and statistical dislocations; Dislocation multiplication; Dislocation reactions; Slip and twinning; Critical resolved shear stress; Strain hardening; Hall-Petch relationship	10
Module-V	**Fracture** Fracture in engineering materials; Modes and mechanisms of fractures; Linear elastic fracture mechanisms; Elastic-plastic fracture mechanisms; Measurement of fracture toughness	08
Module-VI	**Fatigue** Types of dynamic loading; S-N curves; Classification of fatigue; Fatigue of engineering materials; Mechanisms of fatigue failure; Fatigue life prediction	06
Module-VII	**Creep** Time dependent deformation; Different stages of creep; Creep and stress rupture; Creep mechanisms and maps; Design of materials for high temperature applications	06
	Total contact hours	**42**

Learning Resources	**Deformation and Fracture Mechanics of Engineering Materials**: R.W. Hertzberg, John Wiley and Sons **Mechanical Metallurgy**, G.E. Dieter, McGraw-Hill **Mechanical Behavior of Materials**: M.A. Meyers, K K. Chawla, Cambridge Press **Fatigue of Materials**: S. Suresh, Cambridge Univ. Press **Mechanical Behavior of Materials**: N. E. Dowling, Prentice-Hall. **Fracture Mechanics: Fundamentals and Applications**: T.L. Anderson, CRC Press

Course Code	MM5162	*Course Name*	Multiscale Modelling	*Course Category*	Open Elective	L	T	P
						3	0	0
Course Offering Department		Metallurgy and Materials Engineering		*Pre-requisite Courses*		*NIL*		

Module	Syllabus	Duration (h)
Module-I	Mathematical description of physical phenomena-basics of partial differential equations, statistical techniques and numerical analysis.	10
Module-II	Paradigms of simulations-analytical, physical and data-driven.	03
Module-III	Coupling in multiscale modelling	02
Module-IV	Coarse-graining strategies.	04
Module-V	Uncertainty quantification in multiscale modelling-traditional and Bayesian approaches	10
Module-VI	Case-studies (representative examples, anyone can be chosen): *1.* Integrated Computational Materials Engineering of plasticity in materials. *2.* Multiscale modelling of biological processes (e.g., protein folding)	10
Module-VII	Advanced algorithms in multiscale simulation	01
	Total contact hours	**40**

Learning Resources	**Multiscale materials modelling: Fundamentals and applications**, Z. Xiao Guo, CRC press. **Multiscale Modelling: A Bayesian Perspective**, Springer. **Integrated Computational Materials Engineering (ICME) for Metals: Using multiscale modelling to invigorate engineering design with science**, M.E. Horstemeyer, Wiley.

Course Code	MM5163	*Course Name*	Microstructure Modelling	*Course Category*	Open Elective	L	T	P
						3	0	0
Course Offering Department		Metallurgy and Materials Engineering		*Pre-requisite Courses*		*NIL*		

Module	Syllabus	Duration (h)
Module-I	**Thermodynamics of Phase Transformation:** Solution thermodynamics, Introduction to CALPHAD thermodynamic modelling, Irreversible Thermodynamics	8
Module-II	**Modeling of precipitation:** Nucleation, Diffusion controlled growth, Sharp interface theory, Interface controlled growth, JMAK kinetics, Application in Multiparticle precipitation kinetics.	8
Module - III	**Monte Carlo Potts Model**: Hamiltoninan and dynamics, Ising model, Q-state Potts Model, Application in Grain growth and Recrystallisation	6
Module -1V	**Phase-field Model:** Concept of diffuse interface, Allen-Cahn equation, Multiphase-field model, Diffusion coupled phase-field model, Application in Solidification, Cahn-Hilliard Model for Phase Separation.	12
Module-V	**Cellular Automata:** Basic algorithm of Cellular Automata, Coupling of diffusion, Application in Phase Transformation.	6
	Total contact hours	**40**

Learning Resources	**Computational Materials Engineering** by Koenraad G. F. Janssens, Dierk Raabe, Ernst Kozeschnik, Mark A Miodownik, Britta Nestler; Elsevier. **Continuum Scale Simulation of Engineering Materials** by Dierk Raabe, Franz Roters, Frederic Barlat, Long-Qing Chen; Wiley-VCH. Methods.

