I - Semester

S.No.	Code	Subject		L	T	P	Credits	Marks
1	MST101	Mechanical Behavior of Materials		3	-	-	3	100
2	MST102	Materials Characterization and Evaluation		3	-	-	3	100
3	Program Elective - I	MST1031	Advances in Iron and Steel Making	3	-		3	100
		MST1032	Physical Metallurgy and Heat Treatment					
		MST1033	Additive Manufacturing					
4	Program Elective – II	MST1041	Polymers and Composites	3	-	-	3	100
		MST1042	Ceramic Materials					
		MST1043	Metallurgical Failure Analysis					
5	MST105	Research Methodology and IPR		2	-	-	2	100
6	MST106	Mechanical Behavior of Materials lab		-	-	4	2	100
7	MST107	Materials characterization Lab		-	-	4	2	100
8	MST108	Writing skills for Scientific Communication		2	-	-	0	100
		Total		16	0	8	18	800

II – Semester

S.No.	Code	Subject		L	T	P	Credits	Marks
1	MST201	Metal Forming and Severe plastic deformation		3	-	-	3	100
2	MST202	Advanced Powder Metallurgy		3	-	-	3	100
3	Program Elective – III	MST2031	Non-destructive Evaluation	3	-		3	100
		MST2032	Nano composites and applications					
		MST2033	Statistical Quality Control					
4	Program Elective – IV	MST2041	Plasticity and plastic deformation	3	-	-	3	100
		MST2042	Corrosion and Surface Engineering					
		MST2043	Advanced Manufacturing Techniques					
5	MST205	Metal Forming and simulation Lab		-	-	4	2	100
6	MST206	Advanced Powder Metallurgy lab		-	-	4	2	100
7	MST207	Mini Project with Seminar		-	-	4	2	100
8	MST208	Personality development through life-enlightenment skills		2	-	-	0	100
		Total		14	0	12	18	800

III Semester

S.No	Code	Subject		L	T	P	Credits	Marks
1	Program Elective - V	MST3011	MOOCS	3	-	-	3	100
		MST3012	Advanced Metallurgical thermodynamics					
		MST3013	FEM Techniques In Materials Processing					
2	Open Elective	MST3021	Nano technology and Engineering applications	3	-	-	3	100
		MST3022	Engineering Materials and structures					
		MST3023	Advanced Metal Joining techniques					
3	MST303	Dissertation Phase 1		-	-	20	10	
		Total		6	0	20	16	200

IV Semester

S.No	Code	Subject	L	T	P	Credits	Marks
1	MST401	Dissertation Phase 2	-	-	32	16	200
		Total	0	0	32	16	200

MST101	MECHANICAL BEHAVIOR OF MATERIALS	L	P	C
		3	0	3

M. Tech. – I Sem.

***Objective**:*

1. To equip students with a wide ranging knowledge of the response of solid materials to stress.
2. To know about the yield criterion and strengthening mechanisms
3. To acquire the knowledge about variety of mechanical testings

***Outcome of the study**:*

1. Student's ability to understand and apply the definitions of stress and strain in three dimensions along with the application of simple constitutive laws
2. Students will identify, formulate, and solve engineering problems involving resistance to plastic deformation
3. Students will acquire the knowledge about fatigue and creep.

UNIT I: Concepts of stress and strain

Definition of stress and strain; transformation of axes, tensor notations; relationship between stress and strain; concepts of principal stress and principal strain; concepts of modulus; Hooke's law and understanding stiffness and compliance tensors; Elastic anisotropy.

UNIT II: Yielding

Yield criterion; equivalent stress and plastic strain, theoretical shear of perfect crystal; Moh's circle, concept of dislocations and dislocation theory; dislocation interaction; kink and jog; sessile and glissiles, partial dislocations, Thomson tetrahedra.

UNIT III: Strengthening mechanisms

Work hardening; solid solution strengthening; grain boundary strengthening; strengthening by grain refinement, ageing; particle hardening; types of reinforcements.

UNIT IV: Hardness Types of hardness measurements; comparison among hardness methods and scales; microhardness; nanoindentation.

UNIT V: Fatigue and creep

S-N cuves; life data presentation; influence of stress; linear elastic fracture mechanics in fatigue, crack growth studies, Paris law, metallurgical aspects of fatigue failure; concepts of remedial

methods; stress rupture and creep studies; deformation mechanism maps; superplasticity; fatigue-creep interaction.

Text books:

1. Dieter G.E., Mechanical Metallurgy, McGraw Hill, 1988
2. Thomas H. Courtney, Mechanical Behavior of Materials, 2nd Edition, Overseas Press India Private Limited

References:

1. Suryanarayana, Testing of Metallic Materials; Prentice Hall India
2. Dowling N.E., Mechanical Behavior of Materials, International Edition, contributed by K.Sivaprasad and R.Narayanasamy, 2013, Pearson Education Limited.

MST102	MATERIALS CHARACTERIZATION AND EVALUATION	L	P	C
		3	0	3

M. Tech. – I Sem.

***Objective**:*

1. To explain and describe the various working techniques of optical microscope, Scanning and Transmission Microscopes used for evaluating material properties.
2. To explain and describe the various working techniques of XRD, SPM, AFM for evaluating material properties.
3. To differentiate and compare between various characterization techniques.
4. Obtain knowledge on the various Non-destructive techniques.

***Outcome of the study**:*

1. Able to use metallurgical microscopes to analyze the experimental results.
2. Understand the various specimen preparation techniques for SEM, TEM and analyze the experimental results.
3.Describe the construction of XRD machine and understand its principle and analyze / interpret the experimental results.
4.The student gets expertise with the NDT techniques

UNIT I: Optical Microscopy and Image Analysis

Fundamentals of optics, Optical microscope and its instrumental details, Variants in the optical microscopes and image formation, Phase contrast, Polarised light, Differential interference contrast, Fluorescence microscopy, Sample preparation and applications

UNIT II: Scanning Electron Microscopy

Introduction to Scanning electron microscopy, Instrumental details and image formation, Various imaging techniques and spectroscopy, Sample preparation and Applications

UNIT III: Transmission Electron Microscopy

Introduction to Transmission electron microscopy (TEM), Science of Imaging and diffraction TEM instrumental details and variants in imaging techniques, Sample preparation procedures and instruments for various materials, Introduction to Atomic force microscopy (AFM)

UNIT IV: Diffraction

Introduction to diffraction phenomena, Instrumental details of X-ray and electron diffraction, analysis of XRD pattern, Residual stress measurements.

UNIT V:

Introduction to visual inspection; dye penetrant testing, magnetic particle inspection, ultrasonic testing, eddy current testing; radiography and thermography

Text books:

1. Elements of X-Ray diffraction, Addision-Wesley Metallurgy Series
2. The Principles of metallogrphy laboratory practices –George L.Khel-Eurasia publishing house (Pvt Ltd)
3. Transmission electron Microscopy of metals –Garet Thomas.-John wiley and sons

References:

1. Modern Metallographic Techniques & their application – victor phillips.
2. Experimental Techniques in Physical Metallurgy – VT Cherepin and AK Mallik.
3. Electron Microscopy in the study of materials –P.J.Grundy.

