MATERIALS CURRICULUM

Major:	**Core Courses :**	**21 Credits**
	Core Labs:	**5 Credits**
	Electives:	**9 Credits**
Minor:	**Core Course:**	**9 Credits**
	Core Labs:	**1 credit**
	Electives:	**6 Credits**

List of Courses

Core Courses [Those marked (*) are for Materials Minor]

MT 101	3:0	January	Introduction to Materials Science (*)
MT 102	3:0	January	Introduction to Materials Processing
MT 106	0:1	January	Lab: Materials Processing
MT 111	3:0	August	Structure of Materials (*)
MT 112	3:0	August	Materials Thermodynamics (*)
MT 113	3:0	August	Materials Kinetics
MT 116	0:1	August	Lab: Characterization – I (*)
MT 121	3:0	January	Mechanical Behaviour
MT 122	3:0	January	Electronic Properties
MT 126	0:1	January	Lab: Characterization II
MT 127	0:1	January	Lab: Mechanical Behaviour
MT 136	0:1	August	Lab: Electronic Properties

Electives (100 level; New courses)

MT 151	3:0	Modelling and Simulations
MT 152	3:0	Process Metallurgy
MT 153	3:0	Electrochemistry and Corrosion

Electives (200 level; Existing courses)

MT 203	3:0	Materials Design and Selection
MT 208	3:0	Diffusion in Solids
MT 225	3:0	Deformation and Failure Mechanisms at Elevated Temperatures
MT 233	3:0	Biomaterials
MT 252	2:1	Science of Materials Processing
MT 254	3:0	Mechanics of Contact, Thin Films and Interfaces
MT 255	3:0	Solidification Processing
MT 260	3:0	Polymer Science and Engineering

Other graduate-level courses

MT 231	3:0	Interfacial Phenomena in Materials Processing
MT 245	3:0	Transport Processes in Process Metallurgy
MT 246	3:0	Light Metals, Alloys and Composites
MR 317	3:0	Crystal Growth: Thin Films and Nanostructures

Every year, we will also identify, in consultation with instructors, materials related courses in fields such as mechanical engineering, instrumentation and applied physics, nanoscience, and nanotechnology.

MT 101 3:0 January (4th Semester)
Introduction to Materials Science

Bonding, types of materials, basics of crystal structures and crystallography. Thermodynamics, thermochemistry, unary systems, methods of structural characterization. Thermodynamics of solid solutions, phase diagrams, defects, diffusion. Solidification. Solid-solid phase transformations. Mechanical behaviour: elasticity, plasticity, fracture. Electrochemistry and corrosion. Band structure, electrical, magnetic and optical materials. Classes of practical materials systems: metallic alloys, ceramics, semiconductors, composites.

W.D. Callister: **Materials Science and Engineering**, Wiley India (2007)

MT 102 3:0 January (4th Semester)
Introduction to Materials Processing

Metals: Principles of extraction of metals, hydrometallurgy, electrometallurgy, pyrometallurgy. Solidification Processing. Ceramics: Synthesis of ceramic powders, consolidation, sintering. Polymer synthesis. Growth and processing of thin films.

C.B. Alcock: **Principles of pyrometallurgy**, Academic Press, London
S. Venkatachalam: **Hydrometallurgy**, NarosaPublishing House, New Delhi.
W.D. Kingery, H.K. Bowen, D.R. Uhlmann, **Introduction to Ceramics**, Wiley (1976)
D. Braun, H. Cherdron, M. Rehahn, H. Ritter and B. Voit, **Polymer Synthesis: Theory and Practice: Fundamentals, Methods, Experiments** , Springer (2010)

MT 106 0:1 January (4th Semester)
Materials Processing Lab

Synthesis and processing of ceramic powders. Polymer synthesis. Pyrometallurgy. Hydrometallurgy. Thin film growth.

MT 111 3:0 August (5th Semester)
Structure of Materials
Elements of bonding, structures of simple metallic, ionic and covalent solids; Coordination polyhedra, projections of structures, stacking; Lattices, symmetry operations, stereographic projection; Structure and thermodynamics of point defects and solid solutions, non-stoichiometry, ordered structures; Dislocations and slip, twinning and interfaces.

A. Kelly and G.W.Groves: **Crystallography & Crystal Defects**, Addison Wesley
C.S.Barrett and T.B.Massalski, **Structure of Metals**, Pergamon
A.R. West,: **Introduction to solid state chemistry**, John Wiley

MT 112 3:0 August (5th Semester)
Materials Thermodynamics

First Law, Enthalpy, Thermochemistry; Second Law, Entropy, Statistical Interpretation; Helmholtz and Gibbs Free Energies, Chemical Potential; Solution Thermodynamics; Conditions for Equilibrium, Phase Rule, Phase Diagrams; Chemical Reactions and Equilibria; Surfaces and Interfaces.