Course Code	MM5171	*Course Name*	Materials Technology Lab.	*Course Category*	*Laboratory I*	L	T	P
						0	0	2
Course Offering Department		Metallurgy and Materials Engineering		*Requisite Courses*			*MM0901*	

Module	Syllabus	Duration (h)
Lab. I	***Metallographic Sample preparation -I:*** Sectioning, Mounting, Grinding, Polishing,	03
Lab. I	***Metallographic Sample preparation -II:*** Fine polishing, Electropolishig, Etching	03
Lab. III	**Optical Microscope and micrstructural characterization**	03
Lab. IV	**Microstructure of ferrous materials**	03
Lab. V	**Microstructures of non-ferrous materials**	03
Lab. VI	**Image Analyses**	03
Lab. VII	**Bulk Hardness Testing I**	03
Lab. VIII	**Bulk Hardness Testing II**	03
Lab. IX	**Microhardness Testing**	03
Lab. X	**Impact Testing**	03
Lab. XI	**Tensile Testing**	03
	Total contact hours	**33**

Learning Resources	**Metallographic Specimen Preparation: Optical and Electron Microscopy** ,J. L. McCall, Springer **Metallography Principles and Practice**: G. F. Vander Voort, ASM International **Testing of Metallic Materials:** A. V. K. Suryanarayana, PHI Pub.

Course Code	MM5172	Course Name	Advanced Characterization of Materials laboratory	Course Category	Laboratory II	L	T	P
						0	0	2
Course Offering Department		Metallurgy and Materials Engineering		Requisite Courses			MM0902	

Module	Syllabus	Duration (h)
Lab. I & II	X-ray diffraction pattern analysis: Crystal structure, size and precise lattice parameter determination.	06
Lab. III & IV	Optical microscopy: Sample preparation and microstructural characterization.	09
Lab. V & VI	Electron Microscopes: Scanning Electron Microscopes and Transmission Electron microscopes, Image and diffraction pattern analysis	06
Lab. VII & VIII	Scanning probe Microscope: Scanning tunnelling microscope, Atomic force microscope, Magnetic force microscope demonstration	09
Lab. IX & X	Thermal Characterization techniques: DSC, DTA-TGA demonstration and analysis	06
	Total contact hours	**30**

Learning Resources	B.D Cullity: Elements of x- ray diffraction Yang Leng: Materials Characterization: Introduction to Microscopic and Spectroscopic Methods David B Williams, C. Barry Carter, Transmission Electron Microscopy

Course Code	MM5173	*Course Name*	Mini Project on Materials Technology	*Course Category*	*Laboratory II*	L	T	P
						0	0	3
Course Offering Department		Metallurgy and Materials Engineering		*Requisite Courses*			*NIL*	

Module	Syllabus	Duration (h)
	Course structure to be decided by the concerned faculty member on the basis of the topic selected by the student.	
	Total contact hours	**30**

Course Code	MM5174	*Course Name*	Mini Project on Advanced Characterization of Materials	*Course Category*	*Laboratory II*	L	T	P
						0	0	3
Course Offering Department		Metallurgy and Materials Engineering		*Requisite Courses*			*NIL*	

Module	Syllabus	Duration (h)
	Course structure to be decided by the concerned faculty member on the basis of the topic selected by the student.	
	Total contact hours	**30**

Course Code	MM5175	*Course Name*	Mini Project on Advanced Thermodynamics and Kinetics	*Course Category*	*Laboratory II*	L	T	P
						0	0	3
Course Offering Department		Metallurgy and Materials Engineering		*Requisite Courses*			*NIL*	

Module	Syllabus	Duration (h)
	Course structure to be decided by the concerned faculty member on the basis of the topic selected by the student.	
	Total contact hours	**30**