MST1031	Program Elective - I **ADVANCES IN IRON AND STEEL MAKING**	**L**	**P**	**C**
		3	**0**	**3**

M. Tech. – I Sem.

Objective*:*

1. To learn alternate routes of iron making based on coal based and gas based processes.
2. Gain knowledge about important smelt reduction processes.
3. To enhance the technical knowledge in secondary steel making processes.

Outcome of the study*:*

1. Comprehensive understanding of alternate routes to iron making concomitant to kinetics of reduction of oxides of iron.
2. Analyze, compare and contrast the different coal based and gas based reduction processes.
3. Knowledge about classification, advantages and limitations of smelt reduction processes.
4.Knowledge about the importance of secondary steel making processes and types of processes and their significance.
5.Gets acquainted with solidification and continuous casting processes

UNIT I: Processing of raw materials: Coke making, processing of lime and dolomite stone. Iron ore processing and agglomeration techniques

UNIT II: Iron making: Modern trends in Blast Furnace Operation, alternative routes of Iron Production (COREX, MBF), direct reduction process: HYL, SL/RN processes, Midrex, fluidized bed.

UNIT III: Steel making: Fundamentals of steel making, BOF steel making, Electric furnace steel making, Hybrid steel making processes, Ajax, Twin hearth, Tandem, SIP, OBM, high tension electric steel making, plasma arc steelmaking processes.

UNIT IV: Advanced techniques in steel making: WORCRA, IRSID, Spray steel making, INRED, ELRED processes. Production of High purity steel: Non-metallic inclusions and their effect on properties of steel. Refining techniques, ESR, VAR, and Vacuum Degassing of liquid steel. Alloy steel making, Tool steels and stainless steel making practice. Review of Iron and steel Industry in India.

UNIT V: Solidification and casting operations: Principles of solidification of steel, ingot casting, continuous casting, modelling of steel making process.

Text books:

1. Reduction of Iron Ores – VAN BOGDANDY.
2. Aspects of Modern ferrous Metallurgy – J.S.KIRKALDY & G.WARD.

References:

1. IIM-Silver Jubilee Symposium on Recent Developments in Materials Science and Technology.
2. Making, Shaping Treating of Steel published by United States Steel Corporation.
3. Introduction of Modern Iron Making – R.H.TUPKARY.
4. Introduction of Steel making – R.H.TUPKARY
5. Iron making and steel making-Ahindra Ghosh and Amit chatterjee, PHI Learning Pvt Ltd.

MST1032	Program Elective - I **PHYSICAL METALLURGY AND HEAT TREATMENT**	**L**	**P**	**C**
		3	**0**	**3**

M. Tech. – I Sem.

Objective*:*

1. This course is mainly designed to impart knowledge on CCT and TTT diagrams
2. Gain knowledge about heat-treatment of ferrous and non-ferrous metals and alloys
3. Enhance technical knowledge about controlling of various elements in iron and steel

Outcome of the study*:*

1. Understand the importance of CCT and TTT diagrams
2. Get familiarize with single and binary components and various crystal interfaces.
3. Understand heat-treatment processes applied to ferrous and non-ferrous metals and alloys

UNIT I:

Equilibrium and non equilibrium cooling of Fe-C alloys. CCT and TTT diagrams, hardenability.

UNIT II:

Fundamentals of heat treatment, Heat treatment of Steels, Cast irons, tool steels, stainless steel and heat resistant alloys.

UNIT III:

Non-ferrous alloys: Solution annealing, Aging, Annealing of Al, Cu, Mg, Ti alloys.

UNIT IV:

Thermo mechanical processing

UNIT V:

Furnace atmosphere control, temperature control, control of surface carbon, evaluation of C control in processed parts, furnace safety.

Text books:

1. Introduction to Physical Metallurgy – SH Avner
2. Heat treatment – Vijendra Singh

References:

1. Physical Metallurgy – V Raghavan.
2. Heat treatment – Principles and Techniques – Rajan & Sharma

MST1033	Program Elective - I **ADDITIVE MANUFACTURING**	**L**	**P**	**C**
		3	**0**	**3**

M. Tech. – I Sem.

Objective*:*

1. To introduce students the basics of additive manufacturing/rapid prototyping and its applications in various fields, reverse engineering techniques.

2. To familiarize students with different processes in rapid prototyping systems.

3. To teach students about mechanical properties and geometric issues relating to specific rapid prototyping applications.

Outcome of the study*:*

1. Demonstrate the knowledge of Additive Manufacturing and Rapid Prototyping technologies. 2. Describe different RP techniques.

3. Discuss fundamentals of Reverse Engineering.

UNIT I: **Introduction to Additive Manufacturing:**

AM, AM evolution, Distinction between AM & CNC machining, advantages of AM.

UNIT II : AM process chain:

Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation, machine setup, build , removal and clean up, post processing

UNIT III: Classification of AM processes:

Liquid polymer system, discrete particle system, molten material systems, and solid sheet system.

UNIT IV: Design for AM:

Motivation, DFMA concepts and objectives, AM unique capabilities, Exploring design freedoms, Design tools for AM, Part Orientation, Removal of supports, hollowing out parts, Inclusion of undercuts and other manufacturing constraining features, interlocking features.

UNIT V: Application examples for aerospace, defense, automobile, Bio-medical and general engineering industries

Text books:

1. Chua Chee Kai, Leong Kah Fai, "Rapid Prototyping: Principles & Applications", World Scientific, 2003.
2. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010

References:

1. Ali K. Kamrani, Emand Abouel Nasr, "Rapid Prototyping: Theory & Practice", Springer, 2006.
2. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001

MST1041	Program Elective - II **POLYMERS AND COMPOSITES**	**L** **3**	**P** **0**	**C** **3**

M. Tech. – I Sem.

Objective*:*

1. Describe the importance of polymers and composite materials.
2. Familiarize the students with various types of polymers, composites, their properties
3. Familiarize about various process techniques for processing of polymers and composite materials.

Outcome of the study*:*

1. Can classify the composites, know the required properties, reinforcements and matrix materials and uses of composites.
2.Able to explain how common fibers are produced and how the properties of the fibers are related to the internal structure and the interfaces obtained.
3.Knowledge of processing techniques for polymer matrix, ceramic matrix and metal matrix composites and list out their properties and applications.
4. Ability to arrive at different deformation and failure mechanisms of composite materials under different loading conditions in engineering applications.
5. Able to explain the elastic constants and strengths of the composite.
6. Able to undertake any technical assignment in R&D and production of newer and smarter materials

UNIT I: Basics of Polymers: Structure of polymers, characterization and applications of polymers: mechanical behavior of polymers, strengthening of polymers, crystallization and glass transition phenomenon and types of polymers.
UNIT II: Properties of Plastics: Design and selection of plastics, structure property correlation, mechanical properties, degradation, wear and friction, thermal, electrical and optical properties, flammability of plastics and processing of plastics and FRP
UNIT III: Composites: Particle reinforced composites, fiber reinforced composites – influence of fiber length, orientation and concentration. Fiber phase, matrix phase, metal matrix composites, polymer matrix composites, ceramic matrix composites, carbon – carbon composites, hybrid composites and structural composites.

UNIT IV: Processing of composites: Processing of MMC, liquid metal infiltration, squeeze casting, stir casting, compo casting, solid state route and diffusion bonding, powder metallurgy route slip casting.

UNIT V: Advances in composite processing: In-situ composites, eutectic alloy composites and directional solidification, constitutional super cooling and deviation from eutectic with variation in volume fraction of hard face, co extrusion of Cu-Nb composites and manufacturing of superconductors, self-propagating high temperature synthesis, melt oxidation, precipitation reactions.

