NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

SCHEME OF INSTRUCTION AND SYLLABI

for M.Tech. Industrial Metallurgy 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 furnished with the state-of-the-art equipment.

Brief about the Programme:

A post-graduate program with 'Industrial Metallurgy' specialization was introduced in the year 1983. The current intake of students into the programme is 20. This programme offers in-depth knowledge about Physical Metallurgy, Extractive Metallurgy (Design & production of Iron & Steel), 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. The post-graduate studies curriculum has been carefully designed to provide the student with the right mix of tools, techniques, theory, and applications. The students are exposed to the core and advanced areas of metallurgy during the first two semesters. Students will study compulsory and elective courses to enhance their knowledge and understanding of the field. The curriculum also involves a significant research component where the student will get a chance to carry out high-end research work under the guidance of faculty experts. This dissertation work will be carried out in the third and fourth semesters. The department is equipped with state-of-the-art laboratories and provides hands-on experience in different material processing and characterization techniques. Students will get the opportunity to work on research projects sponsored by other government organizations and industries in India. The opportunity to work for 2nd year dissertation as a part of ongoing development projects at various government and corporate organizations provides exposure to the latest developments in the field of metallurgy and to top-notch research facilities.

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/

M. Tech. Industrial Metallurgy

Program Educational Objectives

PEO1	Design and develop metallurgical and manufacturing systems to fulfil industrial and societal needs.
PEO2	Address issues related tomaterials degradation, environmental concerns with a focus on sustainable growth.
PEO3	Practise industrial standards, safety measures and frame new guidelines for metallurgical industries.
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

MTech Industrial Metallurgy:

Program Outcomes (POs)

PO1	Perform independent research and development to provide cost effective solutions to industrial problems.
PO2	Write and present professional and technical reports efficiently.
PO3	Demonstrate professional skills in advanced manufacturing and processing techniques relating to industrial metallurgy.
PO4	Apply thermodynamics and kinetics of metallurgical processes in ferrous and nonferrous industries.
PO5	Assess life of industrial components and implement sustainable measures for their life enhancement.
PO6	Practice industrial standards, professional ethics and project management skills.

SCHEMEOFINSTRUCTION

M. Tech. (INDUSTRIAL METALLURGY) Course Structure

IYear–ISemester

S.No	Course code	Coursetitle	L	T	P	Credits	Cat. code
1	MM5101	Advanced Casting andWeldingTechnology	3	0	0	3	PCC
2	MM5102	AdvancedPowder Processing	3	0	0	3	PCC
3	MM5103	Advanced FerrousProductionTechnology	3	0	0	3	PCC
4		**Elective I**	3	0	0	3	PEC
5		**ElectiveII**	3	0	0	3	PEC
6		**ElectiveIII**	3	0	0	3	PEC
7	MM5104	Advanced Casting andWeldingTechnology Laboratory	0	1	2	2	PCC
8	MM5105	Advanced PowderProcessingLaboratory	0	1	2	2	PCC
9	MM5148	SeminarI	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	MM5151	Advanced Experimental Techniques	3	0	0	3	PCC
2	MM5152	AdvancedMetalWorking	3	0	0	3	PCC
3	MM5153	AdditiveManufacturing	3	0	0	3	PCC
4		**ElectiveIV**	3	0	0	3	PEC
5		**ElectiveV**	3	0	0	3	PEC
6		**ElectiveVI**	3	0	0	3	PEC
7	MM5154	Advanced ExperimentalTechniquesLaboratory	0	1	2	2	PCC
8	MM5155	MaterialsTestingandMetalWorkingLaboratory	0	1	2	2	PCC
9	MM5198	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	MM6147	ComprehensiveVivaVoce				2	CVV
2	MM6149	DissertationPart A				12	DW
		Total				**14**	

IIYear –IISemester

S.No	Course code	Coursetitle	L	T	P	credits	Cat. code
1	MM6199	DissertationPart 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					
CategoryCode	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	MM5111	NonDestructiveTesting
2	MM5112	IndustrialHeatTreatment
3	MM5113	TextureofMaterials
4	MM5114	CorrosionEngineering
5	MM5115	MaterialsRecycling andWasteManagement
6	MM5116	WearofEngineeringMaterials
7	MM5117	Nanotechnology
8	MM5118	Computational Approaches in Materials Engineering
9	MM5119	FractureandFailureAnalysis
Elective – IV, V, VI (I Year, II Semester)		
1	MM5161	SurfaceEngineeringandCoatingTechnology
2	MM5162	CompositeMaterials
3	MM5163	SpecialSteels
4	MM5164	AdvancedNon FerrousProductionTechnology
5	MM5165	RareandReactiveMetal Extraction
6	MM5166	NuclearTechnology
7	MM5167	ProcessModellingandSimulation
8	MM5168	SafetyManagementandPollutionControl
9	MM5169	StatisticalQualityControlandManagement

DETAILED SYLLABUS

M.Tech. - Industrial Metallurgy

Course Code: MM5101	ADVANCED CASTING AND WELDING TECHNOLOGY	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 fundamental concepts of patterns, molding and casting
CO2	Differentiate working principles of welding processes
CO3	Analyze metallurgical aspects of welding and casting processes
CO4	Employ inspection methods for quality assurance of cast and weld components

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Casting: Types of foundries, different steps, allowances of patterns; moulding materials; testing of sand, gating and risering, die casting, investment casting, squeeze casting, different types of melting furnaces; solidification, casting defects and remedies, inspection and quality control, CAD modelling and simulation of castings.

Welding: Different types of welding processes; heat flow, fusion zone boundaries, temperature distribution & cooling rate effect on weldment, weld solidification, weld metal nucleation, grain structure control, welding parameters, effect of travel speed,phase transformations during welding, factors influencing residual stresses, PWHT, dilution,weldability of low alloy steels, welding of stainless steels, Welding of Al, Mg, Ti and Ni alloys, welding of ceramics and composites, Joining of thin and thick sections, welding of dissimilar materials, welding defects and its remedy, weldability tests.