Course Code	MM5201	*Course Name*	Manufacturing Processes	*Course Category*	Core	L	T	P
						3	0	0
Course Offering Department		Metallurgy and Materials Engineering		*Pre-requisite Courses*		*NIL*		

Module	Syllabus	Duration (h)
Module-I	**Introduction to manufacturing processes** Product design process; Computer-aided design; Selection of materials and manufacturing processes; Interrelation amongst chemistry-processing-property-performance; Computer Integrated Manufacturing; Quality assurance; Total Quality Management; Green manufacturing	02
Module-II	**Metal Casting Processes** Fundamental of metal casting; Cast structure; Casting processes; Sand casting; Permanent mold casting; Rapid solidification; Casting defects	05
Module-III	**Forming and Shaping Processes** Fundamental of metal forming; Hot, warm and cold working; Forming and shaping practices - forging, rolling, extrusion, wire drawing, sheet metal forming; Equipments; Die materials and design; Defects; Residual stresses; Economics of forming	05
Module-IV	**Machining Processes** Mechanics of cutting; Chip formation; Cutting force and power; Turning process; Laths and their operations; Tool materials; Tool wear and failure; Tool life; Machinability	04
Module-V	**Joining Processes** Fundamental of joining; Classification of joining; Fusion welding - Oxyfuel Gas welding, Arc Welding, TIG, MIG; Solid-state joining- Diffusion bonding, Friction stir welding, Resistance welding; Weldibilty; Carbon equivalent; Inspection, quality control and testing;	04
Module-VI	**Processing of non-metals** **Glass working:** Raw materials, melting, shaping, heat treatment and finishing **Plastic shaping:** Extrusion, production of sheet and film, production of fiber and filament, coating processes, injection molding, polymer foam processing and forming **Rubber processing:** Rubber processing and shaping, manufacturing of tires and other rubber products **Case studies**	06
Module-VII	**Non-equilibrium processing** **Thermodynamics and kinetics of metastable phase formation** **Rapid solidification:** methods; constitution and microstructure formation; properties, performance and applications of rapidly solidified materials **Mechanical alloying:** Process; mechanism; consolidation; synthesis of non-equilibrium phases; applications **Chemical Vapor Deposition:** Gas-phase transport and reactivity; Solid phase formation; applications **Physical Vapor Deposition:** Deposition methods; Influence of energy on coating, Applications, future trends **Case studies**	08
Module-VIII	**Processing of Integrated Circuit** **Clean room and Process sequence** **Silicon processing:** raw material; MGS to EGS conversion; Crystal growth, cleaning **Lithography:** Photolithography and other lithography techniques **Oxidation:** Thermal oxidation, kinetics of oxidation, different types of oxidation **Doping:** Diffusion, Ionimplantation **Metallization** **Testing and packaging** **Case studies**	06
	Total contact hours	40

Learning Resources	**Manufacturing Engineering and Technology**, S Kalpakjian and S Schmid, 7th Ed., Pearson **Fundamentals of Modern Manufacturing**, Mikell P. Groover **Materials and Processes in Manufacturing**, DeGarmo, Black, and Kohser, Wiley & Sons, Inc, **Non-equilibrium processing of materials**, C. Suryanarayana **Device Electronics for Integrated Circuit**, R. S. Muller, T. I. Kamins and M. Cha

Course Code	MM5202	Course Name	Design and Selection of Materials	Course Category	Core	L	T	P
						3	0	0
Course Offering Department		Metallurgy and Materials Engineering		Pre-requisite Courses		NIL		

Module	Syllabus	Duration (h)
Module-I	Relationship between processing-structure-properties of various engineering materials	04
Module-II	Materials selection criteria-shape, micro structural factors, performance criteria in service and other strategic requirements of engineering components to be designed. Economic considerations	10
Module-III	Technologically important material properties: physical, mechanical, chemical, thermal, optical and electrical properties	08
Module-IV	Materials used in important engineering sectors	04
Module-V	Types of design, materials data and design tools	05
Module-VI	Methodology for selection of materials for the components, selection of processes to meet the design requirements	05
Module-VII	Systematic selection process-pertinent case studies, Multiple constraints; its handling strategies	04
	Total contact hours	**40**