Text Books:

1. Introduction to polymers, R.J. Young and P. A. Lovell, CRC Press, 3rd edition , 2013
2. Composite materials science and engineering, Krishnan k Chawla, 3rd edition

References:

1. R.J. Crawford, Plastics engineering, Pergamon Presss, II edition, 1987
2. W.D Callister. Jr, Materials Science and Engineering, Wiley India Pvt. Ltd, 2007
3. F.W.Billmeyer, Text book of polymer science, John Wiley &Sons, Newyork,1984

MST1042	Program Elective - II **CERAMIC MATERIALS**	**L**	**P**	**C**
		3	**0**	**3**

M. Tech. – I Sem.

Objective*:*

1. To give the knowledge about the structural aspects of various ceramic materials & processing of various ceramic materials

2. To understand various applications of ceramic and refractory material

3. To understand about the advanced ceramics

Outcome of the study*:*

1. Will have the basic knowledge about ceramics.

2. Students will be able to recognize and describe common ceramic crystal structures and important ceramic systems

3. Students will understand the basics of ceramic processing, including sintering theory and grain growth.

4. Students will be able to describe key electrical, magnetic and optical applications of ceramic materials.

UNIT I: Basics of ceramics: Ceramics as a class of material, classification of ceramics, bonding and structure of various ceramic materials; crystal structure and defects; chronological developments, structure of silicates; polymorphic transformations, raw materials.

UNIT II: Non crystalline materials: Non crystalline materials - structure, requirement for glass formation, Zachariasen rules, viscosity based transition points, devitrification; glass forming methods; important ceramic systems: one component system- silica; binary and ternary systems. Silicate glasses and glass ceramics.

UNIT III: Processing of ceramics: Powder processing, pre-consolidation - shape forming processes; Fundamental Sintering mechanisms, various advanced sintering techniques; Mechnacial behaviour of structural ceramics-Brittleness of ceramics, Concept of fracture toughness and different toughness and strength measurement techniques; Concept of various toughening mechanisms. Thermal properties of ceramics

UNIT IV: Functional Ceramics: Electrical, magnetic and optical properties of ceramic materials - emphasis on the effects of composition, microstructure, processing, temperature and

atmosphere on these properties, Thin film techniques for electronic applications, growth of single crystals.

UNIT V: Advanced Ceramics: Introduction to specific ceramic materials – structure property correlation, processing and applications – Bioceramics and bio-glass, ceramic sensors, cermets, superconducting ceramics, cements, refractories, thermal barrier coatings and other functional coatings.

Text Books:

1. Introduction to Ceramics – W.D. Kingery et al. 1976, John Wiley
2. Richerson D. W., 'Modern Ceramic Engineering - Properties Processing and Use in Design, 3rd Edition, CRC Press, 2006

References:

1. Kingery W. D., Bowen, H. K., Uhlhmen D. R., 'Introduction to Ceramics', 2nd Edition, John Wiley, 1976
2. James E. Shelby., 'Introduction to Glass Science and Technology' 2nd Edition, The Royal Society of Chemistry Publications, 2005
3. Callister's Mateials Science and Engineering, Adapted by R.Balasubramaniam, second edition, Wiley, 2015
4. Ceramic processing- M. N. Rahaman 2006, CRC Press
5. Chiang Y.M., Birnie D. P., Kingery W.D., Physical Ceramics: Principles for Ceramic Science and Engineering, John Wiley, 1997

MST1043	Program Elective - II **METALLURGICAL FAILURE ANALYSIS**	**L**	**P**	**C**
		3	**0**	**3**

M. Tech. – I Sem.

Objective*:*

1. To understand the concepts on materials failure and fracture analysis of materials

2. To design new materials that can with stand catastrophic failures at different environment.

Outcome of the study*:*

1. Understand factors responsible failure of materials

2. Differentiate fracture modes and failure mechanisms for ductile, brittle, fatigue, creep, corrosion and wear failure

3. Determine fracture toughness of brittle and ductile materials

4. Predict life of materials under fatigue loading

5.Analyze failure through case studies and select tools for failure analysis

UNIT I: Stages of failure analysis, classification and identification of various types of fracture. Overview of fracture mechanics, characteristics of ductile and brittle fracture.

UNIT II: General concepts, fracture characteristics revealed by microscopy, factors affecting fatigue life Creep, stress rupture, elevated temperature fatigue, metallurgical instabilities, environmental induced failure. Some case studies failures.

UNIT III: Analysis of wear failure. Corrosion failures- factors influencing corrosion and wear failures, Procedure for analyzing wear and corrosion failures, various types of hydrogen damage failures.

UNIT IV: Causes of failure in forming, failure of iron and steel castings, improper heat treatment, stress concentration and service conditions. Failure of weldments - reasons for failure procedure for weld failure analysis.

UNIT V: Reliability concept and hazard function, life prediction, condition monitoring, application of Poisson, exponential and Weibull distribution for reliability, bath tub curve, parallel and series system, mean time between failures and life testing.

Text Books:

1. ASM Metals Handbook "Failure Analysis and Prevention", ASM Metals Park. Ohio, Vol.10, 10th Edition, 1995.
2. Colangelo.V.J. and Heiser.F.A., "Analysis of Metallurgical Failures", John Wiley and Sons Inc. New York, USA, 1974.

MST105	RESEARCH METHODOLOGY AND IPR	L	P	C
		2	0	2

M. Tech. – I Sem.

***Objective**:*

1. To know the defining of problems
2. To know about writing of technical paper and research proposal
3. To know about IPR and patent rights

***Outcome of the study**:*

1. Student will be able to understand research problem formulation.
2. Student will be able to analyze research related information & follow research ethics
3. Student will be able to understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
4. Student will be able to understand that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
5. Student will be able to understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Unit 1: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit 2: Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit 3: Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit 4: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit 5: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Text books:

1. Introducing Research Methodology: A Beginner's Guide to Doing a Research Project 2nd ed. Edition, by Uwe Flick
2. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 4th Edition, by John W. Creswell

References:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
5. Mayall, "Industrial Design", McGraw Hill, 1992.
6. Niebel, "Product Design", McGraw Hill, 1974.
7. Asimov, "Introduction to Design", Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.
9. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

MST106	MECHANICAL BEHAVIOR OF MATERIALS LAB	L	P	C
		0	4	2

M. Tech. – I Sem.

***Objective**:*

1. To learn the principles of material testing apply them for various engineering applications.

***Outcome of the study**:*

1. The student will be able to demonstrate tensile, compression testing and its applications
2. The student will be able to demonstrate hardness testing techniques and its applications
3. The student will be able to demonstrate creep and stress rupture test and their implications
4. The student will be able to demonstrate fatigue and torsion testing and its applications

List of experiments:

1. Determination of the tensile properties of metals and polymers
2. Determination of Vickers hardness and Vickers micro hardness of different materials
3. Impact testing of materials at different temperatures
4. Creep testing of materials
5. Low cycle and high cycle Fatigue testing
6. Torsion testing of metals
7. Determination of age hardening behavior of different alloys

Equipment Required:

1. Computer controlled UTM
2. Computer controlled tensile testing machine for polymers
3. Vickers hardness testing machine
4. Vickers micro hardness testing machine
5. Impact testing experimental setup to conduct tests at different temperatures
6. Computer controlled creep testing machine
7. Computer controlled fatigue testing machine
8. Torsion testing machine

MST107	MATERIALS CHARACTERIZATION LAB	L	P	C
		0	4	2

M. Tech. – I Sem.

Objective*:*
To get expertise with different characterization techniques

Outcome of the study*:*
1. The student will be able to prepare specimens for optical, SEM and TEM observations
2. The student will be able to analyze the crystal structure using X-ray diffraction technique
3. The student will be able toaAnalyze the composition of material using SEM-EDS technique
4. The student will be able to select a technique to characterize a material for a given application

List of Experiments:

1. Optical microscopy and image analyses
2. X-ray diffraction analysis – phase and crystal structure identification & quantification
3. X-ray peak broadening analyses
4. Scanning Electron microscopy
5. Thermal analysis (DSC / TGA /DTA)
6. Scanning probe microscopy (AFM, etc.)

