Course Code	Course Title
AcSIR-35-ID-001	Computer Simulation and Modelling
AcSIR-35-ID-002	Heat Treatment
AcSIR-35-ID-003	Integrated Sensor Systems
AcSIR-35-ID-004	Material Engineering and Characterization
AcSIR-35-ID-005	Material Engineering for Inter-Disciplines
AcSIR-35-ID-006	Material Synthesis and Processing
AcSIR-35-ID-007	Nano Science and Nanotechnology
AcSIR-35-ID-008	Phase Transformation
AcSIR-35-ID-009	Polymer Science and Engineering
AcSIR-35-ID-010	Tribology-Science and Engineering

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AcSIR Academic Centre Code: 35

CSIR-Advanced Materials and Processes Research Institute **CSIR-AMPRI**

Course 2 : Inter-disciplinary / Cross-disciplinary **Total Credits 2**

Title:	Course Code	Credits
Computer Simulation and Modelling	**AcSIR-35-ID-001**	**1**

Basic concepts, approach and significance, meshing, software, hardware, algorithms, introduction to finite element analysis, steps in finite element analysis, plane stress and plane strain, axi-symmetric conditions, elements in 2d and 3d problems, development of element and global stiffness matrix, convergence criteria, linear and non-linear analysis, features of FEA software, pre-processing, post- processing and analysis in different software Artificial neural network (ANN), supervised and unsupervised learning of ANN, fuzzy logic, fuzzy logic rules, engineering applications of modeling and optimization.

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Title:	Course Code	Credits
Heat Treatment	**AcSIR-35-ID-002**	**1**

General principles and concepts, equilibrium diagram, lever rule, TTT diagram, processes, atmospheres (salt baths, gases), furnaces, quenching media, mechanism of quenching, mechanism and kinetics of oxidation, carburization and decarburization, vacuum as controlled atmosphere, residual (thermal and transformation) stresses, shape and size distortion and control, quenching cracks, transformation induced plasticity Heat treatment of steels and cast irons: Fe-Cequilibrium diagram, carbon equivalent, effects of alloying elements on heat treatment parameters, annealing, normalizing, hardening, hardenability, tempering, austempring, martempering, ausforming, subzero treatment, patenting, themomechanical treatments, case hardening (carburinzing, nitriding, carbonitriding, aluminizing, sheradizing), microstructural changes during heat treatment, malleablizing, fluidized bed treatments, induction hardening, selection of heat treatment parameters and cycles, thermal cycling, Heat treatment of some common Non-ferrous(Al-, Zn-, Mg- and Cu-based) alloys (solutionizing, natural and artificial ageing, continuous and discontinuous precipitates, grain growth and precipitate coarsening, coherent, semicoherent and incoherent precipitates, coherency strains, ASTM temper designations).

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Course 2 : Inter-disciplinary / Cross-disciplinary **Total Credits 2**

Title:	Course Code	Credits
Integrated Sensor Systems	**AcSIR-35-ID-003**	**1**

Fundamentals of sensors and networked sensor systems, with special emphasis on sensor-fabrication. Smart Materials and Devices, Physics of Low Dimensions Devices, Electrochemical Sensors, Optical Sensors, Piezoelectric Sensors, Humidity Sensors, Field Effect Transistor, Micro and Nanofabrication Technologies and Characterization Techniques, Sensors Modelling and Simulation, Nanophotonics, Science and Technologies of semiconductor, Integrated Chip to System Design, Micro/Nanofluidics and sensor, Flexible sensors, Quantum dots based sensors, Micromachining, 3D Printing in Sensors, Nanorod-sensor probes; Magnetic Particles-sensor probes; NanowiresFET sensing system, Micro-Electro-Mechanical Systems (MEMS), Nanomachines, Advanced carbon nanotube/Graphene structures for sensing applications.

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Course 2 : Inter-disciplinary / Cross-disciplinary **Total Credits 2**

Title:	Course Code	Credits
Material Engineering and Characterization	**AcSIR-35-ID-004**	**1**

Property Characterization Basic concept, approach and methodology, SI units and their uses, test types, design of experiments, factors controlling test results, sources of error in experimental results, confidence limit, standard deviation, determinate and indeterminate errors, properties (physical, mechanical, chemical, electrochemical, thermal, tribological, rheological, interfacial, magnetic, electrical), compositional, phase and microscopic analysis (surface, subsurface, removed mass) and
interpretation, specimen preparation, quantitative metallography, microstructure-property correlation, failure analysis, interpretation of information, microanalysis, corrosion characterization (electrochemical/galvanic series, potential-pH diagram), chemical and thermal analysis of minerals and wastes, toxicity studies of solid wastes, evaluation of mechanical properties, characterization of radiation shielding
and nano materials.
Separation Techniques Introduction & classification of chromatographic methods, theory of chromatography, retention time, relationship between retention time and partition coefficient, the rate of solute migration, differential migration rates, bandbroadening & column efficiency, kinetic variables affecting band broadening.