Learning Resources	**Engineering Design: A materials and processing approach:** George E Dieter. McGraw-Hill Pub. **Materials & Design**: Michael Ashby and Kara Johnson. Elsevier Pub. **Materials and Process Selection for Engineering Design:** Mahmoud M. Farag. CRC Press Pub. **Materials Selection and Design**, Md AbdulMaleque and MohdSapuanSalit, Springer. **Selection and Use of Engineering Materials**: F A A Crane, J A CharlesJ. Furness. Butterworth-Heinemann Pub.

Course Code	MM5203	*Course Name*	Defects in Materials	*Course Category*	Core	L	T	P
						3	0	0
Course Offering Department		Metallurgy and Materials Engineering		*Pre-requisite Courses*		*NIL*		

Module	Syllabus	Duration (h)
Module-I	**Point defects:** Thermodynamics of vacancy,, Effect of radiation on vacancy, Frenkel defect, Schottky defect, Holes in semiconductors, Role of defects in conductivity; Antisite defects, Vacancy diffusion, Interstitial diffusion, Interstitialcy diffusion.	15
Module-II	**Line defects:** Types of dislocations, Burger circuit, Deformation by slip, Glide and Climb of dislocation, Mixed dislocation, Interaction between dislocations, Cottrell atmosphere, Dislocations in nonmetallic crystals	8
Module - III	**Surface defects:** Grain-boundary, Low angle boundary (Tilt and Twist), High angle boundary, Coincident site lattice, Thermally activated migration of boundary, Diffusion through grain-boundary; Stacking fault and partial dislocation; Twin boundaries; Free surface, Wulff plot for equilibrium shape; Antiphase boundaries, Domains in ferroic Materials.	15
Module -1V	**Volume defects:** Voids and inclusion; Effect on the material properties	2
	Total contact hours	**40**

Learning Resources	**Defects in Solids** by Richard J. D. Tilley, Wiley Publishing House. **Physical Metallurgy** by R.W.Cahn and Peter Hassen, North Holland Publisher.

Course Code	MM5221	Course Name	Surface Degradation and Protection	Course Category	Departmental/ Specialisation Elective	L	T	P
						3	0	0
Course Offering Department		Metallurgy and Materials Engineering		Pre-requisite Courses		MM0904		

Module	Syllabus	Duration (h)
Module-I	An introduction: Technical and economic aspect of the study of surface degradation.	2
Module-II	Electrochemical principles of corrosion cell; exchange current density; electrode potential and standard cells, EMF series and galvanic series— their applications, application of Faraday's law in corrosion.	4
Module-III	Thermodynamics of corrosion: Pourbaix diagram constriction and application, Polarization: types, factors involved, effect on degradation rate; Passivation: factor involved, effect on degradation rate	8
Module-IV	Mixed Potential theory; Tafel equation, construction and interpretation of Polarization diagrams.	6
Module-V	Different forms of degradation -uniform attack, galvanic, crevice, pitting, intergranular, selective leaching, erosion corrosion and stress corrosion cracking, Hydrogen effect, corrosion fatigue and microbes induced corrosion. Liquid metal embrittlement-their characteristic features, causes and remedial measures. Surfce degradation testing methods and interpretation of results.	8
Module-VI	High temperature surface degradation — Mechanism to formation films on the surface, Ellingham diagrams, Pilling-Bedworth ratio, and their effects on kinetics, oxide defect structures, rate laws, types of oxidation, materials for use at elevated temperatures.	6
Module-VII	Degradation by wear of materials; its characteristics, wear testing and measurement, Wear-resistant materials	3
Module-VII	Preventive measurement of surface degradation: material selection and design aspects; control of environment including inhibitors, cathodic and anodic protection, coatings and other surface protection techniques of metals and alloys.	4
	Total contact hours	**40**