Text Books:

1. R.A. Flinn: Fundamentals of Metal casting, Addison Wesley, 1963.
2. R.W. Heine, C.R. Loper, P.C. Rosenthal: Principles of Metal Casting, Tata McGraw-Hill Education, 2001.
3. Cary, Howard B. and Scott C. Helzer, Modern Welding Technology. Upper Saddle River, New Jersey: Pearson Education, USA, 2005.
4. G.E. Linnert: Welding Metallurgy, Vols I-II, 4th Ed, AWS, 1994.
5. Sindo Kou: Welding Metallurgy, 2nd Ed, John Wiley & Sons, 2002.
6. H Granjon: Fundamentals of Welding Metallurgy, Jaico Publishing House, 1994.
7. Kenneth Easterling: Introduction to Physical Metallurgy of Welding, 2nd Ed, Butterworth Heinmann, 1992.
8. M.D. Jackson: Welding Methods and Metallurgy, Griffin, London, 1967.
9. R.S. Mishra, M.W. Mahoney: Friction Stir Welding and Processing, ASM, 2007.

Reference Books:

1. Welding Handbook, Vol 2- Welding Processes, 9th Ed, AWS, 2004.
2. ASM International Handbook Committee. ASM Handbook, Volume 15-Casting. ASM International., 2008.

Online Resources:

1. https://www.twi-global.com/technical-knowledge/faqs/what-is-welding

2.

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: MM5103	ADVANCED FERROUS PRODUCTION TECHNOLOGY	Credits 3-0-0: 3

Pre-Requisites: None

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

CO1	Explain iron ores used for extraction and ore beneficiation techniques
CO2	Discuss the iron extraction and steel making techniques from iron ores.
CO3	Discuss the steel ingots and semi-finished products production.
CO4	Analyse the modern processing techniques of alternative iron production
CO5	Describe the physico-chemical processes occurring in secondary iron and steel making.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Iron and steel production techniques, Burden Preparation and requirements. Blast Furnace Iron production and its limitations, Thermodynamic and kinetic aspects in iron making. Steel making, Alternative iron making: Sponge Iron Processes- HYL, SL/RN, Midrex, HIB and Fluidised bed Processes, Smelt reduction Processes- COREX, INRED and ELRED and mini blast furnaces, modern steel making processes, Physical Chemistry of steel making, Deoxidation, Secondary Steel Making processes. Modern trends in steel making.

Text Books:

1. R.H. Tupkary, V.R. Tupkary, Modern Iron making handbook, MLI Handbook Series, 2017.
2. C. Bodsworth, Physical Chemistry of Iron and Steel manufacture, Metallurgy and Metallurgical Engineering Series, 2014.
3. A. K. Biswas: Principles of Blast Furnace Iron Making- Theory and Practice, SBA Publications, 1984.
4. Amit Chatterjee: Beyond the Blast Furnace, CRC Press, 1992.
5. Amit Chatterjee: Hot Metal Production by Smelting Reduction of Iron Oxide, PHI Learning Pvt. Ltd. New Delhi, 2010.
6. A K Chakravorthi: Steel Making, Prentice-Hall of India Pvt Ltd., New Delhi, 2007.
7. Ahindra Ghosh, Amit Chatterjee: Iron Making and Steel Making - Theory and Practice, Prentice-Hall of India Pvt. Ltd, New Delhi, 2008.

Course Code: MM5104	ADVANCED CASTING AND WELDING LABORATORY	Credits 0-1-2: 2

Pre-Requisites:MM5101 – Advanced Casting and Welding Technology

Course Outcomes:

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

CO1	Determine moulding sand properties
CO2	Demonstrate the preparation of moulds and melting practice
CO3	Demonstrate material joining by gas welding, manual metal arc welding, submerged arc welding, resistance welding techniques
CO4	Evaluate microstructure and mechanical properties of weldments

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Sand Testing:

Green and dry strength testing, determination of permeability, shatter index, clay content, moisture content, cured transverse strength of shell sands.

Mould preparation:

Mould hardness testing.

Demonstration of Melting and casting:Casting of metals using induction furnace, casting of metals using vacuum arc melting furnace, casting of metals using resistance heating furnace.

Welding:Preparation of weld joint using gas welding, manual metal arc welding, submerged arc welding; resistance welding; heat input calculation in arc welding; preparation of all weldtensile test specimen and characterization of weldments, study of microstructure of fusion zone, heat affected zone and base metal of the welded specimen, determine the tensile strength and ductility of a weld as per ASTM standards.

Text Books:

1. Casting and Welding Laboratory manual
2. Cary, Howard B. and Scott C. Helzer, Modern Welding Technology. Upper Saddle River, New Jersey: Pearson Education, USA, 2005.

Reference Books:

1. Welding Handbook, Vol 2- Welding Processes, 9th Ed, AWS, 2004.
2. ASM International Handbook Committee. ASM Handbook, Volume 15-Casting. ASM International., 2008.

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: MM5148	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 technological advances related to the metallurgical and materials industry
CO2	Evaluate the available literature
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					1
CO2	3					1
CO3	1	3				1
CO4	2	3				1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Any topic of relevance to industrial metallurgy 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: MM5151	ADVANCED EXPERIMENTAL TECHNIQUES	Credits 3-0-0: 3

Pre-Requisites:None

Course Outcomes:

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

CO1	Demonstrate the principle and operation of electron microscopes
CO2	Explain the operation of dilatometers and interferometers for the characterization of materials
CO3	Analyze images of optical and electron microscopes
CO4	Make use of suitable specimen preparation technique for a particular characterization method
CO5	Distinguish suitable thermal analysis techniques for different purposes

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to stereomicroscopy and its applications,Basic introduction about transmission electron microscope (TEM): Comparison with optical microscope and X-ray diffraction, Properties of electrons, electron beam-specimen interaction, Design of electron microscope: signal detectors, electron lenses, resolving power, image formation, arrangement for microscopy and diffraction. Specimen preparation and image interpretation: case studies. Field Emission Microscope. Scanning electron microscope (SEM), principles of microprobe analysis. principles of microprobe analysis, Introduction to EBSD.Thermal analysis of phase transformations: ordinary thermal method, inverse rate curves, differential thermal analysis, derived differential thermal analysis, thermal analysis at high temperatures, thermal analysis with rapid heating and cooling. Thermogravimetric analysis: TG design and experimental concerns. Cahn microbalance operation. Simultaneous thermal analysis. Dilatometry: Single push rod dilatometer, dual push rod dilatometer, calibration. Interferometry: Principles, Michelson interferometer, dilatometric interferometer. Growth of single crystals by zone melting.

