# M.Tech. PROGRAMME MATERIALS ENGINEERING

(Duration : 2 Years, 64 credits)

## Hard core (8 credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Credit Hours</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>MT 202</td>
<td>3:0</td>
<td>Thermodynamics and Kinetics</td>
</tr>
<tr>
<td>MT 241</td>
<td>3:0</td>
<td>Structure and Characterisation of Materials</td>
</tr>
<tr>
<td>MT 243</td>
<td>0:2</td>
<td>Laboratory Experiments in Metallurgy</td>
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## Soft core (9 credits): Any three out of the following eight courses

<table>
<thead>
<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>MT 203</td>
<td>3:0</td>
<td>Materials Design and Selection</td>
</tr>
<tr>
<td>MT 209</td>
<td>3:0</td>
<td>Defects in Materials</td>
</tr>
<tr>
<td>MT 220</td>
<td>3:0</td>
<td>Microstructural Design and Development of Engineering Materials</td>
</tr>
<tr>
<td>MT 231</td>
<td>3:0</td>
<td>Interfacial Phenomena in Materials Processing</td>
</tr>
<tr>
<td>MT 245</td>
<td>3:0</td>
<td>Transport Processes in Process Metallurgy</td>
</tr>
<tr>
<td>MT 252</td>
<td>3:0</td>
<td>Science of Materials Processing</td>
</tr>
<tr>
<td>MT 253</td>
<td>3:0</td>
<td>Mechanical Behaviour of Materials</td>
</tr>
<tr>
<td>MT 260</td>
<td>3:0</td>
<td>Polymer Science and Engineering – I</td>
</tr>
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## Project (32 credits)

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<tr>
<th>Course Code</th>
<th>Credit Hours</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>MT 299</td>
<td>0:32</td>
<td>Dissertation Project</td>
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**Electives (15 credits):** At least 9 credits must be taken from the courses offered by the Department.

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### MT 209 (AUG) 3:0

**Defects in Materials**

- Review of defect classification and concept of defect equilibrium.
- Review of point defects in metallic, ionic and covalent crystals.
- Dislocation theory - continuum and atomistic.
- Dislocations in different lattices. Role of anisotropy.
- Dislocation kinetics. Interface thermodynamics and structure.
- Overview of grain boundaries, interphase boundaries, stacking faults and special boundaries.
- Interface kinetics: migration and sliding.
- Defect interactions: point defect-dislocation interaction, dislocation-interface interactions, segregation, etc.
- Overview of methods for studying defects including computational techniques.

**Karthikeyan Subramanian**


### MT 202 (AUG) 3:0

**Thermodynamics and Kinetics**

- Classical and statistical thermodynamics, Interstitial and substitutional solid solutions, solution models,
phase diagrams, stability criteria, critical phenomena, disorder-to-order transformations and ordered alloys, ternary alloys and phase diagrams, Thermodynamics of point defects, surfaces and interfaces. Diffusion, fluid flow and heat transfer.

Abinandanan T A


MT 218 (AUG) 3:0
Modeling and Simulation in Materials Engineering

Importance of modeling and simulation in Materials Engineering. nd numerical approaches. Numerical solution of ODEs and PDEs, explicit and implicit methods, Concept of diffusion, phase field technique, modelling of diffusive coupled phase transformations, spinodal decomposition. Level Set methods, Celula Automata,: simple models for simulating microstructure,.. Finite element modelling,: Examples in 1D, variational approach, interpolation functions for simple geometries, (rectangular and triangular elements); Atomistic modelling techniques,: Molecular and Monte-Carlo Methods.

Abhik N Choudhury


MT 235 (AUG) 3:0
Corrosion Technology

Basic electrochemical principles governing corrosion. Types and mechanisms of corrosion. Advances in corrosion engineering and control. Anodic and Cathodic control-Biocorrosion, mechanisms and microbiological aspects. Corrosion under sub-soil and sea water conditions- Marine biofouling and biocorrosion with respect to industrial conditions. Methods of abatement.