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Course 2 : Inter-disciplinary / Cross-disciplinary **Total Credits 2**

Title:	Course Code	Credits
Material Engineering for Inter-Disciplines	**AcSIR-35-ID-005**	**1**

Periodic table and specific features/characteristics of group wise elements, electronic structure of materials (ionic, covalent, coordinate, conduction, valence, metallic and van der Waal bonds, noncrystalline and amorphous), crystalline solids (crystal system, unit cell, space lattice, Miller indices, packing factor, coordination number, slip system, planes and directions in crystals), defects, diffusion, thermal and electrical conduction, electronic & ionic conduction, semiconductors, solid solution, intermetallic compounds, Hume-Rothery rules, dielectric behaviour (types of polarization, frequency dependence of dielectric permittivity, piezo and ferroelectricity), solution and transport phenomena, solid/liquid interfaces, electrical double layer, introduction to polymers, classification of polymers, structure and properties of polymers, polymer composites, techniques of polymerization, Material classification (metals and alloys, foams, composites, polymers, ceramics, functional and smart materials, semiconductors,nanostructured materials, construction materials etc.)

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Course 2 : Inter-disciplinary / Cross-disciplinary **Total Credits 2**

Title:	Course Code	Credits
Material Synthesis and Processing	**AcSIR-35-ID-006**	**1**

Basic concept and approach, material systems/types (metals and alloys, composites, polymers, ceramics, industrial wastes, porous materials/foams, sandwich, fibres etc.), synthesizing and processing techniques (casting, secondary deformation, powder metallurgy, foaming, process modelling, fibre extraction), characteristics, application potential and limitations Concept, approach and methodology, techniques for metallic materials (liquid metallurgy, powder metallurgy, deformation processing, severe plastic deformation, thermo mechanical treatment, heat treatment, surface modification/ engineering, joining, plasma and laser processing, rapid prototyping), functionally graded materials, natural and bio fibres, natural fibre composites, biodegradable composites, hybrid composites, polymers (moulding, extrusion, heat treatment, post curing and joining

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Course 2 : Inter-disciplinary / Cross-disciplinary **Total Credits 2**

Title:	Course Code	Credits
Nano Science and Nanotechnology	**AcSIR-35-ID-007**	**1**

Concept and approach, Introduction to nanomaterials: Definition and classification, top down and bottom up approaches, Synthesis methodologies, processing and characterization techniques, functionalization and applications, Fundamental properties of various primary material classes (metals, ceramics and polymers), Size dependent properties, Challenges in processing bulk ceramic nanomaterials, Processing structure properties of important bulk nanomaterials, Mechanical, thermal, tribological and biological properties.

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Course 2 : Inter-disciplinary / Cross-disciplinary **Total Credits 2**

Title:	Course Code	Credits
Phase Transformation	**AcSIR-35-ID-008**	**1**

Principles and concepts, free energy - composition diagrams, diffusion in solids, high diffusivity paths, nucleation and growth, homogeneous and heterogeneous nucleation, interface and diffusion controlled growth, coherent, semicoherent and incoherent interfaces, transformations controlled by heat flow like solidification, various growth mechanisms, kinetics of eutectic and eutectoid transformations, precipitation and dispersion strengthening, recovery, static and dynamic recrystallization, grain growth, peritectic, spinodal, pearlitic, ferritic, and martensitic transformations, ordered-disordered transformation.

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Course 2 : Inter-disciplinary / Cross-disciplinary **Total Credits 2**

Title:	Course Code	Credits
Polymer Science and Engineering	**AcSIR-35-ID-009**	**1**

Introduction to polymers, polymer crystallinity, classification of polymers, structure & properties, techniques and aspects of structure determination, crystalline polymers, supermolecular organization of amorphous polymers, concept of physical states, the rubbery state, elasticity of an ideal rubber, kinetics theoryof rubber elasticity, elasticity of a system of isolated polymeric chains, James-Guth theory, glassy state, transition of polymer from the rubbery to the glassy state, theories of glass transition, thermal, mechanical and electrical properties of polymers, heat capacity of polymers & solids, theories of heat capacity of polymers, thermal conductivity of polymers and dielectrics, structural scattering, thermal expansion of polymers and solids, equations of state for thermal expansion of solids, mechanical behaviour of polymers, strength and durability, mechanism of polymer fracture, thermofluctuational theory, effect of relaxation processes on strength properties, DMA of polymers, physics of polymers, characterization (morphology, mechanical, chemical, thermal, degradation and rheological behaviour), processing (additives, moulding, extrusion, injection moulding, thermoforming etc.) and recycling, engineering and special polymers Introduction to conducting polymers, synthesis of PANI, synthesis of polypyrrole, electrical testing of conducting polymers, applications of conducting polymers, carbon filled polymers. Physical properties of PANI, Electrical properties of PANI, PANI Composites

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Course 2 : Inter-disciplinary / Cross-disciplinary **Total Credits 2**

Title:	Course Code	Credits
Tribology-Science and Engineering	**AcSIR-35-ID-010**	**1**

Tribology (basic definition, concept and approach, Archard's laws, delamination theory), friction and wear types/modes (adhesion, abrasion, erosion, fretting, chemical etc.), wear testing (configurations, systems, methodology), high temperature tribology, simulated tests, measurement techniques, surface, subsurface and debris analysis, mechanism maps, controlling factors, interpretation of information, microstructure-property correlation, lubrication modes and types (mixed, boundary, hydrodynamic, elastohydrodynamic), Stribeck curve, P-V limit, lubricants (basic requirements, features, types, additives), tribomaterials (basic concept & approach, functions, material types and development, applications)Introduction to tribology of polymers (basic definition, concept and approach, Archard's laws, delamination theory), friction and wear types/modes (adhesion, abrasion, erosion, fretting, chemical etc.), wear testing (configurations, systems, methodology), measurement techniques, surface, subsurface and debris analysis, controlling factors, microstructureproperty correlation, P-V limit, lubricants (basic requirements, features, types, additives).

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