INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

Subject Code: MTC-501 **Course Title:** Mathematics and Numerical Methods

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Introduction to tensors and their role in describing physical phenomena with examples, Ordinary (ODE) and partial differential equations (PDE) and their classification, Analytical solution techniques for initial and boundary value problems, Numerical solution techniques of ODEs and PDEs: introduction to finite difference, finite volume, and finite element techniques, Basics of statistical analysis and probability distribution functions.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

Subject Code: MTC-503 **Course Title:** Structure of Materials

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PCC

Course Outlines: Atomic bonding, crystals geometry and classification of structures, symmetry, crystal structure of metals, ceramics and polymers, defects in crystal structure, influence of crystal structure on deformation and mechanical behavior, failure mechanism in materials, principles of alloy formation, diffusion in solids, basics of phase diagram, discussion of some important binary system, ternary phase diagram.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

Subject Code: MTC-505 **Course Title:** Atomistic Modeling: Methods and Applications

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Introduction to Density Functional Theory; Brief review of classical and statistical mechanics; Interatomic potentials and boundary conditions; Molecular statics (MS) and molecular dynamics (MD); Monte-Carlo (MC) simulations and its applications.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

Subject Code: MTC-507 **Course Title:** Continuum modeling: Methods and applications

L-T-P: 3-0-0 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Finite element method, Finite Elements and Shape Functions, Stiffness Matrix, Solid-State Kinematics, Conjugate Stress-Strain Measures, Discrete Element Method, Non-Hertzian and Hertzian contacts, Initial and boundary conditions, Governing Equation Discretization, Polycrystal Elasticity and Plasticity, Homogeneous Elastic Strain and Stress Models, Eshelby's Approach, Kroner's Approach, Taylor-Bishop-Hill model, Polycrystal Modeling, Anisotropic plasticity; Dislocation density-related constitutive modeling, Phase-Field Method, Diffusional phase transformations, Cellular, Lattice Gas, and Boltzmann Automata, Probabilistic Cellular Automata; Simulation of Non-Equilibrium Phenomena

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

Subject Code: MTC-513 **Course Title:** Characterization of Materials

L-T-P: 0-0-6 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Calculation of structure factor of different crystal structures. Determination of crystal structure using powder XRD. Determination of phases in multiphase powder sample using XRD. Precise lattice parameter determination using XRD. Estimation of crystallite size using Scherrer formula. SEM micrography. Chemical analysis using energy dispersive X-ray analysis in SEM (spot and line analysis). TEM sample preparation and TEM analysis. Indexing of selected area diffraction patterns. DSC/DTA analysis. Dilatometry analysis. Four probe resistivity measurement. B-H loop measurement.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

Subject Code: MTC-515 **Course Title:** Phase Transformations

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PCC

Course Outlines: Brief background on related thermodynamic aspects; Diffusion, Fick's laws, Interfaces, Classical nucleation theory, Solidification, Phase diagram and invariant transformations; Heat treatment operations; TTT and CCT curves; Diffusional phase transformation; Non-diffusional phase transformation.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

Subject Code: MTC-521 **Course Title:** Mechanical Behavior of Materials

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PCC

Course Outlines: Stress, strain tensors, elasticity, plasticity, dislocation theory, mechanisms of plastic deformation: slip, twinning, strengthening mechanisms, Mechanical Testing, Fracture mechanics: ductile and brittle fracture, fatigue and creep, factors influencing fatigue behavior: fatigue failure mechanisms and fatigue life prediction. creep behavior, impact, and dynamic loading etc., Case studies.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

Subject Code: MTC-523 **Course Title:** Advanced Thermodynamics

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PCC

Course Outlines: Laws of thermodynamics, Maxwell's relations, Clausius-Clayperon equation. Solution models, statistical thermodynamics, multicomponent systems. Equilibrium Concepts: Unary, binary and multicomponent systems, phase equilibria, evolution of phase diagrams, metastable phase diagrams, First and second order transitions. Heterogeneous Systems: Equilibrium constant, Ellingham diagrams and their application to commercially important reactions.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Metallurgical and Materials Engineering