Text Books:

1. Thermal Analysis of Materials, Robert F Speyer, Marcel Dekker, 1994
2. Characterization of Materials, Kauffmann, Vol. I and II, John Wiley, 2005
3. Materials Characterization, ASM Handbook, Vol. 10, ASM, 2004

Course Code: MM5152	ADVANCED METAL WORKING	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 stress-strain relationship.
CO2	Describe deformation behaviour, yield criteria and metal working.
CO3	Differentiate metal forming processes of forging, rolling, extrusion, and drawing.
CO4	Classify defects of forging, rolling, extrusion and drawing.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Stresses/Strains: Review of two dimensional stress and strain, state of stress in three dimensions, Stress tensor, Invariants, Mohr's circle for 3-dimensional state of stress, strain at a point Mohr's circle for strain, Hydrostatic & Deviatory components of stress, Elastic stress strain relations.

Elements of theory of plasticity; Flow curve, True stress & true strain, Yield criteria for ductile metals, Von Misses & Teresa yield criteria, combined stress tests. The yield locus, Anisotropy in yielding, Classification of forming processes variables in metal forming and their optimization, Flow stress determination, Hot working, Cold working, Strain rate effect, Friction and lubrication, Deformation zone geometry, Workability, Residual stresses.

Forging: Classification of Forging Processes, Forging Equipment, Forging in Plane Strain, Open-Die Forging, Closed-Die Forging, Calculation of Forging Loads in Closed-Die Forging, Forging Defects, Residual Stresses in Forgings

Rolling: Classification of Rolling Processes, Rolling Mills, Hot-Rolling, Cold-Rolling, Rolling of Bars and, Shapes, Forces and Geometrical Relationships in Rolling, Simplified Analysis of Rolling Load: Rolling Variables, Problems and Defects in Rolled Products, Rolling-Mill Control, Theories of Cold-Rolling, Theories of Hot-Rolling, Torque and Power

Extrusion: Classification of Extrusion Processes, Extrusion Equipment, Hot Extrusion, Deformation, Lubrication, and Defects in Extrusion, Analysis of the Extrusion Process, Cold Extrusion and Cold-Forming, Hydrostatic Extrusion, Extrusion of Tubing, Production of Seamless Pipe and Tubing, Equal channel angular extrusion/pressing (ECAP).

Drawing: Introduction, Rod and Wiredrawing, Analysis of Wiredrawing, Tube-Drawing Processes, Analysis of Tube Drawing. Residual Stresses in Rods, Wires, and Tubes. Deep Drawing, Forming Limit Criteria and Diagrams, Defects in Formed Parts

High Energy Rate Forming (HERF) Processes: Principle / important features of HERF processes, Advantages of HERF Processes, Limitations, Applications, Explosive Forming, Electro hydraulic Forming, Electromagnetic forming

Defects in forged, rolled, extruded, drawn and formed parts and their remedies.

Text Books:

1. G.E. Dieter, Mechanical Metallurgy, 3rd Edition, McGraw Hill, New York, 2013.
2. C. J. Richardson, Worked Examples in Metal Working, Institute of Metals, London, 1985.

3. Surender Kumar, Principles of Metal Working, 2nd Edition, Oxford & IBH, 2001.

Reference Books:

1. ASM Hand Book, Vol. 14: Forming and Forging, ASM International, 2012.

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: MM5154	ADVANCED EXPERIMENTAL TECHNIQUES LABORATORY	Credits 0-1-2: 2

Pre-Requisites:MM5151 - Advanced Experimental Techniques

Course Outcomes:

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

CO1	Practice thermal analysis techniques for the determination of various characteristics.
CO2	Apply microscopic techniques for microstructural analysis and interpretation of images
CO3	Interpret the fracture surfaces and perform chemical analysis
CO4	Analyze X-ray diffraction data

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

1. Quantitative image analysis of phase fraction, grain size, nodularity and nodule countas per ASTM standards.
2. Calculation of structure factor for different crystal structures.
3. Determination of crystal structure by X-ray Diffraction (XRD)
4. Determination of lattice parameter by XRD
5. Determination of crystallite size by XRD
6. Determination of lattice strain of a deformed sample using XRD
7. Fractography analysis using Scanning electron microscopy (SEM)
8. Determination of inter-lamellar spacing of pearlite using SEM
9. Chemical analysis using energy dispersive X-ray analysis in SEM (spot and line analysis).
10. Determination of glass transition temperature and a melting point of a given polymer
11. Study of TGA, DSC, and DMA
12. Determination of welding defects through NDT technique

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.
3. B.D. Cullity, S.R. Stock, “Elements of X-Ray Diffraction”, Pearson; 3 edition, 2001

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.

Course Code: MM5155	MATERIALS TESTING AND METAL WORKING LABORATORY	Credits 0-1-2: 2

Course Outcomes:

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

CO1	Perform hardness tests for the qualitative evaluation of materials
CO2	Perform tensile, compression and impact testing on industrial materials
CO3	Demonstrate creep and stress rupture test and their implications
CO4	Interpret mechanical testing data and evaluate properties

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Hardness test, Tensile test, Compression test, Impact test, Microhardness and indentation fracture toughness test, Nanoindentation, Fracture toughness test, Fatigue testing, Creep and Rupture tests, Effect of strain rate studies on mechanical properties.

Perform rolling of copper, brass, stainless steel and plain carbon steel using laboratory rolling mill, mechanical properties and microstructural change of cold-worked metals, Annealing of cold-worked metal and microstructural changes.

