UNIVERSITY INSTITUTE OF ENGINEERING AND TECHNOLOGY
Kurukshetra University, Kurukshetra

M.Tech. (Material Science and Technology) – Scheme

Semester - I

Paper code	Subject	Teaching Schedule			Marks Allocation			Credit
		L	P	Total	External	Internal	Total	
MMST-101	Introduction to Materials	4	-	4	60	40	100	4
MMST-102	Characterization Techniques	4	-	4	60	40	100	4
MMST-103	Polymer Science and Technology	4	-	4	60	40	100	4
MMST-104	Thermodynamics of Materials	4	-	4	60	40	100	4
MMST-105	Material Science and Technology Lab - I	-	8	8	60	40	100	4
MMST-106	Seminar - I	-	-	2	-	50	50	2
	Total	*16*	*8*	*26*	*300*	*250*	*550*	*22*

Semester - II

Paper code	Subject	Teaching Schedule			Marks Allocation			Credit
		L	P	Total	External	Internal	Total	
MMST-201	Ion Beam Based Characterization Techniques	4	-	4	60	40	100	4
MMST-202	Statistical Methods for Data Analysis	4	-	4	60	40	100	4
MMST-203	Nanomaterials	4	-	4	60	40	100	4
MMST-204	Environmental Materials	4	-	4	60	40	100	4
MMST-205	Material Science and Technology Lab - II	-	8	8	60	40	100	4
MMST-206	Seminar - II	-	-	2	-	50	50	2
	Total	*16*	*8*	*26*	*300*	*250*	*550*	*22*

Semester - III

Paper code	Subject	Teaching Schedule			Marks Allocation			Credit
		L	D	Total	External	Internal	Total	
	Elective Paper - I*	4	-	4	60	40	100	4
	Elective Paper - II*	4	-	4	60	40	100	4
MMST-301	Major Project (Stage-1) : Literature Survey, Formulation of the Problem and Dissertation)	-	2	2	60	40	100	12
	Total	*8*	*2*	*10*	*180*	*120*	*300*	*20*

* Any advance course/area approved by BOS.

Semester - IV

Paper code	Subject	Teaching Schedule			Marks Allocation			Credit
		L	D	Total	External	Internal	Total	
MMST-401	Major Project (Stage-2) : Experimental Work, Data Analysis and Dissertation)*	-	4	4	100	100	200	20
	Total	*-*	*4*	*4*	*100*	*100*	*200*	*20*

* Each student is required to publish at least two research papers (minimum standards: one paper in a referred journal and one presentation in a National/International conference). Student has to submit proof of his/her publications/acceptance of research papers prior to the submission of Dissertation.

Introduction to Materials

MMST - 101

L	*P*	
4	*0*	*Theory : 60 marks* *Sessional: 40 marks* *Total: 100 marks* *Time: 3hrs*

Unit - I

Introduction: Historical perspective of materials, Material science and technology, Classification of materials, Advanced materials, Materials of the future, Modern materials' needs.

Metallic Materials: Ferrous alloys: Steels, Cast irons; Non-ferrous alloys: Copper, Aluminum, Magnesium, Titanium and its alloys, refractory metals, super alloys, noble metals; Fabrication of metals: forming operations, casting, miscellaneous techniques; Thermal processing of metals: annealing processes, heat treatment of steels, precipitation hardening.

Unit - II

Crystalline Materials: Crystalline and non-crystalline materials; Fundamental concepts: lattice translational vector, symmetry operation, space lattice, basis, crystal structure, unit and primitive cell, two and three-dimensional lattice types; Metallic crystal structures: FCC, BCC, HCP and their unit cell characteristics; Some simple crystal structures: Sodium chloride, Cesium Chloride, Diamond and cubic Zinc sulfide; Crystallographic points, directions and planes.

Unit - III

Dielectric Materials: Introduction, Types of dielectric materials, Different types of polarizations, Local or internal field, Clausius - Mosotti equation, Dielectric loss, Dielectric breakdown, Ferroelectric materials, Dielectric properties, Frequency and temperature dependence of dielectric properties, Applications of dielectrics.

Superconducting Materials: Introduction, Types of superconductors, Properties and applications of superconducting materials.