Subject Code: MTC-509 **Course Title:** Materials Modelling and Simulation Lab

L-T-P: 0-0-6 **Credits:** 3 **Subject Area:** PCC

Course Outlines: Defect energy calculation; MD simulation of melting; Simulations of deformation; Metropolis Monte-Carlo study of the Ising model; Self-consistent modelling of texture evolution; FE simulations of hot compression; FE simulations of heat transfer during welding; Dislocation density-based simulation of work hardening; Mass diffusion using Fick's second law; Phase-field modeling of spinodal decomposition, grain growth; Cellular automata simulations for dendritic growth.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT/CENTRE: Department of Metallurgical and Materials Engineering

Subject Code: MTC-517 **Course Title:** Heat and Mass Transfer

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PCC

Course Outlines: Steady-state heat conduction problems in slabs, hollow cylinders, spheres, composite walls, composite pipes, unsteady heat transfer in metallic specimens. Free and forced convection. Emissivity, absoptivity, Planck's distribution law, Wein's displacement law, Stefen-Boltzman law, radiative heat transfer between two black bodies. Diffusive mass transfer, Fick's law, differential and overall mass balance equations, diffusion in solids and stationary media. Differential equation of convective mass transfer.

Appendix-B

Common departmental elective courses for M.Tech (IM+ME+CME)

Teaching Scheme					Contact Hours/Week			Exam. Duration		Relative Weight (%)				
S. No.	Subject Code	Course Title	Subject Area	Credits	L	T	P	Theory	Practical	CWS	PRS	MTE	ETE	PRE
1.	MTL-501	Crystal Plasticity Modeling	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
2.	MTL-502	Additive Manufacturing: Modeling and Simulation	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
3.	MTL-503	Materials Informatics	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
4.	MTL-504	Modeling and simulations of diffusion-based processes in metallurgy	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
5.	MTL-511	Principles of Solidification	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
6.	MTL-512	Engineering Ceramics	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
7.	MTL-513	Principles of Materials - Selection	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
8.	MTL-514	High Temperature Materials	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
9.	MTL-515	Composite Materials	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
10.	MTL-516	Diffusion in Solids	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
11.	MTL-517	Defects in Crystalline Materials	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
12.	MTL-518	Nanotechnology: Materials & Devices	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
13.	MTL-519	Advanced Steel Technology	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
14.	MTL-520	Physical Metallurgy of light metals & alloys	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-

15.	MTL-521	Corrosion protection methods	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-

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16.	MTL-522	Microsensors, MEMS & Smart Devices	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
17.	MTL-523	Electro-Ceramics	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
18.	MTL-524	Materials for Renewable Energy	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
19.	MTL-525	Biomaterials	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
20.	MTL-526	Energy storage Materials	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
21.	MTL-527	Failure Analysis	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
22.	MTL-528	Tribology of Engineering Materials	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
23.	MTL-529	Non-ferrous extraction	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
24.	MTL-530	Materials Modeling and Simulation	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
25.	MTL-531	Non Destructive testing	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
26.	MTL-532	Casting and Solidification	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
27.	MTL-533	Joining of Materials	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
28.	MTL-534	Theory of Metal Forming	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
29	MTL-535	Powder Metallurgy	PEC	4	3	1	0	3	-	20-35	-	20-30	40-50	-
30	MTL-536	Thin Film Technology	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
31	MTL-537	Electronic Materials	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-
32	MTL-538	Nanomaterials and Applications	PEC	4	3	1	0	3	0	20-35	-	20-30	40-50	-