Learning Resources	**Corrosion Engineering**, 3rd Ed., Mars G. Fontana, McGraw-Hill, Singapore. **Corrosion and its Control**, 3rd Ed., H.H. Uhlig and R.W. Revie, John Wiley, Singapore. **Stress corrosion cracking : Theory and Practice**, V S Raja and T Shoji (eds), Woodhaed Publishing Limited, Oxford. **Corrosion Failures: Theory, Case Studies and Solutions**, K.E. Perumal and V.S. Raja; John Wiley & Sons, USA 2 A.S. Khanna, **Introduction to High Temperature Oxidation and Corrosion**, ASM International, Materials Park, Ohio

Course Code	MM5222	Course Name	Engineering Tribology	Course Category	Departmental/ Specialisation Elective	L	T	P
						3	0	0
Course Offering Department		Metallurgy and Materials Engineering		Pre-requisite Courses		NIL		

Module	Syllabus	Duration (h)
Module-I	**Introduction to Tribology:** Structure of surfaces, Surface topography, Chemical and physical state of the solid surface; Surface Engineering for tribology	04
Module-II	**Fundamental of contact between solid surfaces**	04
Module-III	**Friction and its measurement**	04
Module- IV	**Wear and its measurement:** Classification of wear; Adhesive, Abrasive, Erosive, Cavitation, Corrosive, Oxidative, Fatigue and Fretting Wear	08
Module-V	**Wear of** alloys, polymers and ceramic; Mechanisms of wear; Wear Maps	04
Module-VI	**Lubricant:** Classification of lubricants, Physical properties of lubricants, Lubricants and their composition, Viscosity and its measurements	04
Module-VII	**Hydrodynamic Lubrication:** Frictional force, power loss, mechanism of pressure development, Reynold's equation, Navier-Stokes equation, Coefficient of friction	04
Module-VIII	**Hydrostatic Lubrication:** Hydrostatic step bearings, load carrying capacity, Oil flow through the hydrostatic step bearing	04
Module-IX	**Tribology in practice:** Material selection, Improved design and surface engineering;	04
Module-X	**Design of** (*any one*)- Cutting tool, Low friction surface, Seal	02
Module-XI	**Bio-tribology and Nano-tribology**	02
	Total contact hours	**44**

Learning Resources	**Engineering Tribology:** G. Stachowiak and A. Batchelor, Butterworth-Heinemann **Introduction to Tribology:** B. Bhushan, John Wiley & Sons **Fundamentals of Tribology:** R. Gohar and H. Rahnejat, World Scientific **Friction, Wear, Lubrication:** K.C. Ludema and L. Ajayi, CRC Press

Course Code	MM5223	Course Name	Advanced Ferrous Materials	Course Category	Departmental/ Specialisation Elective	L	T	P
						3	0	0
Course Offering Department		Metallurgy and Materials Engineering		Pre-requisite Courses		MM0906		