D.R. Gaskell: **Introduction to the Thermodynamics of Materials** (4th Edition), Taylor & Francis (2003).

MT 113 3:0 August (5th Semester)
Materials Kinetics

Diffusion: Fick's Law, Diffusion Equation; Heat Conduction, Convection; Solidification: Pure Metals, Alloys, Microstructures, Castings; Phase Transformations: Nucleation, Growth and Coarsening. Precipitation and Spinodal Decomposition, Eutectoid Transformation, Massive Transformation, Ordering, Marensitic Transformation; Principles of Thermomechanical Treatment.

R.E. Reed-Hill and R. Abbaschian: **Physical Metallurgy Principles** (Third Edition), Thomson Brooks/Cole (1994)
G. Gottstein: **Physical Foundations of Materials Science**, Springer (2004)
D.A. Porter, K.E. Easterling and M.Y. Sherif: **Phase Transformations in Metals and Alloys** (Third Edition), CRC Press (2009).

MT 116 0:1 August (5th Semester)
Materials Characterization Laboratory – I

Optical microscopy. Sample preparation, grinding, polishing and etching. Microstructures of copper and aluminium alloys, and steels. X-ray diffraction. Scanning electron microscopy.

MT 121 3:0 January (6th Semester)
Mechanical Behaviour

Mechanics of solids. Stress and Strain. Normal and shear stresses. Theory of elasticity. Tensile Testing. Plastic Deformation. Work hardening. Dislocations. Deformation of single and polycrystals. Strengthening mechanisms. High temperature deformation. Cyclic deformation, fatigue failure. Fracture. Failure mechanisms.

G.E. Dieter: **Mechanical Metallurgy**, McGraw-Hill, London (1988).
T.H. Courtney: **Mechanical Behaviour of Materials**, McGraw-Hill (1999)

MT 122 3:0 January (6th Semester)
Electronic Properties of Materials

Brief review of the fundamentals of quantum and statistical mechanics; Schrodinger equation and its application to simple model systems; Lattice vibration and thermal properties of materials; Free electron theory and band theory of solid; Semiconductor-theory and devices; Superconductivity; Magnetic, Dielectric and Optical properties of materials.

C. Kittel: **Introduction to Solid State Physics**, McGraw-Hill.
M. Ali Omar: **Elementary Solid State Physics**
R.E. Hummel: **Electronic Properties of Materials**

MT 126 0:1 January (6th Semester)
Materials Characterization Laboratory - II

Phase diagram determination. Phase transformations. Heat treatment of steels. Heat treatment of aluminium alloys, Thermal analysis. Surface characterization.

MT 127 0:1 January (6th Semester)
Mechanical Behaviour Laboratory

Hardness tests. Tensile and compression testing. Fatigue. Impact testing. Non-destructive testing. Dynamic properties of materials. Hardenability of steels.

MT 136 0:1 August (7th Semester)
Electronic Properties Laboratory

Resistivity of materials. Superconductivity. Meissner effect. Hall effect. Seebeck effect. Magnetic characterization of materials. Ferroelectric materials. Magnetoresistance. Optical band gap. Photoconductivity.

MT 151 2:1 January (6th Semester)
Modelling and Simulations

Solution of linear and non-linear simultaneous equations. Numerical differentiation and integration. Continuum Techniques: Finite Difference, Finite Element and Control Volume Methods. Atomistic Models: Molecular Dynamics, Monte Carlo Simulations.
S.C. Chapra and R. Canale: **Numerical Methods for Engineers**, McGraw-Hill (2009)
D.P. Landau and K. Binder: **A Guide to Monte Carlo Methods in Statistical Physics**, Cambridge University Press (2009)

MT 152 3:0 August (5th Semester)
Electrochemistry and Corrosion

Basics of electrode kinetics and electrochemical techniques, Corrosion mechanisms, Mixed potential theory, Tafel plots and polarization phenomena, Cathodic protection, Fundamentals of batteries, fuel cells, Prevention strategies

M.G. Fontana: **Corrosion Engineering**, McGraw Hill
E. Gileadi: **Electrode kinetics for chemists, chemical engineers and material scientists**, Ellis Harwood Ltd.,
C.A. Vincent: **Modern Batteries**, Edward Arnold, (UK)

MT 153 3:0 August (5th Semester)
Process Metallurgy

Basics of pyro-, hydro- and electro-metallurgical operations, physical chemistry of iron and steel making and non-ferrous metal extraction, solvent extraction and ion-exchange, illustrative examples from industrial operations

C.B. Alcock: **Principles of pyrometallurgy**, Academic Press, London
H.S. Ray, R. Sridhar, and K.P. Abraham.: **Extraction of non-ferrous metals**, Affiated East West Press, New Delhi.
S. Venkatachalam: **Hydrometallurgy**, NarosaPublishing House, New Delhi.