Equipment Required:

1. Metallurgical microscope with image analysis
2. X-ray diffraction unit
3. Scanning electron microscope
4. Differential scanning calorimetry unit

MST108	WRITING SKILLS FOR SCIENTIFIC COMMUNICATION	L	P	C
		2	0	0

M. Tech. – I Sem.

Objective*:*

1. To get acquainted with writing skills for scientific communication

Outcome of the study*:*

1. Understand that how to improve your writing skills and level of readability

2. Learn about what to write in each section

3. Understand the skills needed when writing a Title Ensure the good quality of paper at very first-time submission

Unit-1:

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness**,** Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising.

Unit-2: Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

Unit-3:

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature.

Unit-4:

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions.

Unit-5:

Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

Suggested studies:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

MST201	METAL FORMING AND SEVERE PLASTIC DEFORMATION	L	P	C
		3	0	3

M. Tech. – II Sem.

Objective:

1. To know about the fundamentals of metal forming and different bulk metal forming and sheet metal forming techniques

2. to know about SPD techniques and their importance

Outcome of the study:

1. Understand various mechanical processing techniques of materials

2. Competent to know principles in different mechanical processing of materials

3. able to comment on various SPD techniques like ECAP & ECAR

UNIT – I

FUNDAMENTALS OF METAL FORMING: Components of stress, symmetry of stress tensor, principal stresses, stress deviator, Von Mises, Tresca yield criteria, comparison of yield criteria, Octahedral shear stress and shear strain. Effect of temperature, strain rate and metallurgical structure on metal working. Deformation zone geometry, Workability, Residual stresses.

UNIT – II

FORGING AND ROLLING: Classification of forming processes, Forging-types of presses and hammers, Open die forging and Closed die forging, forging in plane strain, calculation of forging loads, forging defects- causes and remedies

Classification of rolling processes, types of rolling mills, hot and cold rolling, rolling of bars and shapes, forces and geometrical relationship in rolling, analysis of rolling load, rolling defects - causes and remedies. Simple problems.

UNIT – III

EXTRUSION AND DRAWING : Direct and indirect extrusion, variables affecting extrusion, deformation pattern, equipments, design of extrusion die, hydrostatic extrusion, defects and

remedies, Analysis of extrusion force, tube extrusion and production of seamless pipe and tube. Drawing of rods, wires and tubes**.** Simple problems

UNIT – IV

Sheet Metal Forming and Other Processes: Forming methods - Shearing, blanking, bending, stretch forming, deep drawing. Types of dies used in press working, defects in formed part and remedial measures, sheet metal formability, formability limit diagram.

High velocity forming: Comparison with conventional forming. Explosive forming, Electro hydraulic, Electro Magnetic forming, Dynapak and Petro-forge forming.

UNIT – V

Severe Plastic Deformation: Introduction, Classification of SPD processes, Equi-channel angular Extrusion (ECAE) and Equi-channel angular rolling (ECAR), Die design, effect of various parameters on mechanical properties of the ECAPed product, High pressure torsion, accumulative roll bonding. Advantages and limitations of different SPD techniques.

Text books:

1. Dieter.G.E ., "Mechanical Metallurgy", McGraw-Hill Co., SI Edition, 1995.
2. Nagpal.G.R., "Metal Forming Processes", Khanna Pub., New Delhi, 2000.

References:

1. Kurt Lange "Handbook of Metal Forming", Society of Manufacturing Engineers. Michigan, USA, 1988
2. Avitzur, "Metal Forming - Processes and Analysis", Tata McGraw-Hill Co., New Delhi, 1977.
3. ASM Metals Handbook. Vol.14, "Forming and Forging", Metals Park, Ohio, USA, 1990.
4. Taylor Altan, Soo I.K. Oh, Harold.L.Gegel. "Metal Forming: Fundamentals and Applications", ASM, Metals Park, Ohio, USA, 1983

MST202	ADVANCED POWDER METALLURGY	L	P	C
		3	0	3

M. Tech. – II Sem.

***Objective**:*

1. To build the necessary background of emergence and importance of powder metallurgy, scope and limitations.

2. Obtain a necessary knowledge about various powder production techniques and characteristics.

3. Obtain a working knowledge of compaction and sintering techniques.

4. Gain an effective knowledge of applications of powder metallurgy products.

***Outcome of the study**:*

1. Classify powder preparation techniques.

2. Explain the characterization techniques of powders.

3. Describe hot, cold and pressure-less powder compaction and sintering techniques of powder compacts.

4. To understand sintering zones and gain knowledge about sintering atmospheres.

UNIT I: Introduction to particulate processing – advantages, limitations and applications of particulate processing

UNIT II: Science of particulate processing – issues related to particle morphology – differences in mechanical behaviour (with respect to cast and wrought materials) and related mathematical treatment - similarities and differences between metal powder and ceramic powder processing

UNIT III: Production and characterisation of metal and ceramic powders – compaction processes – powder properties and powder compaction – Pressing, Hot Isostatic Processing and extrusion

UNIT IV: Sintering – thermodynamic and process aspects – recent developments in mechanical alloying and reaction milling

UNIT V: Production of particulate composites - application of P/M based on case studies - manufacturing of typical products – near net shape processing

Text books:

1. German R.M., 'Powder Metallurgy Science', Metal Powder Industries Federation, New Jersey, 1994
2. A.K.Sinha, Powder Metallurgy.

References:

1. Kuhn H. A. and Alan Lawley, 'Powder Metallurgy Processing - New Techniques and Analysis', Oxford IBH, Delhi, 1978.
2. P.C. Angelo, R.Subramanyam, Powder Metallurgy,

MST2031	Program Elective - III **NON DESTRUCTIVE EVALUATION**	**L**	**P**	**C**
		3	**0**	**3**

M. Tech. – II Sem.

Objective:

1. *Provide an opportunity to learn visual methods, electrical methods and magnetic methods.*
2. *To develop a fundamental understanding of ultrasonic testing of material and radiographic methods.*
3. *To be able to select the suitable NDT methods for particular environments.*

Outcome of the study:

1. *Complete knowledge on microscopic evaluation and dynamic inspection.*
2. *Knowledge about applications of NDT methods like visual observation, penetrant detection, electrical methods etc.*
3. *Ability to use ultrasonic testing and radiographic methods for checking various types of defects.*
4. *Ability to use thermography techniques to find out the defects*
5. *Selection of suitable NDT methods for various environments.*

UNIT I: Visual Inspection:

Visual Inspection- tools, applications and limitations. Liquid Penetrant Inspection - principles, types and properties of penetrants and developers. Advantages and limitations of various methods of LPI. Magnetic particle inspection- principles, applications, advantages and limitations

UNIT II: Ultrasonic testing:

Ultrasonic testing(UT) - Nature of sound waves, wave propagation - modes of sound wave generation - Various methods of ultrasonic wave generation, types of UT Principles, applications, advantages, limitations, A, B and C scan - Time of Flight Diffraction (TOFD)

UNIT III: Radiography:

Radiography testing (RT) – Principles, applications, advantages and limitations of RT. Types and characteristics of X ray and gamma radiation sources, Principles and applications of Fluoroscopy/Real-time radioscopy - advantages and limitations - recent advances.