Module	Syllabus	Duration (h)
Module-I	**The iron-carbon equilibrium diagram and plain carbon steels:** The iron–carbon equilibrium diagram. The austenite–ferrite transformation. The austenite–cementite transformation. The kinetics of the γ→α transformation. The austenite–pearlite reaction. Ferrite–pearlite steels.	05
Module-II	**The effects of alloying elements on iron–carbon alloys:** γ- and α-phase fields, distribution of alloying elements in steels, effect of alloying elements on the kinetics of the γ/α transformation, structural changes resulting from alloying additions, transformation diagrams for alloy steels.	03
Module-III	**Martensitic transformation:** General characteristics &crystal structure of martensite, crystallography of martensitic transformations, morphology of ferrous martensites**,** kinetics of transformation to martensite**,** strength of martensite, shape memory effect & tempering of martensite.	05
Module- IV	**The bainite reaction:** Introduction, Upper bainite, Lower bainite, The shape change, role of carbon in bainite, Kinetics, transition from upper to lower bainite, Atomic mechanism of bainitic transformation, Granular bainite, Tempering of bainite, Role of alloying elements, Use of bainitic steels, Nanostructured bainite & Acicular ferrite.	05
Module-V	**Low carbon steels:** Batch annealing and continuously annealed formable DD, EDD, IF steels, Precipitation hardened microalloyed steels, Multiphase steels, Advanced high strength steels: Dual-phase steels, TRIP-assisted steels, TWIP steels.	05
Module-VI	**Thermo-mechanical treatment of steels:** Introduction, Controlled rolling of low-alloy steels, Industrial steels subjected to thermo-mechanical treatments.	03
Module-VII	**Structural C-Mn steels:** Weathering steels, Ship Building steels, Line pipe steels & Pressure vessel steels.	04
Module-VIII	**Stainless steels**: Austenitic stainless steels, The iron–chromium–nickel system, Chromium carbide in Cr–Ni austenitic steels Intermetallic precipitation in austenite, Austenitic steels in practical applications, Duplex and ferritic stainless steels, Mechanically alloyed stainless steels & the transformation of metastable austenite.	06
Module-IX	**Specialty steels**: Electrical steels (GO & NGO), Rail steels, Maraging steels &High-Speed tool steels.	07
Module-X	**Cast iron:** Nucleation and growth of graphite in cast iron. Alloying of cast iron. Emerging alloy cast iron of varying morphology of graphite. Effect of microstructure on the properties of alloy cast iron.	07
	Total contact hours	**45**

Learning Resources	**Physical Metallurgy of Steels** - W. C. Leslie **Physical Metallurgy and the Design of Steels** - F. B. Pickering **Steels: Microstructure and Properties** - H. K. D. H. Bhadeshia and R. W. K. Honeycombe **Cast Iron Technology** - Roy Elliott

Course Code	MM5224	Course Name	Advanced Joining Techniques	Course Category	Departmental/ Specialisation Elective	L	T	P
						3	0	0
Course Offering Department		Metallurgy and Materials Engineering		Pre-requisite Courses		NIL		

Module	Syllabus	Duration (h)
	Introduction to advanced joining techniques of similar and dissimilar materials	**2**
Module-I	Explosive Welding and Adhesive Bonding: theory and Key Variables, Parameters, Weld Quality, Equipment and Tooling, Advantages, Limitations and Applications,	4
Module-II	Electron Beam Welding- Background of the Process, Guns, Weld Environment, Welding in Different Degrees of Vacuum, Equipment and Applications, Laser Beam Welding, Physics of Lasers, Types of Lasers, Process Parameters, Applications and Limitations.	6
Module-III	Plasma arc welding: Plasma Arc Welding- theory and Principles, Transferred arc and Non-Transferred arc Techniques, Equipment, Joint Design Advantages, Disadvantages, and Applications, Magnetically impelled arc butt (MIAB) welding, Under Water Welding- Wet and Dry Under Water Welding	6
Module-IV	Vacuum brazing- Theory, Mechanisms and Key Variables, Equipment, Stop-Off and Parting Agents, Advantages, Limitations and Applications.	6
Module-V	Ultrasonic welding-Principles of operation, Process Characteristics and Applications,	2
Module-VI	Diffusion Welding- theory and Principle of Process, Key Variables, Intermediate Materials, Deformation Welding, Equipment, Advantages, Limitations, Materials, Applications, Cold Pressure Welding- Process, Equipment and Setup, Applications	8
Module-VII	Friction Welding- Basic Principles, Process Variants, Different Stages of Friction Welding, Mechanism of Bonding, Influence of Process Parameters, Weld Quality and Process Control, Joining of Dissimilar Materials, Advantages, Limitations and Applications, Friction Stir Welding-Metal flow phenomena, tools, process variables and applications, Friction Stir Processing- Process, Application	8
	Total contact hours	**42**

Learning Resources	**Welding Engineers Hand Book**- ASHE Vol . I, II, III and IV. Parmar R.S., **Welding Processes and Technology**, Khanna Publishers, Delhi Rossi, **Welding Engineering**, McGraw Hill. Schwartz M.M., **Metals Joining Manual**, McGraw-Hill Inc. Udin et al., **Welding for Engineers**, John Wiley & Sons.