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

Subject Code: MTL-501 **Course Title:** Crystal Plasticity Modeling

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Anisotropic elasticity; Sachs Model; Strain and Lattice rotation due to slip; Independent slip systems; Taylor-Bishop-Hill analysis; Yield locus calculation; Deformation texture modeling; anisotropic plasticity; flow curve simulations; crystal plasticity simulations using EBSD data; Modeling of Bauschinger loop, Fatigue simulations.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

Subject Code: MTL-503 **Course Title:** Materials Informatics

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Data visualization and preprocessing, Introduction to ML, supervised learning, regression models, unsupervised learning, principal component analysis, clustering, materials property prediction, materials discovery, image-based prediction.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

Subject Code: MTL-504 **Course Title:** Modelling and Simulations of Diffusion-based Processes in Metallurgy

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Fick's law, Onsager's continuity equation, Einstein's random walk model, Boltzmann-Matano analysis, Kirkendall effect, Darken's equation, Sherstnev-Lang-Kozeschnik model, Sigma- Theta model, Grain growth kinetics and coefficients, Calphad approach, PARROT optimization module, Scheil's solidification simulation, Diffusion in planar, spherical and cylindrical geometry, Fischer-Svoboda-Appel-Kozeschnik (FSAK) model, Monte-Carlo simulation, Phase field simulation, Diffuse interface theory, Cahn-Hilliard and Allen-Cahn equations.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

Subject Code: MTL-512 **Course Title:** Engineering Ceramics

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Crystal Structures; Powder Synthesis; Die Compaction; Slip Casting, Pressure Casting, Tape Casting; Sintering Mechanisms; Thermodynamics and Kinetics of Sintering; Phase Diagrams; Brittle Fracture; Cracking; Toughening Mechanisms; Nanoceramics.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

Subject Code: MTL-513 **Course Title:** Principles of Materials Selection

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Materials in Design, Material Selection, Material reserve, Materials Classification, Materials for automobile, Ashby Selection Process, Performance Index and Material Index, Constraints and Conflicting Objectives, Materials and Product Characteristics.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

Subject Code: MTL-517 **Course Title:** Defects in Crystalline Materials

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Crystal structures, point defects, substitutional and interstitial solutes**,** Point defect reactions and complexes, Dislocations, Continuum (Volterra) model of dislocations, Atomistic (P-N) model of dislocations, Interfaces, coincident site lattice and grain boundary engineering.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

Subject Code: MTL-519 **Course Title:** Advanced steel technology

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Historical background, steel metallurgy, transformation induced plasticity steel (TRIP), twinning induced plasticity steel (TWIP), Advanced high strength steel, Stainless steels, Quench and partitioning steel, Maraging steel, high strength low alloyed steel (HSLA), Pipeline steel, Hydrogen susceptibility.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

Subject Code: MTL-520 **Course Title:** Physical Metallurgy of Light Metals and Alloys

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Introduction and properties to light metals; Physical metallurgy of aluminum alloys; Magnesium alloys; Titanium alloys; Heat treatment and mechanical properties; Processing techniques; Advanced applications; Novel alloys.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

Subject Code: MTL-521 **Course Title**: Corrosion Protection Methods

L-T-P: 3-1-0 **Credits**: 4 **Subject Area:** PEC

Course Outlines: Corrosion forms and remedial measures, protection by inorganic and organic coatings, cathodic protection, anodic protection, protection in various corrosive environments, protection by inhibitors, selecting materials of construction, designing to prevent corrosion, monitoring, economics of corrosion protection.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: Department of Metallurgical and Materials Engineering

Subject Code: MTL-536 **Course Title:** Thin film Technology

L-T-P: 3-1-0 **Credits:** 4 **Subject Area:** PEC

Course Outlines: Vacuum technology, Kinetic theory of gases, thin film deposition techniques: Epitaxial thin films. Thermodynamics of surfaces, terrace-ledge-kink model, BCF theory, Roughening transition, Equilibrium shape of the crystals. Atomistic description of growth, Monte Carlo simulations, Mechanics of thin films.