Text Books:

1. G.E. Dieter, Mechanical Metallurgy, 3rd Edition, McGraw Hill, New York, 2013.
2. C. J. Richardson, Worked Examples in Metal Working, Institute of Metals, London, 1985.
3. ASM Hand Book, Vol. 14: Forming and Forging, ASM International, 2012.
4. Surender Kumar, Principles of Metal Working, 2nd Edition, Oxford & IBH, 2001.
5. Lab Manual.

Course Code: MM5198	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 process industries
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			1
CO4	2	3	1			1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Any topic of relevance to industrial metallurgy 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: MM5111	NON DESTRUCTIVE TESTING	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 basic principles of non-destructive testing (NDT) methods
CO2	Differentiate between NDT methods
CO3	Identify suitable surface NDE methods for defect detection
CO4	Evaluate defects in engineering components using NDT methods

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Introduction to NDT, need and advantages of NDT, Classification of NDT processes; Visual inspection – aided and unaided visual inspection.

Eddy Current Testing and Liquid penetrant testing: Principle, Influencing factors, Equipment used, Advantages, Limitations and applications of eddy current testing; Liquid penetrant testing - Principle, Characteristics, Precautions, Penetrant materials, Advantages, Limitations and applications.

Magnetic Particle Testing: Principle, Procedure, Magnetic media, Methods to generate magnetic fields, Method of De-Magnetization, Interpretation of indications, Advantages, limitations and applications.

Radiographic Testing: Principle, Gamma radiography, X-ray radiography and Neutron radiography, Imaging modalities, Radiograph Interpretation, Precautions against radiation hazards.

Ultrasonic Testing and Acoustic Emission Testing: Principles of ultrasonic testing, Ultrasonic propagation, Test techniques – normal and angle beam, Probes, Transducers, Applications, Advantages and limitations of ultrasonic testing.

Acoustic emission testing – principle, sources of acoustic emission, acoustic emission signal parameters, industrial applications

Other NDT Techniques: Ground penetrating radar, Guided wave testing, Laser testing methods, Microwave testing methods, Thermal/infrared testing

Text Books:

1. Practical Non-Destructive Testing, Baldev Raj, T.Jayakumar, M.Thavasimuthu, Narosa Publishing House, 2014.
2. Non-Destructive Testing Techniques, Ravi Prakash,New Age International Publishers, 2010, 1st revised edition.

Reference Books:

1. Non-Destructive Testing - Theory, Practice and Industrial Applications, Wong B StephenLAP
2. Lambert Academic Publishing, USA, 2014,1st edition
3. Non Destructive Test and Evaluation of Materials, J. Prasad and C. G. K. Nair,Tata McGraw-Hill Education, 2011, 2nd edition.

4. ASM Metals Handbook,Non-Destructive Evaluation and Quality Control, American Society of Metals, Metals Park, Ohio, USA, Volume-17.
5. Charles, J. Hellier, Handbook of Nondestructive Evaluation, Charles, J. Hellier, McGraw Hill, New York, 2001.
6. Paul E Mix, Introduction to Non-destructive testing: a training guide, Wiley, 2nd Edition New Jersey, 2005

Online Resources:

1. www.ndt.edu
2. www.nde-ed.org

Course Code: MM5112	INDUSTRIAL HEAT TREATMENT	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 of phase transformations in the heat treatment industry
CO2	Design a heat treatment process to achieve the desired property in engineering materials
CO3	Identify defects arising due to heat treatment of ferrous and non-ferrous materials
CO4	Apply surface hardening techniques to enhance the life of components

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Basic of Heat treatment (HT) and its position in the industry with goals, HT cycle, Importance of The Fe-Fe3C binary phase diagram in HT of steels and cast irons, Effect of Austenitic grain size, TTT and CCT plots, Annealing, Normalising, Hardening, Tempering, age hardening, Subzero treatment, Austempering, Martempering, Defects arising due to heat treatment, Importance of Hardenability; HT of steels, HSLA steels, Tool steels, Die casting steels, Cast Iron, Stainless Steel, Maraging steel, Al alloys, Ti alloys and Superalloys, Thermal and Thermochemical Treatments, Study of HT furnace design, Quality control of heat treated samples, Diffusion kinetics of heat treatment processes.

Text Books:

1. Engineering Physical Metallurgy, Y. Lakhtin, Mir Publishers, 6th ed., 1977.
2. Heat Treatment of Metals, B. Zakharov, Mir Publishers, 1st ed., 1998.
3. Introduction to Physical Metallurgy, S.H. Avener, Tata McGraw-Hill Education, 2nd ed., 2011.
4. Materials science and Engineering: An Introduction, W.D. Callister, D.G. Rethwisch, Wiley Publisher, 8th ed., 2010.
5. ASM, Metals Hand Book: Heat Treating, Vol. 4, 9th Ed., Metals Parks, Ohio.
6. Heat Treatment: Principles and Techniques, T.V. Rajan, C.P Sharma, Ashok Sharma, Prentice Hall India Learning Private Limited, 2nd ed., 2011.

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 correct 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 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: MM5114	CORROSION ENGINEERING	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 mechanisms of corrosion in engineering components
CO2	Explain the influence of metallurgical structure and environment on corrosion
CO3	Assess the corrosion behaviour of engineering materials
CO4	Suggest methods to mitigate corrosion

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Corrosion cost and economics, electrochemical thermodynamics and electrode potential: EMF series, free energy determinations, Pourbaix diagram of commercial important metals, kinetics: types of polarization, mixed-potential theory, polarization curve, evaluation of corrosion rate, corrosion measurements, Galvanic cells and electrode potential, effects of metallurgical structure on corrosion, forms of corrosion, high temperature corrosion and oxidation, erosion corrosion – environmental variables, cavitation, fretting corrosion, erosive and corrosive wear, corrosion of ceramics, laboratory assessment of corrosion: linear polarisation techniques, Tafel extrapolation, oxidation, free energy-temperature diagrams, corrosion control: materials selection and design, protective coatings, inhibitors, passivators, electrical methods.