Unit - IV

Magnetic Materials: Basic terminology, Classification of magnetic materials, Langevin theory of diamagnetism and paramagnetism, Weiss theory of paramagnetism and Ferromagnetism, Ferrimagnetic materials: structure and applications; Hard and Soft magnetic materials; Energy product of magnetic material, Magnetic recording materials, Magnetic principle of analog recording and reading, Magnetic bubble memory, Magnetic principle in computer data storage, Magnetic tape, Floppy disk, Magnetic hard disk, Computer aided tomography.

Biomaterials: Introduction, Classification of biomaterials, Applications.

References Books:

1. Material Science and Engineering: An Introduction, W.D. Callister, *Wiley- India Pvt. Ltd., New Delhi.*
2. Introduction to Solid State Physics, C. Kittel, *John Wiley & Sons (ASIA) Pte. Ltd. Singapore.*
3. Material Science and Engineering, V. Raghavan, *PHI Learning Private Limited, New Delhi*.
4. Material Science, V. Rajendran, A. Marikani, *Tata McGraw-Hill Publishing Company Limited, New Delhi*.
5. Engineering Materials: Properties and Applications of Metals and Alloys, C.P. Sharma, *Prentice-Hall of India Private Limited, New Delhi*.
6. Biomaterials: The intersection of Biology and Materials Science, J.S. Temenoff, A.G. Mikos, *Pearson, New Delhi*.

Note: The examiner will set eight questions, taking two questions from each unit. Students will attempt five questions selecting at least one question from each unit. All questions will carry equal marks.

Characterization Techniques

MMST-102

L	*P*	
4	*0*	*Theory : 60 marks* *Sessional: 40 marks* *Total: 100 marks* *Time: 3hrs*

Unit - I

Hardness Testing Techniques: Introduction, Brinell hardness test: technique, precautions, advantages and applications, disadvantages; Vickers hardness test: process, derivation of Vickers formula, sources of errors, advantages and applications, disadvantages; Rockwell hardness test: introduction, dial reading, principle of operation, advantages, precautions; Superficial Rockwell hardness test: method, precautions; Microhardness test: method, precautions, applications; Comparison of Macrohardness and Microhardness tests.

Unit - II

Thermal Analysis Techniques: Introduction, Factors affecting thermal analysis results, Thermo-gravimetric Analysis (TGA) technique: components, kinetics of reactions, applications; Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC) Techniques: components, applications; Simultaneous TG-DTA and TG-DSC: techniques and applications.

Unit - III

Microscopic Analysis Techniques: Light Microscopy: elementary geometrical optics, limits of resolution, different types of microscopy; Electron Microscopy: introduction, electron optics; Principle, instrumentation, methodology and applications of Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM) and Atomic Force Microscope (AFM).

Unit - IV

Spectroscopy Techniques: Infrared Spectroscopy: introduction, molecular vibrations, instrumentation, modes of operations, sampling techniques and applications; Ultraviolet and Visible Spectroscopy: introduction, colour and light absorption- the chromophore concept, theory of electronic spectroscopy, instrumentation and sampling, solvent effects and applications.

References Books

1. Mechanical Behaviour and Testing of Materials, A.K. Bhargava, C.P. Sharma, *PHI Learning Private Limited, New Delhi*.

2. Instrumental Methods of Analysis, H.W. Willard, L.L. Merritt, J.A. Dean, F.A. Settle, *CBS Publishers & Distributers*, *New Delhi*.
3. Thermal Methods of Analysis: Principles, Applications and Problems, P.J. Haines, Blackie Academic & Professional, London.
4. Biophysics, V. Pattabhi, N. Gautham, *Narosa Publishing House, Kolkata.*
5. Organic Spectroscopy, *W. Kamp, Replika Press Pvt. Ltd. India*.

Note: The examiner will set eight questions, taking two questions from each unit. Students will attempt five questions selecting at least one question from each unit. All questions will carry equal marks.