Abinandanan T A


MT 260 (AUG) 3:0
Polymer Science and Engineering

Fundamentals of polymer science. Polymer nomenclature and classification. Current theories for describing molecular weight, molecular weight distributions. Synthesis of monomers and polymers. Mechanisms of polymerization reactions. Introduction to polymer processing (thermoplastic and thermoset). Structure, property relationships of polymers: crystalline and amorphous states, the degree of crystallinity, cross-linking, and branching. Stereochemistry of polymers. Instrumental methods for the elucidation of polymer structure and properties; basic principles and unique problems encountered when techniques such as thermal (DSC, TGA, DMA, TMA, TOA), electrical, and spectroscopic (IR, Raman, NMR, ESCA, SIMS) analysis GPC, GC-MS, applied to polymeric materials. Polymer Processing - Injection Molding, Extrusion, Compression Molding, Blow Molding, Casting and Spin Coat, Calendering.
Praveen C Ramamurthy


MT 253 (AUG) 3:0

Mechanical Behaviour of Materials


Subodh Kumar


MT 245 (AUG) 3:0

Transport Processes in Process Metallurgy


Govind S Gupta


MT 241 (AUG) 3:0

Structure and Characterization

Bonding and crystal structures, Stereographic projection, Point and space groups, Defects in crystals, Schottky and Frenkel defects, Charged defects, Vacancies and interstitials in non stoichiometric crystals, Basics of diffraction theory, X-ray powder diffraction and its applications, Electron diffraction and Electron microscopy.

Rajeev Ranjan


MT 258 (JAN) 3:0

Mechanical Behavior of Thin Films
Short description of common thin film deposition techniques; Origin of residual stresses; Determination of stress state in thin films deposited on substrate; Stress relaxation processes, including hillocking and whiskering, grain boundary sliding, and interface governed phenomenon, such as dewetting, buckling, interfacial fracture, interfacial sliding, etc.; Size effects; Mechanical testing of thin films, including nanoindentation.

Praveen Kumar


MT 250 (JAN) 3:0
Introduction to Materials Science and Engineering

Compulsory for M.E. students who do not have BE Metallurgy; Compulsory for research students without materials background


Subodh Kumar


MT 208 (JAN) 3:0
Diffusion in Solids

Aloke Paul


MT 213 (JAN) 3:0
Electronic Properties of Materials

Introduction to electronic properties; Drude model, its success and failure; energy bands in crystals; density of states; electrical conduction in metals; semiconductors; semiconductor devices; p-n junctions, LEDs, transistors; electrical properties of polymers, ceramics, metal oxides, amorphous semiconductors; dielectric and ferroelectrics; polarization theories; optical, magnetic and thermal properties of materials; application of electronic materials: microelectronics, optoelectronics and magnetoelectrics.
Subho Dasgupta


MT 225 (JAN) 3:0
Deformation and Failure Mechanisms at Elevated Temperatures

Phenomenology of Creep, Microstructural considerations in metals, alloys, ceramics and composites. Creep mechanisms, Deformation mechanism maps, Superplasticity in metal alloys, ceramics and nanophase materials, Commercial applications and considerations, Cavitation failure at elevated temperatures by nucleation, growth and interlinkage of cavities.

The course will also include some laboratory demonstrations of the phenomena discussed in the class together with an appropriate analysis of the data.

Atul H Chokshi


MT 256 (JAN) 3:0
Fracture


Vikram Jayaram


MT 299 (JAN) 0:32
Dissertation Project

The M.E. Project is aimed at training the students to analyse independently any problem posed to them. The project may be a purely analytical piece of work, a completely experimental one or a combination of both. In a few cases, the project can also involve a sophisticated design work. The project report is expected to show clarity of thought and expression, critical appreciation of the existing literature and analytical and/or experimental or design skill.

MT 231 (JAN) 3:0
Interfacial Phenomena in Materials Processing

Materials and surfaces, Adsorption from solution, Thermodynamics of adsorption - surface excess and surface free energy, Gibbs equation, adsorption isotherms, wetting, contact angle, Young’s equation, Monolayer and interfacial reactions, Electrical phenomena at interfaces, electrochemistry of the double layer, electrophoresis, flocculation, coagulation and dispersion, Polymers at interfaces, Emulsions. Applications in Materials Processing.

Subramanian S


MT 248 (JAN) 3:0
Modelling and Computational Methods in Metallurgy

Basic principles of physical and mathematical modelling. Similarity criteria and dimensional analysis. Detailed study of modelling of various metallurgical processes such as blast furnace, induction furnace, ladle steelmaking, rolling, carburizing and drying. Finite difference method. Solution of differential equations using various numerical techniques. Convergence and stability criteria.