Text Books:

1. Denny A Jones, Principles and Prevention of Corrosion 2Ed., Pearson, 2014
2. R. D. Angel, Principles and Prevention of Corrosion, Narosa, 2010
3. Mars Guy Fontana: Corrosion Engineering, Tata McGraw-Hill Education, New York, 2005.
4. H.H. Uhlig, R. Winston Revie: An Introduction to Corrosion and Corrosion Engineering, 4th Ed, John Wiley & Sons, 2008.
5. Philip A. Schweitzer, Fundamentals of Metallic Corrosion: Atmospheric and Media Corrosion of Metals, CRC Press, 2006
6. Ronald A. McCauley, Corrosion of Ceramic Materials 3 Ed., CRC Press, 2017

Course Code: MM5115	MATERIALS RECYCLING AND WASTE MANAGEMENT	Credits 3-0-0: 3

Pre-Requisites: None

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

CO1	Identify types and sources of materials waste.
CO2	Describe methods of recycling engineering materials.
CO3	Suggest a suitable energy-saving technique for industries.
CO4	Analyze the economic, social and environmental impact of materials waste and its recycling.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Introduction to recycling of materials, statistics on materials recycling, recycling chain, principles of recycling, Economical, technological and environmental aspects of materials recycling.

Recycling of Materials: Recycling metals and rare-earth metals, polymers, composites, electronic wastes, nuclear materials and nuclear wastes, recycling of (lead-acid, lithium-ion) batteries,recovery from lean sources.

Materials wastes: Primary and secondary solid wastes in metallurgical and powder industry, Wastes from polymer and ceramic industries, Nuclear waste.

Waste Management: Economic uses of solid waste such as B.F. slag and fly ash & wastes from metallurgical and materials industry.

Energy saving: Alternative routes of processing of materials for energy saving, Role of optimal selection of materials processing route, Conservation through protection of materials against decay, Waste heat recovery methods.

Environmental Protection: General concepts of environment, toxicology of materials, Stack gases of Electric Arc Furnaces and industrial production processes.

Text Books:

1. Ernst Worrell, Markus Reuter (Eds): Handbook of Recycling, Elsevier, 2014.
2. Donald L Stewart, James C Delay, Robert L Stephens: Recycling of Metals and Engineered Materials (Proceedings of the fourth international symposium), TMS Publications, 2000.
3. S. Ramachandra Rao, Resource recovery and recycling from metallurgical wastes, Elsevier, 2006.
4. Hugo Marcelo Veit, Andrea Bernardes (Eds): Electronic Waste- Recycling Techniques, Springer, 2015.
5. M. Kutz, Environmentally conscious materials and chemicals processing, John Wiley & Sons, 2007.
6. Subramanian Senthilkannan Muthu (Ed): Environmental Implications of Recycling and Recycled Products, Springer, 2015.

Reference Books:

1. F. Woodard, Industrial waste treatment handbook: Butterworth-Heinemann, 2001.
2. H.F. Lund, Recycling Handbook, 2nd Edition, McGraw-Hill, 2000.

Course Code: MM5116	WEAR OF ENGINEERING MATERIALS	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 issues related to the wear of engineering materials
CO2	Identify the types of wear and their mechanisms
CO3	Employ techniques for combating wear to enhance the service life of engineering components
CO4	Investigate the worn-out surfaces using suitable characterization techniques

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Tribology and wear, industrial importance of wear, wear classification
Sliding wear, mechanism, variables, sliding wear of metallic and non-metallic materials, wear maps, test method

Wear by abrasion: Types, models of abrasion, Factors affecting abrasive wear, abrasive behaviour of engineering materials, abrasive wear testing, abrasion-resistant materials

Wear by erosion: Models of erosion, factors affecting erosion, erosion behaviour of engineering materials, erosion resistant materials.

Friction: Friction and laws of friction, frictional behaviour of meals and non metallic materials. Protection techniques of materials against Wear.

Wear characterization techniques, Miscellaneous forms of wear, Lubrication, types, Liquid and solid lubricants

Text Books:

1. I.M. Huchings: Tribology, Friction and wear of Engineering Materials; Butterworth & Heinemann, 1992.
2. R.D. Arnell, P.B.Davies; Tribology - Principles and Design Applications; Spriger Verlag, 1991.
3. A.S.M. Handbook : Friction, Lubrication Wear and Tribology (Vol. 18); ASM.
4. J. Takadoum : Materials and Surface Engineering in Tribology, John Wiley & Sons, 2007.

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 Limited 2013.
2. Sulabha K. Kulkarni: Nanotechnology Principles and Practices, Capital Publishing Company, 2007.
3. H. Hosono, Y. Mishima, H. Takezoe, K.J.D Mackenzie: Nanomaterials- From Research to Applications, Elsevier, 2008.
4. Massimilano Di Ventra, S. Evoy, James R. Heflin Jr: Introduction to Nanoscale Science and Technology, Springer, 2009.
5. Charles P. Poole Jr., Frank J. Owens: Introduction to Nanotechnology, Wiley India, New Delhi, 2010.
6. 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	
CO3			2			
CO4		1	2			

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. Application of artificial neural network 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: MM5119	FRACTURE AND FAILURE ANALYSIS	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 importance of fracture mechanics in the failure of engineering components
CO2	Differentiate the modes of fracture and failure mechanisms
CO3	Summarize tools for failure analysis
CO4	Criticize reasons for the failure of engineering components

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Fracture: Toughness and fracture mechanics, Linear-Elastic Fracture Mechanics, Elasto Plastic Fracture Mechanics, Modes of Loading, Plain Stress and Plain Strain, Factors affecting fracture toughness, Subcritical Crack growth -The Fracture Mechanics Approach to Fatigue, Fracture toughness testing, Application of fracture Mechanics, Fracture Control.

Tools and Techniques of Failure Analysis: Procedure for Failure Analysis, Investigative Techniques, Normal Location of Fracture, Questions to Ask about Fractures.

Basic Single-Load Fracture Modes: Shear Mode, Cleavage Mode, Other Fracture Modes, Factors Affecting the Ductile Brittle Relationship.