Polymer Science and Technology

MMST-103

L	*P*	
4	*0*	*Theory : 60 marks* *Sessional: 40 marks* *Total: 100 marks* *Time: 3hrs*

Unit - I

Basic Concepts: Specific features of polymer structure: regular, irregular polymers, chemical heterogenity, polydisperity, polar and non polar polymers; Classification of polymers, Polymerization mechanisms, Molecular weight of polymers: number-average, weight-average, Z-average and viscosity average; Chemical transformation of polymers: degradation, effect of high temperature, mechanical transformations, light and ionizing radiations, chemical degradation.

Unit - II

Glass Transition Temperature: Definition, Glassy solids and glass transition, Transition and associated properties, Factors affecting glass transition temperature, Glass transition temperature and molecular weight, Glass transition temperature and plasticizers, Glass transition temperature of co-polymers, Glass transition temperature and melting point, Importance of glass transition temperature, Heat distortion temperature, Determination of glass transition temperature.

Unit - III

Crystallinty in Polymers: Crystalline solids and their behaviour towards x-rays polymers and x-ray diffraction, Degree of crystallinity, Crystallisability, Crystallites, Helix structures, Spherulites, Polymer single crystals, Effect of crystallinity on preparation of polymers.

Unit - IV

Ceramics: Clays, Silica, Feldspars, Methods for fabrication of ceramic ware, Ceramic products, Glazes procelain and Vitreous enamels.

Composite Materials: Introduction, Constitution, Classification: particle-reinforced composites, fibre-reinforced composites, structural composites, hybrid composites; Processing of Fibre: reinforced composites, Applications of composite materials.

References Books

1. Physical Chemistry of Polymers, A. Tager, Mir Publishers.
2. A Text book of engineering Chemistry, S.S. Dara, S. Chand & Company Ltd.
3. Industrial Chemistry, O.P. Vermani, A.K. Narula, Galgotia Publications Pvt. Ltd.

Note: The examiner will set eight questions, taking two questions from each unit. Students will attempt five questions selecting at least one question from each unit. All questions will carry equal marks.

Thermodynamics of Materials

MMST-104

L	*P*	
4	*0*	*Theory: 60 marks* *Sessional: 40 marks* *Total: 100 marks* *Time: 3hrs*

Unit - I

Basic Concepts of Classical Thermodynamics: Methodology and scope of thermodynamics, Thermodynamics system, State and phase, Equilibrium and non-equilibrium systems, Reversible, Irreversible and Quasistatic processes, State parameters and functions, The zeroth and first laws of thermodynamics and their consequences.

Thermodynamics Potentials: Definitions, Physical meaning and transformations of thermodynamics potentials, Maxwell relations and transformations of thermodynamic parameters, Chemical potential as natural variable.

Laws and Equations of Thermodynamics: The second law of thermodynamics, The third law of thermodynamics, Extremum principles in equilibrium thermodynamics, Equations of state.

Unit - II

Entropy: Entropy as state functions, Entropy differentials, Entropy as a measure of energy quality, Balance of entropy in isolated, closed and open systems, Micro- and macro-states molecular interpretation of entropy and increase of disorder.

Chosen Elements of Statistical Thermodynamics: Distribution function, Boltzmann probability distribution, Canonical Ensemble, Entropy of mixing.

Chosen Applications of Classical Thermodynamics: Ideal and real gases, Thermo-dynamical quantities for pure liquids and solids, Many component solutions: ideal, non-ideal, dilute, regular; Thermodynamics functions of mixing.

Unit - III

Thermodynamics of Chemical Transformations: Energy conservation in chemical reactions, Thermal effects of chemical reactions, Hess law, Kirchoff law, Chemical reaction rate, Chemical equilibrium and the law of mass action, Entropy production in chemical reaction, Coupled reactions, Le Chatelier-Braun principle.

Stationary States: Entropy production in the stationary state, Stability of stationary state, Stationary state with chemical reactions, Coupling of stationary states.

Unit - IV

Thermodynamics of Phase Changes: Phase equilibrium and the Gibbs phase rules, Phase diagram, Phase transitions: thermodynamics, classification and free energy at the phase transition, Gibb theory of crystallisation, Crystallisation rate, Avrami equation.

Fundamentals of Non-equilibrium Thermodynamics: Characteristic of the non-equilibrium systems, Entropy production in irreversible processes.

Local Equilibrium and Local Formulation of the Second Law: Maximum and minimum of entropy production, Minimisation of energy dissipation, Negentropy.