Assignments will be based on developing computer code to solve the given problem. Prerequisite: Knowledge of transport phenomena, program language

Govind S Gupta


MT 243 (JAN) 0:2
Laboratory Experiments in Materials Engineering

Experiments in Metallographic techniques, heat treatment, diffraction mineral beneficiation, chemical and process metallurgy, and mechanical metallurgy.

Rajeev Ranjan

MT 201 (JAN) 3:0
Phase Transformations

Overview of phase transformations, nucleation and growth theories, coarsening, precipitation, spinodal decomposition, eutectoid, massive, disorder-to-order, martensitic transformations, crystal interfaces and microstructure. topics in the theory of phase transformations: linear stability analysis, elastic stress effects, sharp interface and diffuse interface models of microstructural evolution.
Chandan Srivastava

MT 255 (JAN) 3:0
Solidification Processing

Advantage of solidification route to manufacturing, the basics of solidification including fluid dynamics, solidification dynamics and the influence of mould in the process of casting. Origin of shrinkage, linear contraction and casting defects in the design and manufacturing of casting, continuous casting, Semi-solid processing including pressure casting, stir casting and thixo casting. Welding as a special form of manufacturing process involving solidification. Modern techniques of welding, the classification of different weld zones, their origin and the influence on properties and weld design. Physical and computer modeling of solidification processes and development of expert systems. New developments and their possible impact on the manufacturing technology in the future with particular reference to the processes adaptable to the flexible manufacturing system.

Abhik N Choudhury

MT 257 (JAN) 3:0
Finite Element Method for Materials Engineers

This course has been specially designed for those students, who did not get a chance to study FEM during undergrad, but want to use FEM as a tool to gain some insight into their project/research problems. The syllabus includes the following: Quick recap of relevant mathematical concepts. Introduction to fundamentals of elasticity and plasticity. Crystal plasticity. Philosophy of FEM. Fundamentals of FEM, such as concepts of meshing, stiffness matrix, interpolation functions. Residual methods, Rayleigh - Ritz method, Galerkin method. 1-D, 2-D and 3-D example problems in elasticity and heat transfer. Solving linear and non-linear structural, thermal and electrical problems using a commercial FEM software (mostly, ANSYS). Finite element crystal plasticity.

Praveen Kumar,Cook,R. D.,et al,Concept and Applications of Finite Element Analysis

MT 261 (JAN) 3:0
Organic Electronics

Praveen C Ramamurthy

MT 271 (JAN) 3:0
Introduction to Biomaterials Science and Engineering

This course will introduce basic concepts of biomaterials research and development including discussion on different types of materials used for biomedical applications and their relevant properties. Content: Surface engineering for biocompatibility; Protein adsorption to materials surfaces; Blood compatibility of materials; Immune response to materials; Corrosion and wear of implanted medical devices; Scaffolds for tissue engineering and regenerative medicine; Concepts in drug delivery;

Kaushik Chatterjee

MT 262 (JAN) 3:0
Concepts in Polymer Blends and Nanocomposites

Introduction to polymer blends and composites, nanostructured materials and nanocomposites, Polymer-polymer miscibility, factors governing miscibility, immiscible systems and phase separation, Importance of interface on the property development, compatibilizers and compatibilization, Blends of amorphous & semi-crystalline polymers, rubber toughened polymers, particulate, fiber reinforced composites. Nanostructured materials like nano clay, carbon nanotubes, graphene etc. and polymer nanocomposites. Surface treatment of the reinforcing materials and interface/interphase structures of composites / nanocomposites. Various processing techniques like solution mixing, melt processing. Unique properties of blends, composites/nanocomposites in rheological, mechanical, and physical properties and applications

Suryasarathi Bose

MT 220 (JAN) 3:0
Microstructural Engineering of Structural Materials

Review of crystal defects: dislocation theory, grain boundaries and heterophase boundaries, defect kinetics and defect interactions; Role of microstructure on mechanical properties: strengthening mechanisms, ductilizing mechanisms, toughening mechanisms, effect of microstructure on creep, fatigue and impact resistance; Methods of controlling microstructures: phase transformations (L?S, V?S, S? S), heat treatments, solidification, mechanical processing, texture control, recovery and recrystallization, sintering, etc; Case studies of microstructural control of engineering metals, alloys and ceramics (Ni-base superalloys, YSZ, ceramic-matric composites, Ti-alloys, steels, etc)

Karthikeyan Subramaniam, Dipankar Banerjee, Abhik N Choudhury