UNIT IV: Eddy current testing

Eddy current testing - Principles, types, applications, advantages and limitations of eddy current testing.

UNIT V: Thermography

Thermography - Principles, types, applications, advantages and limitations. Optical & Acoustical holography- Principles, types, applications, advantages and limitations. Case studies: weld, cast and formed components.

Text Books:

1. Practical Non – Destructive Testing, Baldev raj, Narosa Publishing House(1997).

References:

1. Non-Destructive Testing, B.Hull and V.John, Macmillan (1988)
2. Krautkramer, Josef and Hebert Krautkramer, Ultrasonic Testing of Materials, 3rd edition, New York, Springer-Verlag (1983)

MST2032	Program Elective – III **NANO COMPOSITES AND APPLICATIONS**	**L** **3**	**P** **0**	**C** **3**

M. Tech. – II Sem.

Objective*:*

1. Provides knowledge about nanocomposites, reinforcing nanostructures dispersed in various matrix materials like polymers, ceramics, metals, etc,.

2. Brings the knowledge about the synthesis methods, modelling and evaluation of nanocomposites.

Outcome of the study*:*

1. Student can able to discuss the basic concepts of Nano Composites.

2. Student can able to prioritize the role of Ceramic Metal Composites in Nano Technology.

3. To understand the role of Synthesis Methods for various Nano Composite materials.

4. Learn about the concepts of Indentations and types of Indentations.

5. Correlate the applications of Polymer Nano Composites and ImpregnationTechniques.

Unit – I Introduction to Nanocomposites, Composite material, Mechanical properties of Nano composite material: stress - strain relationship, toughness, strength, plasticity.

Unit – II Ceramic-Metal Nanocomposites, Ceramic based nanoporous composite, Metal matrix nanocomposites, Polymer-based nanocomposites Carbon nanotube based nanocomposites and Natural nanobiocomposites, Biomimetic nanocomposites and Biologically inspired nanocomposites; Applications to Strategic Sector (Aerospace, Defense - CNT based structures - CNT based Nose cones for reentry vehicles), Armour protection (Polymer-Tungsten, Polymer-CNT Nanocomposites)

Unit – III Synthesis methods for various nanocomposite materials: mechanical alloying, thermal spray synthesis etc. Nano composites for hard coatings; DLC coatings; Thin film nanocomposites; Modeling of nanocomposites.

Unit – IV Nano Indentation, Types of indentation: Oliver & Pharr method, Vickers Indentation process, Berkovich indentation process, Brinell test, Knoop test

Unit – V Processing of polymer nanocomposites, properties of nanocomposites, Salt infiltration, Powder mixing, Intrusion method, Exfoliation & interaction, Gel-casting impregnation techniques: Hot melt impregnation, solution impregnation.

Text Books:

1. Nanocomposite Science & Technology by P.M. Ajayan, L.S. Schadler and P.V. Braun, Wiley-VCH GmbH Co.
2. Thomas E. Twardowski, Introduction to Nanocomposite Materials, Properties, Processing, Characterization, DesTech Publications, April 2007

Reference Books:

1. Encyclopedia of Nanotechnology by H.S.Nalwa
2. Encyclopedia of Nano Technology by M.Balakrishna rao and K.Krishna Reddy, Vol I to X
3. Introduction to Nano Technology by Charles. P.Poole Jr and Frank J. Owens; Wiley India Pvt Ltd.
4. Nanotechnology, A gentle introduction to the next big idea by Mark Ratner, Daniel Ratner Pearson education.

MST2033	Program Elective - III **STATISTICAL QUALITY CONTROL**	**L** **3**	**P** **0**	**C** **3**

M. Tech. – II Sem.

Objective*:*

1. To learn the concepts of quality control and quality management and their applications related to the manufacture of metallurgical products.

Outcome of the study*:*

1. The student will be able to understand the basic concepts in quality control and management

2. The student will learn about the statistics and probability and distribution functions related to quality management

3. The student will understand the process of inspection, sampling and their statistical approach in quality management in industry

UNIT I: Quality – philosophy; cost of quality; overview of the works of Juran, Deming, Crosby, Taguchi; quality loss function; PDCA cycle; quality control; quality assurance; quality audit; vendor quality assurance.

UNIT II: Quality organization; quality management; quality system; total quality management; quality awards; quality certification; typical procedure for ISO 9000, ISO 14000, QS 9000.

UNIT III: Review of some calculation procedures involving statistics and probability; exposure to some applications of statistics and probability; distribution functions; normal distribution curve.

UNIT IV: Variations; analysis of variance – statistical tools – statistical quality control; control charts; process capability analysis; statistical process control; introduction to six sigma

UNIT V: Inspection; inspection by sampling; acceptance sampling; statistical approaches; single, double and multiple sampling plans; statistical design of experiments.

Text Books:

1. Hansen B.L., P.M. Ghare, 'Quality Control and Application', PHI – EEE, 1997.

2. Juran J.M., and F.M.Gryna, 'Quality Planning and Analysis', McGraw Hill, New York, 2nd Edition, 1980

MST2041	Program Elective - IV **PLASTICITY AND PLASTIC DEFORMATION**	**L**	**P**	**C**
		3	**0**	**3**

M. Tech. – II Sem.

Objective*:*

1. To get knowledge on theory of plasticity
2. To get knowledge on elastic theory
3. To know about different stress states and crystal defects-dislocations
4. To understand the concept of severe plastic deformation

Outcome of the study*:*

1. Understands the theory of plasticity and theory of elasticity
2. The student gets acquainted with the stress states and its importance in yielding
3. Understands the concept of severe plastic deformation

UNIT-I: Elements of theory of plasticity, Basics of plastic deformation, The flow curve. True stress and true strain – Mohr's circle: one dimension, two dimensions and three dimension- Von Mises distortion energy criterion, maximum shear stress or Tresca criterion.

UNIT-II: Elasticity Theory**:** The State of Stress and strain, stress and strain tensor, tensor transformation, principal stress and strain, elastic stress-strain relation, anisotropy, elastic behaviour of metal

UNIT-III: Hydrostatic and Deviatoric stress, Octahedral stress, texture and distortion of yield surface, Limitation of engineering strain at large deformation,strain hardening, Ramberg-Osgood equation, stress - strain relation in plasticity.