References Books

1. Introduction to Modern Thermodynamics, D. Kondepudi, *John Wiley & Sons, New York*.
2. Modern Thermodynamics: From Heat Engine to Dissipative Structures, D. Kondepudi, IIya Prigogine, *John Wiley & Sons, New York*.
3. Thermodynamics of Materials: Tom 1, D.V. Ragone, *John Wiley & Sons, New York*.
4. Thermodynamics of Materials: Tom 2, D.V. Ragone, *John Wiley & Sons, New York*.
5. Introduction to the Thermodynamics of Materials, D.R. Gaskell, *Taylor & Francis, New York.*
6. Physical Ceramics: Principles for Ceramic Science and Engineering, Y. Ming, D.P. Birnie, W.D. Kingery, *John Wiley & Sons, New York.*

Note: The examiner will set eight questions, taking two questions from each unit. Students will attempt five questions selecting at least one question from each unit. All questions will carry equal marks.

Material Science and Technology Lab- I

MMST-105

L	*P*	
0	*3*	*Practical : 60 marks* *Sessional : 40 marks* *Total : 100 marks* *Time : 3hrs*

1. To characterize the thermo-gram and differential thermo-grams of some compounds.
2. To determine the molecular weight of polystyrene sample using viscometric method.
3. To prepare phenol-formaldehyde resin (Resole) and then convert it into phenolic laminate.
4. To prepare Hexamethylene –diamine and Adipic acid (Nylon 66) polymer.
5. To determine the amount of sodium and potassium in different water samples by flame photometer.
6. To find the band gap of semiconductor using four probe method.
7. To study the hysteresis loss by tracing a BH curve.
8. To study the hardness of materials by Brinell hardness testing machine.
9. To study the hardness of materials by Rockwell hardness testing machine.
10. To study the hardness of materials by Vicker hardness testing machine.

Note: At least eight experiments should be performed by the students. The experiments may be included or excluded depending upon lab facility.

Ion Beam Based Characterization Techniques

MMST-201

L	*P*	
4	*0*	*Theory: 60 marks* *Sessional: 40 marks* *Total: 100 marks* *Time: 3hrs*

Unit - I

Rutherford Backscattering Spectroscopy: Introduction, Scattering fundamentals: kinematic factor, stopping cross-section, Rutherford scattering cross-section; Principle of Rutherford Backscattering Spectroscopy, Fundamental of RBS techniques and its characteristics, Deviations from Rutherford formula, Instrumentation/Experimental, RBS spectra from thin and thick layer, Spectrum Analysis/Simulation, Applications and limitations of RBS.

Unit - II

Elastic Recoil Detection Technique: Introduction, Fundamentals of the ERDA technique, Principle and characteristics of ERDA, ERDA using E-detection, ERDA with particle identification and depth resolution: ERD using transmission telescope, position-sensitive detector, Time-of-flight spectrometry; Heavy ion ERDA, Data analysis, Advantages and limitations of ERDA.

Unit - III

Accelerator Mass Spectrometry (AMS): Introduction, Principle, Experimental, AMS using low-energy accelerators, Sample preparation for AMS, Time-of-Flight Spectrometry (TOF-MS), Detection limits of particle analyzed by AMS, Applications of AMS, Advantages and limitations of AMS.

Unit - IV

XRF and PIXE Techniques: Introduction, Principle of XRF and PIXE techniques, Theory and concept, Instrumentation/Experimentation: modes of excitation for XRF analysis, x-ray detection and analysis in XRF, Source of excitation and x-ray detection in PIXE analysis: ion sources, choice of beam/PIXE using heavy ion beams, Qualitative and Quantitative analysis, Sources of background, Applications of XRF and PIXE techniques.

References Books

1. Atomic and Nuclear Analytical Methods, H.R. Verma, *Springer Berlin Heidelberg, New York*.
2. Fundamentals of Surface and Thin Film Analysis, L.C. Feldman, J.W. Mayer, *North Holland, New York*.

Note: The examiner will set eight questions, taking two questions from each unit. Students will attempt five questions selecting at least one question from each unit. All questions will carry equal marks.