Stress Systems Related to Single-Load Fracture of Ductile and Brittle Metals: Pure Loading Systems, Tension Loading, Torsional Loading, Compression Loading, Bending Loading, cyclic loading.

Types of failures: Ductile, Brittle, Fatigue, Creep, Corrosion, Wear etc., fractography, mixed mode and fatigue failures,

Failure mechanisms, Embrittlement phenomena, environmental effects, Failures due to faulty heat treatments, Failures in metal forming and welding,

Case studies in failure analysis, Prevention of failures, case histories of component failures.

Text Books:

1. A.J. McEvily, J. Kasivitamnuay, Metal Failures: Mechanisms, Analysis, Prevention, Wiley-Interscience, 2013.
2. S. Suresh: Fatigue of Materials, 2nd Ed., CUP, 1998.
3. D. Broek: Elementary Engineering Fracture Mechanics, 3rd Rev. Ed., Springer, 1982.

Reference Books:

1. ASM Metals Hand Book, Vol 11: Failure Analysis and Prevention, ASM, 2002.

Course Code: MM5161	SURFACE ENGINEERING & 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: MM5162	COMPOSITE MATERIALS	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	Identify suitable processing route to manufacture industrial composites
CO3	Distinguish the failure mechanisms arising in composite materials
CO4	Select the appropriate composite materials to suit the environmental condition

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Composites, Properties of composites, Functional requirements of reinforcement and matrix. Types of reinforcements, Types of matrices, Rule of mixtures, Classification of composites – Matrix- Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC), Carbon-carbon matrix composites (CCMC) – Reinforcement - particle reinforced composites, Fibre reinforced composites.

Fiber production techniques for glass, carbon and ceramic fibers. Composite manufacturing routes: Hand and spray lay - up, injection molding, resin injection, filament winding, pultrusion, centrifugal casting and prepregs.

Joining Methods, Geometry, Strength and Failure concepts, Properties of composites in comparison with standard materials, Industrial applications of composites.

Text Books:

1. Structure and Properties of Composites, Materials Science and Technology, Vol. 13, Weinheim, Germany, 1993.
2. Composite Materials: Engineering and Science, F.L. Matthews and R.D. Rawlings, Chapman & Hall, London, 1994.
3. Composite Materials- Science and Engineering, Krishan Kumar Chawla, Springer,2012.
4. Engineering Materials: Polymers, Ceramics and Composites, A.K Bhargava, PHI Learning Private Limited, 2012, 2nd ed.

Reference Books:

1. Composites, Engineered Materials Handbook, ASM International, Vol.1, Ohio, 1988.
2. Principles of composite material mechanics, Ronald F. Gibson, CRC Press, 2011.

Online Resources:

1. https://compositesuk.co.uk/composite-materials/public-library/documents
2. https://nptel.ac.in/courses/112/104/112104229/

Course Code: MM5163	SPECIAL STEELS	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 development of the special steel for modern-day engineering applications.
CO2	Analyse the structure, property and processing relationship of specialty steels
CO3	Evaluate the principles of micro-alloying and thermo-mechanical processing
CO4	Discuss the heat treatment principlesof tool steels and ultrafine-grained steels.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

General Introduction – properties and importance of various steels. Review of strengthening mechanisms applicable to steels –, grain refinement, solid solution, precipitation, dispersion of second phases, martensite, twinning, workhardening.

Development of various steels –principles of alloying, microalloying, heat treatment and thermomechanical processing in steels. Production of dual-phase steels, TRIP steels, TWIP steels; bainitic steels, IF steels, HSLA &advanced high strength low alloy steels,maraging steels, stainless steels, high nitrogen stainless steels, tool steels, ultrafine-grained steels,Cold Rolled Grain Oriented (CRGO) Steels, Oxide Dispersion Strengthened (ODS) steels, Cr-Mo-V steels, Armour steels, High N_2 steels.

Non-equilibrium processing of steels. Structure-property correlations in various steels.

Applications – structural, consumer, automotive and aerospace industries.

Text Books:

1. W.C. Leslie: Physical Metallurgy of Steels, Tech Books, 1991.
2. F.B. Pickering: Physical Metallurgy and Design of Steels, Applied Science Publishers, 1978.
3. H. K. D. H. Bhadeshia: Bainite in Steels- Transformations, Microstructure and Properties, CUP, 2001.
4. George Adam Roberts, Richard Kennedy, G. Krauss: Tool Steels, 5th Ed., ASM, 1998.
5. Albert M. Hall: Introduction to Today's Ultrahigh-strength Structural Steels, ASTM Special Technical Publication, 1973.
6. R.F. Decker: Source Book on Maraging Steels, ASM, 1979.

Course Code: MM5164	ADVANCED NON FERROUS PRODUCTION TECHNOLOGY	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 principles of hydro, pyro and electro metallurgical techniques for nonferrous metals extraction.
CO2	Identify potential ores and suitable processes employed for the economical extraction of nonferrous metals.
CO3	Design flow sheets for the extraction of nonferrous metals.
CO4	Evaluate advances in the extractive metallurgy techniques of light, rare and nuclear metals.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction, Unit operations for pyrometallurgy, hydrometallurgy, electrometallurgy and advantages and disadvantages. Brief outline of essential requirement of non-ferrous materials, minerals, their occurrence in India. Brief review of traditional methods of metal production of common metals such as copper, zinc, lead, aluminium - advanced converters for copper extraction- Hydrometallurgical processes for the extraction of zinc- flow sheets for the extraction of thorium, niobium, cobalt, zirconium, tungsten, molybdenum, gold, rare and nuclear metals.

Text Books:

1. R. Raghavan, Extractive Metallurgy of Non-Ferrous Metals, Vijay Nicole Imprints Private Limited, 2016.
2. T. Rosenqvist, Principles of Extractive Metallurgy, McGraw Hill, 2004.
3. H.S. Ray and A. Ghosh, Principles of Extractive Metallurgy, New Age International Publishers, 1991.
4. H. S. Ray, R. Sridhar and K.P. Abraham, Extraction of Non-ferrous Metals, Affiliated East West, 1985.
5. Seshadri Seetharaman (Ed), Treatise on Process Metallurgy, Volume 3: Industrial Processes, Elsevier, 2014.