UNIT-IV: Microscopic view of plastic deformation**:** classification of defects, geometry of dislocations, slip and glide, - Frank Read and grain boundary sources, stress and strain field around dislocations. Dislocation interactions, twinning, dislocation movement ,deformation behavior of single crystal, critical resolved shear stress (CRSS), deformation of poly-crystals

UNIT-V: Hall-Petch and other hardening mechanisms, grain size effect - source limited plasticity. Severe plastic deformation by ECAP – types – microstructural variation with different processing routes – multichannel ECAP – strain distribution and texturing.

Text Books:

1. G.E. Dieter, "Mechanical Metallurgy", McGraw-Hill, 1986.
2. R.W. Hertzberg, "Deformation and Fracture Mechanics of Engineering Materials", John Wiley and Sons, 1976.

References:

1. Hosford W.F. and Caddell R.M. “Metal forming mechanics and metallurgy”, Printice Hall 1983.
2. Aliofkhazraei (Ed), “Handbook of Mechanical nanostructuring” Contributed by .B.Ravisankar, Wiley-VCH Publishers, Germany, 2015.

MST2042	Program Elective - IV **CORROSION AND SURFACE ENGINEERING**	**L**	**P**	**C**
		3	**0**	**3**

M. Tech. – II Sem.

Objective*:*

1. To provide a practical knowledge about corrosion and its prevention in engineering field

2. To analyze various concepts of surface engineering and comprehend the design difficulties.

Outcome of the study*:*

1. The student will understand the corrosion principle and various forms of corrosion

2. Know the types of Pre-treatment methods to be given to surface engineering

3. Select the Type of Deposition and Spraying technique with respect to the application

4. Asses the surface testing methods and Comprehend the degradation properties

UNIT 1: Introduction: Definition of corrosion, Cost of Corrosion, corrosion damage, environments, classification of corrosion. Corrosion Principles: Electrochemical reactions, thermodynamics of corrosion, cell potential, emf and galvanic series, representation of cell / cell diagram, electrode kinetics, exchange current density, polarization - activation, concentration and combined, Pourbaix diagram, Evans diagram, Passivation.

UNIT 2: Forms of Corrosion: Uniform attack; galvanic or two-metal corrosion; crevice corrosion; pitting corrosion; intergranular corrosion – sensitization and weld decay; Selective leaching - dezincification; erosion corrosion; Stress corrosion cracking (SCC) and hydrogen damage. Case studies of corrosion in industry e.g. steel, chemical, fertilizer and food etc. Corrosion Prevention: Materials selection, alteration of environments, design,inhibitors, cathodic and anodic protection, coatings – electroplating.

UNIT 3: Surface modification of steel and ferrous components: Pack carburizing (principle and scope of application); Surface modification using liquid/molten bath: Cyaniding, liquid carburizing (diffusion from liquid state) (principle and scope of application). Surface modification using gaseous medium: Nitriding, carbonitriding (diffusion from gaseous state) (principle and scope of application).

UNIT 4: Advanced surface engineering: Surface engineering by energy beams: General classification, scope and principles, types and intensity/energy deposition profile; Laser assisted

microstructural modification – surface melting, hardening, shocking and similar processes; Laser assisted compositional modification – surface alloying of steel and non-ferrous metals and alloys; surface cladding, composite surfacing and similar techniques; Electron beam assisted modification and joining; Ion beam assisted microstructure and compositional modification

UNIT 5: Surface engineering by spray techniques: Flame spray (principle and scope of application); Plasma coating (principle and scope of application), HVOF, cold spray (principle and scope of application). Characterization of surface microstructure and properties for different surface engineering techniques.

Text Books:

1. Fontana M.G, Corrosion Engineering, Tata McGraw Hill, 3rd Edition, 2005
2. Sudarshan T.S, Surface Modification Technologies-An Engineers guide, Marcel Dekker, Newyork, 1989.

MST2043	Program Elective - IV **ADVANCED MANUFACTURING TECHNIQUES**	**L**	**P**	**C**
		3	**0**	**3**

M. Tech. – II Sem.

Objective*:*

1. To get knowledge on various advanced casting and joining techniques

2. To get knowledge on various advanced machining and forming techniques

Outcome of the study*:*

1. The student will understand the principles of machining manufacture a particular component

2. The student will have the knowledge of manufacturing of a component with modern technology

UNIT I: Advanced machining theory & practices - mechanisms of chip formation, shear angle relations, and theoretical determination of cutting forces in orthogonal cutting; analysis of turning, drilling, and milling operations; mechanics of grinding; dynamometry; thermal aspects of machining; tool wear; economics of machining; processing of polymers, ceramics, and composites.

UNIT II: Advanced machining processes – Process principles, Material removal mechanism, Parametric analysis and applications of processes such as ultrasonic machining (USM), Abrasive jet machining (AJM), Water jet machining (WJM), Abrasive water jet machining (AWJM), Electrochemical machining (ECM), Electro discharge machining (EDM), Electron beam machining (EBM), Laser beam machining (LBM) processes.

UNIT III: Advanced Casting Processes: Metal mould casting, Continuous casting, Squeeze casting, vacuum mould casting, Evaporative pattern casting, ceramic shell casting.

UNIT IV: Advanced Forming processes - electro-magnetic forming, explosive forming, electro-hydraulic forming, stretch forming, and contour roll forming.

UNIT V: Advanced welding processes - EBW, LBW, USW; Advanced foundry processes - metal mould, continuous, squeeze, vacuum mould, evaporative pattern, and ceramic shell casting.

Text books:

1. Materials and Processes in Manufacturing, E.P. DeGarmo, J. T Black, R.A.Kohser
2. Manufacturing Science, A. Ghosh, and A.K. Mallik,
3. Nontraditional Manufacturing Processes, G.F.Benedict, Marcel Dekker

Reference books:

1. ASM Hand book, Volume 15; Casting
2. ASM Hand book, Volume 6; Welding
3. ASM Hand book, Volume 16; Machining
4. ASM Hand book, Volume 14; Forming

MST205	METAL FORMING AND SIMULATION LAB	L	P	C
		0	4	2

M. Tech. – II Sem.

***Objective**:*

1. To know about the various testing methods for evaluation of metal forming techniques.

***Outcome of the study**:*

1. The student will be able to understand various deformation processes in materials.

2. The student will be able to understand various severe plastic deformation techniques like ECAP & ECAR

List of Experiments:

1. To demonstrate the effect of friction and height to diameter ratio in the axi-symmetric compression of a cylinder.
2. To determine the coefficient of interfacial friction during plastic deformation of metals by means of compression of a ring between two compression platens.
3. To learn the forming characteristics of sheet metal specimens with Deep Drawing operation.
4. To extrude a cylindrical cup by backward extrusion.
5. To find out the flow stress behavior of sheet metal under equi-biaxial stress condition.
6. Study of microstructure and hardness with forging condition and annealing temperatures for steel and aluminium specimens.
7. Severe plastic deformation testing using ECAP & ECAR process
8. Formability studies using Deform-2D & Deform-3D software

Equipment / Software required:

1. Compression testing machine
2. Deep drawing press
3. Extrusion press
4. Hydraulic bulge test-rig
5. Extrusion press and rolling mill setup for ECAP & ECAR processes
6. Deform-2D & Deform-3D software

MST206	ADVANCED POWDER METALLURGY LAB	L	P	C
		0	4	2

M. Tech. – II Sem.

Objective*:*

*1. To know about the powders testing, mechanical properties of gree**e**n compacts and sintered products*