Statistical Methods for Data Analysis

MMST-202

L	*P*	
4	*0*	*Theory: 60 marks*
		Sessional: 40 marks
		Total: 100 marks
		Time: 3hrs

Unit - I

Statistical Methods: Introduction, Functions and Importance.

Measures of Central Tendency: Measure of average value: introduction, objectives, requisites of good average and types; Simple Arithmetic Mean: method- individual observations, discrete series, continuous series, open-end classes, properties, merits and demerits; Weighted Arithmetic Mean, Median: method-individual observations, discrete series, continuous series, property, merits and demerits, usefulness; Mode: method-individual observations, discrete series, continuous series, merits, demerits and usefulness; Relation between Mean, Median and Mode, Geometric Mean: properties, methods-individual observations, discrete series, continuous series, uses, merits and demerits; Harmonic mean: methods, usefulness, merits and demerits; Relationship between AM, GM and HM.

Unit - II

Measures of Dispersion: Introduction, Significance, Properties and methods, Range: method, merits, demerits and uses; The Interquartile Range or the Quartile deviation: method, merits, demerits; Mean Deviation: method in discrete and continuous series, merits, demerits and usefulness; The Standard Deviation: method in discrete and continuous series, properties, coefficient of variation, variance, merits and demerits.

Skewness and Kurtosis: Skewness: introduction, tests, methods, moments, moments about arbitrary origin, Sheppard's correction for grouping errors, measure of Skewness based on moments; Measures of Kurtosis.

Unit - III

Theoretical Distribution: Introduction, Binomial Distribution: introduction, properties, constants, standard deviation, importance, fitting; Poisson Distribution: introduction, constants, role, fitting; Normal Distribution: introduction, graph, importance, properties, condition for normality, area under the curve, significance, methods of fitting- ordinates and areas.

Unit - IV

Propagation of Errors: Standard error of a sum, difference, product and compound quantity.

Empirical Laws and Curve fitting: Introduction, Graphical method, Law Reducible to Linear Law, Principle of least squares, Working procedure to fit the straight line, parabola and other curves; χ^2 test and goodness of fit.

References Books

1. Statistical Methods, S.P. Gupta, *Sultan Chand & Sons Educational Publishers, New Delhi*.
2. Theory of Error, J. Topping, *Unwin Brothers Limited, London*.
3. Higher Engineering Mathematics, B.S. Garewal, *Khanna Publications, New Delhi*.
4. An Introduction to Probability: Theory and its Applications, Vol.-I, W. Feller, *Wiley India*.

Note: The examiner will set eight questions, taking two questions from each unit. Students will attempt five questions selecting at least one question from each unit. All questions will carry equal marks.

Nanomaterials
MMST-203

L	*P*	
4	*0*	*Theory : 60 marks* *Sessional: 40 marks* *Total: 100 marks* *Time: 3hrs*

Unit - I

Material Science at Nanoscale: Introduction, Lesson from nature, Nanoworld is uniquely different, Classification of nanomaterials, Applications in various fields.

Nanoparticle Synthesis: Introduction, Classification of nanoparticles synthesis techniques, Solid-state synthesis of nanoparticles, Vapor phase synthesis of nanoparticles: inert gas condensation, plasma based, flame based, spray pyrolysis; Solution processing of nanoparticles: sol-gel, solution precipitation, water-oil microemulsion.

Unit - II

Carbon Nanotubes: Introduction, Structure of carbon nanotubes : single-wall, multiwall; Synthesis of carbon nanotubes, Solid carbon source-based production techniques: laser ablation, electric arc, three phase ac arc plasma; Gaseous carbon source-based production techniques: heterogeneous process, homogeneous process; Synthesis of carbon nanotubes with controlled orientation, Growth mechanism of carbon nanotubes: catalyst-free growth, catalytically activated growth, low and high temperature conditions; Properties of carbon nanotubes, Applications of carbon nanotubes.

Unit - III

Metal Oxide Nanoparticles: Introduction, Synthesis Methods: Hot-injection, Heating-up, Solvothermal, Seed-Mediated growth, Self-Assembled nanoparticles; Organic-Inorganic Hybrid Materials: introduction, rare earth oxide based hybrid nanoparticles, tungsten oxide based hybrid materials, hybrid materials synthesized in other solvents; Properties and Applications.