Reference Books:

1. Hand Book of Extractive Metallurgy, Vols I-IV, Fathi Habashi, Wiley- VCH, 1993.
2. C.A. Hampel: Rare Metals Hand Book, Robert E. Krieger Publishing Company, 1971.

Course Code: MM5165	RARE EARTH AND REFRACTORY METALS	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 importance and applications of refractory and rare earth metals.
CO2	Explain the purification of concentrates/ compounds and production of intermediate salts
CO3	Evaluate flow sheets for the extraction of refractory and rare earth metals.
CO4	Discuss the refining techniques for refractory and rare earth metals.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction – Rare earth and refractory metals and their applications. Resources, principles, techniques and limitations for the production of rare and refractory metals. Purification of concentrates/compounds and production of intermediate salts. Production of rare earth metals and alloys –metallothermic reduction, electrorefining, zone refining and Iodide refining. Flow sheets for the extraction of uranium, zirconium, titanium, Beryllium, Niobium, Tantalum, Tungsten, Molybdenum and Vanadium.

Text Books:

1. C.A. Hampel, Rare Metals Hand Book, Robert E Krieger Publishing Company, 1971.
2. FathiHabashi, Hand Book of Extractive Metallurgy, Vols II & III, Wiley- VCH, 1997.
3. W.D. Jamrack, Rare metal extraction by chemical engineering techniques, Pergamon Press, 1963.
4. J. Luca, P. Lucas, Thierry Le Mercier, Alain Rollat, W. Davenport, Rare Earths – Science, Technology, Production and Use, Elsevier, 2015
5. Nagaiyar Krishnamurthy, Chiranjib Kumar Gupta, Extractive metallurgy of rare earths, CRC Press, 2016.

Course Code: MM5166	NUCLEAR TECHNOLOGY	Credits 3-0-0: 3

Pre-Requisites: None

Course Outcomes:

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

CO1	Explain thestrategic importance of nuclear energy technology in India.
CO2	Discuss the fundamentals of nuclear engineering and nuclear wastes disposal.
CO3	Classify the nuclear reactors, reactor materials and fuels.
CO4	Select suitable techniques for the extraction and processing of uranium, thorium, zirconium and beryllium.
CO5	Discussthe radiation damage of materials, radiation hazards and shielding.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Strategic importance of nuclear energy technology in India. Fundamental Concepts, Binding Energy, Fission Chain Reaction, Nuclear Reactors and Nuclear Power, Classification of Nuclear Reactors. Nuclear Waste Disposal.

Materials for Reactors, Fuel Fabrication, Cladding, Properties of reactor fuels, Production of Nuclear reactor Fuels and other Materials such as uranium, thorium, plutonium, zirconium etc.,

Fuel Reprocessing, Radio Active Waste Disposal, Radiation Doses and hazard Assessment, Radiation hazards and Shielding,

History of Radiation Effects, Radiation Units, Biological Effects of Radiation, Radiation Effects Materials, Medical Applications of Nuclear Technology, Nuclear Power Reactors in India.

Text Books:

1. J. Kenneth Shultis, Richard E. Faw: Fundamentals of Nuclear Science and Engineering, Marcel Dekkar, 2002.
2. John R. Lamarash: Introduction to Nuclear Engineering, 2nd Ed., Addison Wesley,1983.
3. S. Glasstone, A. Sesnoke: Nuclear Reactor Engineering, CBS Publishers, 2003.
4. Bodansky: Nuclear Energy- Practices and Projects, Springer, 2004.

Course Code: MM5167	PROCESS MODELLING AND SIMULATION	Credits 3-0-0: 3

Pre-Requisites: Engineering Mathematics

Course Outcomes:

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

CO1	Discuss applications of modelling and simulation in metallurgical processes.
CO2	Develop models for iron and steel making processes
CO3	Design casting, welding and deformation process models
CO4	Apply thermodynamic modelling in alloy design

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to metallurgical processes, materials deformation processes, importance of modelling the processes, elements of physical modelling, mathematical modelling, few of the following examples: blast furnace phenomena and modelling, modelling of casting, welding, deformation processes: basics, techniques, solving example problems and applications, thermodynamic modelling: applications of ThermoCalc in process modelling, modelling of steel making, neural network and genetic algorithm in steel making

Text Books:

1. G. K. Lal, Modelling Techniques for Metal Forming Processes, Narosa Publishing House, 2011
2. Peter Hartley, Ian Pillinger, Numerical Modelling of Material Deformation Processes: Research, Development and Applications, Springer, 2012
3. Dipak Mazumdar, James W Evans, Modelling of Steelmaking Processes, CRC Press, 2010
4. Zoe Barber, Introduction to Materials Modelling, Maney Publishing, 2005.
5. 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
3. Blast Furnace Phenomena and Modelling, The Iron and Steel Institute of Japan, Springer, 1987
4. John G. Lenard, Modelling Hot Deformation of Steels: An Approach to Understanding and Behaviour, Springer, 1989
5. S. Pal, A. Patra, Process Modeling for Steel Industry, I K International Publishing House Pvt. Ltd., 2018

Online Resources:

1. https://nptel.ac.in/courses/115/103/115103114/
2. https://nptel.ac.in/courses/113/107/113107096/
3. https://ocw.mit.edu/courses/materials-science-and-engineering/3-021j-introduction-to-modeling-and-simulation-spring-2012/

Course Code: MM5168	SAFETY MANAGEMENT AND POLLUTION CONTROL	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 need for safety standards and codes for the process industry
CO2	Describe the accident sequence theory and the responsibilities of authorities
CO3	Suggest strategies for risk assessment and hazard identification
CO4	Examine different types of pollution and its control in metallurgical process industries

Course Articulation Matrix:

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

1: Slightly 2: Moderately 3: Substantially

Syllabus:

Introduction to Industrial Safety: History and development of safety movement, Need for safety, Safety legislation: Acts and rules, Safety standards and codes, Safety policy: safety organization and responsibilities of authorities at different levels. Accident sequence theory, Causes of accidents, Accident prevention and control techniques, Plant safety inspections, Job safety Analysis and investigation of accidents, First aid.