Course Code	MM5261	Course Name	Nanostructures and nanomataerials	Course Category	Open Elective	L	T	P
						3	0	0
Course Offering Department		Metallurgy and Materials Engineering		Pre-requisite Courses		NIL		

Module	Syllabus	Duration (h)
Module-I	Introduction to nanostructures and nanomaterials.	01
Module-II	Classification of nanomaterials . Effect of size on the properties of materials and nanomaterials. Microstructural features of nanomaterials. Characterization of nanostructures and nanomaterials.	08
Module - III	Synthesis of Nanomaterials via chemical routes: Chemical precipitation and coprecipitation;Metal nanocrystals by reduction, Sol-gel synthesis; Solvothermal synthesis; Thermolysis, Microwave heating synthesis; Sonochemical synthesis; Electrochemical synthesis; , Photochemical synthesis, Synthesis in supercritical fluids	08
Module -1V	Preparation of Nanomaterials by Physical Methods: Inert gas condensation, Arc discharge, Plasma arc technique, Laser ablation, Ball Milling, Chemical vapour deposition, Electro deposition	06
Module-V	Properties of nanowires, quantum wells and quantum dots	06
Module VI	Carbon nanostructures : Synthesis and properties of fullerenes, carbon nanotubes, Graphene	08
Module-VII	Application of Nanostructures and nanomaterials	01
	Total contact hours	**38**

Learning Resources	**Nanostructures and nanomaterials : Synthesis, properties & applications** by Guozhong Cao **Chemistry of nanomaterials : Synthesis, properties and applications** by CNR Rao et.al.

Course Code	MM5262	Course Name	Microelectromechanical Systems: Materials and Processes	Course Category	Open Elective	L	T	P
						3	0	0
Course Offering Department		Metallurgy and Materials Engineering		Pre-requisite Courses		NIL		

Module	Syllabus	Duration (h)
Module-I	Introduction to microelectromechanical systems (MEMS)	1
Module-II	Materials for MEMS: Common materials used and their properties	5
Module-III	Micromachining techniques: thin-film deposition; lithography; etching; bonding.	10
Module- IV	Process integration; Case Studies; Integration of nanomaterials to MEMS.	6
Module-V	Packaging of MEMS devices; Packaging materials and processes; Case Studies	14
Module-VI	Reliability of MEMS devices; Failure related to materials; Case Studies	8
	Total contact hours	**44**

Learning Resources	S. D. Senturia, "**Microsystem Design**" Springer. N. Maluf, "**An Introduction to Microelectromechanical Systems Engineering**", Artech House A. L. Hartzell, M. G. da Silva, and Herbert R. Shea, "**MEMS Reliability**", Springer M.JMadou, "**Fundamentals of micro fabrication: The Science of Miniaturization**, Second Edition", CRC Press, USA, 2002. Reza Ghodssiand Pinyen Lin (Editors), "**MEMS Materialsand Processes Handbook**", Springer, 2011.

Course Code	MM5263	Course Name	Biomedical Materials and Devices	Course Category	Open Elective	L	T	P
						3	0	0
Course Offering Department		Metallurgy and Materials Engineering		Pre-requisite Courses		NIL		