Outcome of the study*:*

1. Will understand about the production of nano powders
2. Will be able to determine the mechanical properties of sintered products
3. Will be able to produce the sintered products by HIP technique

List of Experiments:

1. Synthesis of Nano powders by high energy ball milling
2. Determination of Flowability and compressibility of powders
3. Determination of specific surface area of powder particles
4. Determination of powder particle and its distribution
5. Determination of flexural strength of the green powder compacts by three point test
6. Consolidation of powder particles by Cold isostatic pressing
7. Consolidation of powder particles by Hot isostatic pressing
8. Determination of mechanical properties of sintered products

Equipment required:

1. High energy ball mill
2. Hall flow meter
3. B.E.T apparatus
4. Sieve analyzer for micro powder particles
5. Three point attachment for UTM
6. CIP setup
7. HIP setup
8. Sintering furnace with provision to control the atmosphere

M. Tech. – II Sem.

		L	P	C
MST207	**Mini Project with seminar**	**0**	**4**	**2**

MST208	PERSONALITY DEVELOPMENT THROUGH LIFE-ENLIGHTENMENT SKILLS	L	P	C
		2	0	0

M. Tech. – II Sem.

Objective:

1. To improve the overall personality of the student and to improve the skills required for facing an interview

2. To improve the skills required to grow as a good citizen to lead successful life

Outcome of the study:

1. The student will be able to face any kind of interview.

2. The student will be able to excel in his career.

UNIT I

Introduction to Personality Development The concept of personality - Dimensions of personality – Theories of Freud & Erickson-Significance of personality development. The concept of success and failure: What is success? - Hurdles in achieving success - Overcoming hurdles - Factors responsible for success – What is failure - Causes of failure. SWOT analysis.

UNIT II

Attitude & Motivation Attitude - Concept - Significance - Factors affecting attitudes - Positive attitude – Advantages –Negative attitude- Disadvantages - Ways to develop positive attitude - Differences between personalities having positive and negative attitude. Concept of motivation - Significance – Internal and external motives - Importance of self- motivation- Factors leading to de-motivation

UNIT III

Self-esteem Term self-esteem - Symptoms - Advantages - Do's and Don’ts to develop positive self-esteem – Low selfesteem - Symptoms - Personality having low self esteem - Positive and negative self esteem. Interpersonal Relationships – Defining the difference between aggressive, submissive and assertive behaviours - Lateral thinking.

UNIT IV

Other Aspects of Personality Development Body language - Problem-solving - Conflict and Stress Management - Decision-making skills - Leadership and qualities of a successful leader –

Character building -Team-work – Time management - Work ethics –Good manners and etiquette.

UNIT V

Employability Quotient Resume building- The art of participating in Group Discussion – Facing the Personal (HR & Technical) Interview -Frequently Asked Questions - Psychometric Analysis - Mock Interview Sessions.

Text books:

1. Hurlock, E.B (2006). Personality Development, 28th Reprint. New Delhi: Tata McGraw Hill.
2. Stephen P. Robbins and Timothy A. Judge(2014), Organizational Behavior 16th Edition: Prentice Hall.

Reference books:

1. Andrews, Sudhir. How to Succeed at Interviews. 21st (rep.) New Delhi.Tata McGraw-Hill 1988.
2. Heller, Robert.Effective leadership. Essential Manager series. Dk Publishing, 2002
3. Hindle, Tim. Reducing Stress. Essential Manager series. Dk Publishing, 2003
4. Lucas, Stephen. Art of Public Speaking. New Delhi. Tata - Mc-Graw Hill. 2001
5. Mile, D.J Power of positive thinking. Delhi. Rohan Book Company, (2004).
6. Pravesh Kumar. All about Self- Motivation. New Delhi. Goodwill Publishing House. 2005.
7. Smith, B . Body Language. Delhi: Rohan Book Company. 2004

MST3011	Program Elective - V **MOOCS**	**L** **3**	**P** **0**	**C** **3**

M. Tech. – III Sem.

MST3012	Program Elective - V **ADVANCED METALLURGICAL THERMODYNAMICS**	**L**	**P**	**C**
		3	**0**	**3**

M. Tech. – III Sem.

Objective*:*

1. To know the importance and applications of thermodynamics
2. To understand the laws of thermodynamics
3. To know the importance and applications of kinetics

Outcome of the study*:*

1. Understand fundamental laws of thermodynamics
2. Able to apply thermodynamics in understanding allotropic and phase changes in the metal and alloys
3. Competent to predict feasibility of various chemical reactions associated with synthesis of alloys and composites.
4. Familiarize with the role of transport phenomenon and mathematical and physical modeling.

UNIT I: Basics of Thermodynamics and Kinetics

Introduction to thermodynamics and kinetics – Different approaches; emphasis on metallurgical thermodynamics; transport phenomenon and applications

UNIT II: Laws of thermodynamics

Laws of thermodynamics and related applications – concepts of free energy and entropy – Criterion for spontaneity.

UNIT III: Solutions

Introduction to solutions – partial molar entities – Gibbs Duhem relations – thermodynamic aspects of metallic solutions and salt melts – Raoult's law and Henry's law – regular and quasi chemical models

UNIT IV: Thermodynamics of phases

Thermodynamic aspects of phase diagrams – similarity in thermodynamic approach towards different classes of materials – thermodynamic aspects of defect formation in metals and ceramics – approaches used in chemical models

UNIT V: Kinetics

Principles of metallurgical kinetics – reaction rates and reaction mechanisms – Overview of mass transfer, heat transfer and fluid flow – related applications in metallurgical processes – role of transport phenomenon and mathematical and physical modeling.

Text books:

1. Gaskell, David R., Introduction to Metallurgical Thermodynamics, McGraw Hill
2. Mohanty, A.K., Rate Processes in Metallurgy", Prentice Hall of India, 2000

References:

1. Darken and Gurry, Physical Chemistry of metals

MST3013	Program Elective - V **FE TECHNIQUES IN MATERIALS PROCESSING**	**L**	**P**	**C**
		3	**0**	**3**

M. Tech. – III Sem.

Objective*:*

1. To understand the various software in the metallurgical engineering field
2. To be understand finite element method for design optimization
3. To learn new design optimization techniques

Outcome of the study*:*

1. The student will understand the various software used in the metallurgical engineering field and their applications
2. The student will have a sound knowledge of using engineering techniques, tools and resources

UNIT I: FEM modelling - general steps; different approaches for deriving element properties: direct approach, variational approach, and Galerkin's method;

Unit II: Types of elements and interpolation functions; condensation and substructuring; continuity requirements; mesh refining; Gauss quadrature;

UNIT III: FE modelling for structural and thermal problems

UNIT IV: Analysis of deformation processes and microstructures using Deform software

UNIT V: Analysis of solidification for both casting and welding using SYSweld

Text books:

1. Material Science – Callister.
2. Material Science for Engineers – Schakleford.

References:

1. Material Science for Engineers – Vanvlack.

		L	P	C
MST3021	Open Elective **NANO TECHNOLOGY AND ENGINEERING APPLICATIONS**	**3**	**0**	**3**

M. Tech. – III Sem.

Objective*:*

1. The course is impart the knowledge about basics concepts of crystallography, quantum mechanics, matter and energy relation,

2. Provides the sound knowledge about de-Broglie hypothesis, wave function analogies, Schrodinger equation, quantum dot, wires and wells etc.