Risk Assessment & Hazard Identification: Checklist procedure, Preliminary hazard analysis, Failure mode effect analysis, Hazard and operability (HAZOP) studies, Hazard analysis techniques: Fault tree analysis, Event tree analysis, General outline of DOW index, Risk estimation and management, Major hazard control, On-site and Off-site emergency preparedness. Identification of hazard, Categorization methods for elimination of hazard, Mechanical hazards; machine guarding, safety with hand tools/ portable power tools, Pressure vessel hazards and their control, Safety in material handling: hazards and safe Practices, safety with storage of materials, Electrical hazards: classification, safe work practices, Chemical hazards: laboratory safety, bulk handling of chemicals, Fire and explosion hazards, Fire detection, Prevention,control, and extinguishments, Industrial layout, Industrial waste management.

Pollution Control: Environment and environmental pollution from different process industries viz. chemical, ceramic, steel industries, characterization of emission and effluents, environmental Laws and rules, standards for ambient air, noise emission and effluents. Pollution Prevention: Process modification, alternative raw material, recovery of by co-product from industrial emission effluents, recycle and reuse of waste, energy recovery andwaste utilization. Material and energy balance for pollution minimization. Water use minimization, Fugitive emission effluents and leakages and their control-housekeeping and maintenance. Statutory Norms.

Text Books:

1. Industrial Safety and pollution control handbook: National Safety Council and Associate publishers Pvt. Ltd, Hyderabad, 1993.
2. K. Herman and M. Bisesi, : Handbook of Environmental Health and Safety, Jaico Publishing House, Delhi, 1999.

3. CPCB, Ministry of Env. and Forest, G.O.I. : Pollution Control Acts, Rules, Notifications issued there under, 3rd Ed. 2006.
4. Vallero D: Fundamentals of Air Pollution, 4 th Ed; Academic Press, 2007.
5. Eckenfelder W.W: Industrial Water Pollution Control, 2 Ed; McGraw Hill, 1999.
6. Kreith F. and Tchobanoglous G.: Handbook of Solid Waste Management, 2 Ed; Mc Graw Hill, 2002.

Course Code: MM5169	STATISTICAL QUALITY CONTROL AND MANAGEMENT	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 concepts of quality improvement
CO2	Demonstrate the design, use and interpret control charts for variables
CO3	Demonstrate the design, use and interpret control charts for attributes
CO4	Apply exponentially weighted moving average and moving average control charts

Course Articulation Matrix:

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

1: Slightly 2: Moderately 3: Substantially

Syllabus:

Introduction: The Meaning of Quality and Quality Improvement; Brief History of QualityMethodology; Statistical Methods for Quality Control and Improvement; Statistical Methods for Failure Analysis, Total Quality Management (Six sigma concepts, quality philosophy, links between quality and productivity, quality costs, legal aspects of quality implementing, quality improvement).

Modeling Process Quality: Mean, Median, Mode, Standard deviation, Calculating area, The Deming funnel experiment, Normal distribution tables, Finding the Z score, Central limit theorem. Methods And Philosophy Of Statistical Process: Chance and assignable causes, Statistical Basis of the Control Charts (basic principles, choices of control limits, significance of control limits, sample size and sampling frequency, rational subgroups, analysis of pattern on control charts, warning limits, Average Run Length-ARL)

Control Charts For Variables: Control Charts for X-Bar and R- Charts, Type I and Type II errors, the probability of Type II error. Simple Numerical Problems. Process Capability: The foundation of process capability, Natural Tolerance limits, cp – process capability index, cpk, pp – process performance index, summary of process measures. Numerical problems

Control Charts For Attributes: Binomial distribution, Poisson distribution (from the point of view of Quality control) Control Chart for Fraction Nonconforming, Control Chart for number Nonconforming, Control Charts for Nonconformities or Defects, Control Chart for Number of non-conformities per unit. Numerical problems

Lot-By-Lot Acceptance Sampling For Attributes:The acceptance sampling problem, single sampling plan for attributes, Double, Multiple, and Sequential sampling, AOQL, LTPD, OC curves, Military Standard 105E, the Dodge-Romig sampling plans. Numerical problems.Cumulative-Sum (Cusum) & Exponentially Weighted Moving Average (Ewma) Control Charts.

Text Books:

1. D. C. Montgomery, Introduction to Statistical Quality Control, John Wiley & Sons, 3rdEdition.

2. Mitra A., Fundamentals of Quality Control and Improvement,PHI, 2nd Ed., 1998.
3. J Evans and W Linsay, The Management and Control of Quality, 6'th Edition, Thomson, 2005.
4. Besterfield, D H et al., Total Quality Management, 3rd Edition,Pearson Education, 2008.
5. D. C. Montgomery, Design and Analysis of Experiments, John Wiley & Sons, 6thEdition, 2004.

Course Code: MM6147	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 technical proficiency in the courses studied during the program
CO2	Explain the metallurgical principles, phenomena and their applications
CO3	Communicate technical concepts effectively
CO4	Comprehend the metallurgical concepts for solving practical issues

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2		3			1
CO2	2		3		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: MM6149	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 a research problem based on gaps in the literature
CO2	Formulate the objectives in the selected area of research
CO3	Develop a suitable research methodology
CO4	Prepare a comprehensive technical report
CO5	Present the progress of dissertation work

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Course Code: MM6199	DISSERTATION PART-B	Credits 0-0-0: 20

Pre-Requisites: None

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

CO1	Identify the experimental/ simulation tools to achieve the research objectives
CO2	Conduct experiments/ simulation independently
CO3	Analyze the experimental/simulation data
CO4	Prepare a comprehensive dissertation report by following professional ethics
CO5	Demonstrate the outcome of dissertation work

Course Articulation Matrix:

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