Unit - IV

Polymer Nanocomposites: Introduction, Polymer matrices, Synthesis methods, Solution intercalation, Melt intercalation, Roll milling, In-situ polymerization, Emulsion polymerization, High shear mixing, Properties of polymer nanocomposites, Applications of polymer nanocomposites,

References Books

1. Nanomaterials Handbook, edited by Y. Gogotsi, *Taylor & Francis Group, New York.*
2. Springer Handbook of Nano-technology, edited by B. Bhushan, *Springer*.

3. Carbon Nanotubes: Properties and Applications, edited by M.J. O'Connell, *Taylor & Francis Group, New York*
4. Metal Oxide Nanoparticles in Organic Solvents: Synthesis, Formation, Assembly and Applications, M. Niederberger, N.Pinna, *Springer*, *New York*.
5. Polymer Nanocomposites: Processing, Characterization and Applications, J.H. Koo, *McGraw Hill, New York*.
6. Principles of Polymer Science, P. Bahadur, N.V. Sastry, *Narosa Publishing House, New Delhi.*
7. Nanotechnology: Basic Science and Emerging Technologies, M. Wilson, M. Simmons, B. Raguse, *Overseas Press, New Delhi*.
8. Nano Science and Technology, Edited by R.W. Kelsall, I.W. Hamley, M. Geoghegan, *John Wiley & Sons Ltd, India*.

Note: The examiner will set eight questions, taking two questions from each unit. Students will attempt five questions selecting at least one question from each unit. All questions will carry equal marks.

Environmental Materials

MMST-204

L	*P*	
4	*0*	*Theory : 60 marks* *Sessional: 40 marks* *Total: 100 marks* *Time: 3hrs*

Unit - I

Environmental Materials: Introduction, Approaches/Methods of considering environmental impact of a material or product: life cycle analysis.

Raw Material Extraction: Introduction, Extraction of Aluminum and Iron, Environmental impact of extraction metallurgy, Energy consumption in extraction of material and in recycling of a product: in case of Aluminum and Steel.

Unit - II

Design of Materials: Proper material selection, Process selection and product design for successful recycling, Waste minimization, Energy efficiency and increased lifetime.

Impact of Processing of Materials: Environmental problems associated with processing of metals, polymers, ceramics, composites, food and methods to overcome these problems.

Unit - III

Sustainable Materials: Introduction, Uses of sustainable materials generally plant- based materials: wood, natural fiber composites, natural polymers; Recycled materials like polymers, composites, aluminium and steel.

Materials for Green Energy: Need of renewable energy, Brief description of bio-fuel, biomass, hydroelectricity, geothermal, solar energy, tidal power, wind power, wave power as resources for renewable energy, Production of green energy: solar cell materials, fuel cell technology and catalytic pollution control.

Unit - IV

Economic and Legislation Issues: Economic consideration in material science: component design, material selection and manufacturing cost for various techniques; Environmental legislation: various laws and policies regarding environmental impact of materials.

End-of Life issues: Introduction, Recycling issues of metals, glass, composite materials, plastics and rubbers.

References Books

1. Materials and Environment -Eco Informed Material Choice, M.F. Ashby, *Elsevier*.

2. Sustainable Energy without Hot Air, J.C. Mackay, *UIT Cambridge, England*.
3. Environmental Laws, Cases and Materials, P. Weinberg, *University Press of America*.
4. Fundamentals of Materials for Energy and Environmental Sustainability, D.S. Ginley, D. Cahen (Edited book), *Cambridge University Press*.
5. Environmental Ethics and Policy Book: Philosophy, Ecology, Economics, D.V. De Veer, *Wadsworth publisher.*

Note: The examiner will set eight questions, taking two questions from each unit. Students will attempt five questions selecting at least one question from each unit. All questions will carry equal marks.

Material Science and Technology Lab - II

MMST-205

L	*P*	
0	*3*	*Practical: 60 marks* *Sessional: 40 marks* *Total: 100 marks* *Time: 3hrs*

Ten experiments will be included related with the synthesis/characterization of materials. At least eight experiments will be performed by the students.