Outcome of the study*:*

1. Student can able to theorize the importance of crystal structure for property evaluation.

2. Student can assess different types of chemical bonding in materials.

3. To evaluate nano structures in quantum mechanical approaches.

4. Students can able to distinguish between classical electromagnetic theory and Quantum mechanics.

Unit-I: Introduction to Nanomaterials – Definitions – zero, one, two and three dimensional nanostructures; Basics of Chemistry – Chemical bonding, Hybridization, Reduction potentials. Crystal structure: Crystalline and amorphous solids; Crystal lattice and crystal structure; Translational symmetry; Space lattice - Unit cell and primitive cell - Symmetry elements in crystal - Seven crystal systems - Some imperfections in crystals - - Miller indices - Miller-Bravais indices - Indices of a lattice direction; The inter planar spacing of a set of crystal planes.

Unit-II: Reciprocal lattice and crystal imperfections: Bragg law- Reciprocal lattice – Properties of Reciprocal lattice- Reciprocal lattice of simple cube- diffraction conditions- Brillouion zones. Importance of lattice imperfections- types of imperfection-Point defects-dislocations.

Unit-III: Introduction to quantum mechanics - matter waves - De-Broglie hypothesis – wave particle duality- Heisenberg's uncertainty principle-Schrodinger wave equation – General postulates of Quantum mechanics- particle in one dimensional box. Particle in 2D and 3D Box, Bloch Theorem, Band theory of solids.

Unit-IV:Electronic,Optical and Magnetic properties:: Energy bands and gaps in semiconductors, Fermi surfaces ,localized particle, donors, acceptors, deep traps, excitons,

mobility, size dependent effects, conduction electrons and dimensionality Fermi gas and density of states, semiconducting nanoparticles. optical properties of semiconductors, band edge energy, band gap, dependence on nanocrystalline size, Luminescence, Introduction of magnetic materials, basics of ferromagnetism –magnetic clusters, dynamics of nanomagnets, , nanocarbon ferromagnets, ferrofluids.

UnitV: Applications: Nanomaterials in Environment, nanoparticles in air, water and soil. Nanomaterials in Health care, Cosmetics and Medicine. Nanomaterials for building and protection, Carbon Nanotubes – Mechanical reinforcement, Nanocomposites for surface coatings – rubber and polymer nanocomposites, Nanomaterials for clothing and textile products. : Smart electronics and sensors.– nanochips, nano batteries, photo-voltaic solar cells, dye-sensitized solar cells, Carbon nanotubes in fuel cells, catalysis.

Text books:

1. An introduction to solid states electronic devices by Ajay Kumar Saxena Macmillan India Ltd {Unit-I, II}
2. Solid state Physics by Kittle {Unit-I,II}
3. P.M.Mathews and K.Venkatesan, “A textbook of Quantum Mechanics”, Tata McGraw Hill Publishing Company Ltd {Unit-III}
4. Quantum Mechanics – Schiff {Unit-III}
5. Quantum Mechanics by B.k.Agarwal and Hariprakash, PHI {Unit-III}
6. Fundamentals of nanoelectronics by George W.Hanson Pearson education {Unit-IV,V}

References:

1. Quantum mechanics by Brandsen & Joachem
2. J.J.Sakurari, “Modern Quantum Mechanics Mc.Graw Hill, Addison Wesley Longman Inc., USA, 1999
3. Nano Technology and Nano Electronics – Materials, devices and measurement Techniques by WR Fahrner – Springer

MST3022	Open Elective **ENGINEERING MATERIALS AND STRUCTURES**	**L**	**P**	**C**
		3	**0**	**3**

M. Tech. – III Sem.

Objective*:*

1. To get knowledge on different engineering materials and their applications.

Outcome of the study*:*

1. Familiarizes with the concept of engineering materials of different metals, alloys, polymers and ceramics

2. Acquires knowledge with the concept of magnetic materials and Electronic materials

3. Familiarizes with the concept of smart materials and bio materials

UNIT I: Structural Materials

Metals & Alloys, Structural Polymers, Ceramics, Intermetallics, Bulk Metallic Glasses, Amorphous Materials

UNIT II: Magnetic Materials

Ferri and Ferro magnetic materials; Soft Magnets; Hard Magnets; Fe-Si alloys; Fe-Ni Alloys; Ferrites and Garnets; Fine particle magnets; Giant magneto resistance; Nanomagnetic materials.

UNIT III: Electronic Materials

Semi-conducting materials – concept of doping; compound semi-conductors – amorphous silicon, oxide semiconductors; amorphous semiconductors; MOSFET and CMOS

UNIT IV: Smart Materials

Shape memory alloys; rheological fluids

UNIT V: Biomaterials

Biocompatibility; Ti-implants; Hydroxyapatite; Bioactivity; Biopolymers

Text books:

1. Materials Science and Engineering – W.Callister
2.

References:

1. Material Science and Engineering – V. Raghavan

2. Park J.B. and Lakes R.S., Biomaterials: An Introduction
3. Mel Schwartz, " Encyclopedia of Smart Materials", Vol. I, John Wiley and Sons.

MST3023	Open Elective **ADVANCED METAL JOINING TECHNIQUES**	**L**	**P**	**C**
		3	**0**	**3**

M. Tech. – III Sem.

Objective*:*

1. To understand different metal joining techniques and their applicability for various ferrous and non-ferrous metals.

2. To understand the principle and problems associated with the welding of various metals

Outcome of the study*:*

1. The student will understand the basic theoretical knowledge of welding of ferrous metals and non-ferrous metals.

2. The student will have the knowledge about different welding processes and heat affected zone and its analysis.

3. The student will understand the quality control tests conducted on welded joints.

UNIT–I

Heat flow - temperature distribution-cooling rates - influence of heat input, joint geometry, plate thickness, preheat, calculation of heat input and heat affected zone width.

UNIT–II

Flux assisted GTAW process, friction welding processes, friction stir welding and friction surfacing, microwave Joining and hybrid welding.

UNIT–III

Weld metal solidification - Phase transformations- weld CCT diagrams - carbon equivalent-preheating and post heating- weldability of carbon steels and low alloy steels.

UNIT–IV

Welding of stainless steels use of Schaffler and Delong diagrams, welding of cast irons, welding of aluminum alloys.

UNIT–V

Welding of titanium alloys and welding of dissimilar metals. Weld defects: Causes and remedial measures, Weldability tests - effect of metallurgical parameters.

Text books:

1. Linnert G. E.,'Welding Metallurgy', Volume I and II, 4th Edition, AWS, 1994.
2. Granjon H., 'Fundamentals of Welding Metallurgy', Jaico Publishing House, 1994.

References:

1. Kenneth Easterling, 'Introduction to Physical Metallurgy of Welding', 2nd Edition, Butterworth Heinmann, 1992.
2. Saferian D., 'The Metallurgy of Welding', Chapman and Hall, 1985.
3. Jackson M. D., 'Welding Methods and Metallurgy', Griffin, London, 1967.
4. Mishra. R.S and Mahoney. M.W, Friction Stir Welding and Processing, ASM, 2007.
5. Welding Metallurgy – Sindo Kour, 2nd edition, published by Wiley.

MST303	DISSERTATION PHASE -I	L	P	C
		0	20	10

M. Tech. – III Sem.

MST401	DISSERTATION PHASE -II	L	P	C
		0	32	16

M. Tech. – IV Sem.