Module	Syllabus	Duration (h)
Module-I	Basics: Materials and Biology: Metal, Ceramic, Polymer, Composite; Bioresorbale and bioerodable materials	04
Module-II	Biomaterials Surfaces: Physics; Surface Structure and Properties; Surface Energy; Adsorption, Segregation, and Reconstruction at Surfaces; Reactions at surfaces; Protein-Surface Interactions; Host Response to Biomaterials; Cell Adhesion Mechanisms; Coagulation Cascade	08
Module -1II	Testing of biomaterials: In vitro and in vivo assessment; evaluation of blood material interactions; Microscopic techniques; Spectorscopic Techniques	06
Module-IV	Degradation of Materials: Degradation of polymers; Degradation effect on metals and ceramics	04
Module-V	Materials in medicine, biology and artificial organs : Cardiovascular Medical Devices; Implantable Cardiac Assist Devices; Orthopedic Applications; Dental Implantation; Intraocular Lens Implants; Drug Delivery Systems; Biomedical Sensors and Biosensors	12
Module-VI	Case studies : Fiber Optic Biosensors, Nanobarcodes; Drug Delivery: Controlled Release; Mechanical Pumps; Artificial Pancreas, Cartilage, Nerve Regeneration	04
	Total contact hours	**38**

Learning Resources	Ratner, Buddy D., et al. ***Biomaterials Science: An Introduction to Materials in Medicine*** B.Basu, D.Katti and Ashok Kumar; Advanced Biomaterials: Fundamentals, Processing and Applications; John Wiley & Sons, Inc., USA (ISBN: 978-0-470-19340-2), September, 2009.

Course Code	MM5264	Course Name	Non-Destructive Testing	Course Category	Departmental/ Specialisation Elective	L	T	P
						3	0	0
Course Offering Department		Metallurgy and Materials Engineering		Pre-requisite Courses		NIL		

Module	Syllabus	Duration (h)
Module-I	**Fundamentals:** Introduction to destructive and non-destructive testing. Scope and limitations of NDT, Defects in casting, forging, heat-treated and other products namely rolled/machined, welded products etc., Causes of defects.	04
Module-II	**Visual examination**: Methods. Different visual examination aids.	02
Module-III	**Leak and pressure testing of industrial components**: Various methods of pressure and leak testing underlying principles of these testing systems.	03
Module-IV	**Dye penetrant method**:Liquid penetrant testing – procedure; penetrant testing materials, penetrant testing method – sensitivity; application and limitations.	04
Module-V	**Magnetic particle testing**: Definition and principle; magnetizing technique, procedure, equipment, sensitivity and limitations.	04
Module- VI	**Ultrasonic methods**: Basic principles of wave propagation, types of waves, methods of UT, their advantages and limitations. Various types of transducers. Calibration methods, use of standard blocks. inspection methods, technique for normal beam inspection, flaw characterization technique, ultrasonic flaw detection equipment, modes of display, Characterization of defects in castings, forgings, rolled and welded products by UT. Thickness determination by ultrasonic method. Study of A, B and C scan presentations. immersion testing, advantage, limitations; acoustic emission testing – principles of AET and techniques.	10
Module-VII	**Radiographic testing of components**: X-ray and Gamma-Ray radiography. Their principles, methods of generation. Industrial radiography techniques, applications, limitations. Types of films, screens and penetrameters. Interpretation of radiographs. Real time X-ray radiography. Safety in industrial radiography.	05
Module-VIII	**Electrical and thermal methods of NDT**: Conductivity & resistivity methods and their applications. Eddy current testing. Principle, instrument, techniques, sensitivity, application, limitation,Thermal method: principle, equipment, advantages and limitations.	05
Module-IX	**Advanced methods of NDT**: Holography, Tomography, MRI etc.	04
Module-X	**Selection of NDT Methods**: VI, LPT, MPT, ECT, RT, UT, AET and thermography; reliability in NDT.	04
	Total contact hours	**45**

Learning Resources	A. V. K. Suryanarayana: **Testing of Metallic Materials**. PHI Pub. Baldev Raj, T. Jayakumar, M. Thavasimuthu: **Practical Non-Destructive Testing**. Narosa Pub. House. Ravi Prakash: **Non-Destructive Testing Techniques**. New Age International Pub. ASM Metals Handbook (Vol. 17): **Non-Destructive Evaluation of Materials**. American Society of Metals, Metals Park, Ohio, USA. Paul E. Mix**: Introduction to Non-destructive Testing**: A Training Guide. Wiley Pub.