ACADEMY OF SCIENTIFIC AND INNOVATIVE RESEARCH

SYLLABUS

OF

ADVANCED COURSES

FOR

PhD PROGRAM

(*A part of the August 2020 Revised Course Structure*)

Academy of Scientific and Innovative Research

CSIR-HRDC Campus, Sector-19, Ghaziabad, U P., India

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

Revision of course curriculum from several perspectives (including updation to state of art knowledge & others) is a dynamic process restructuring for the contemporary needs and expectations w.r.t. courses of study for an academic program. This dynamic process is driven by growing needs and contemporary advancements in respective fields.

Academy of scientific & Innovative Research (AcSIR) aims to train and create quality human resource with positive attitude towards learning, leading to specialization in Ph.D. curricular education. An endeavour to revise the AcSIR Ph.D. study course syllabus has been done basically to provide opportunities to extend as well as deepen their knowledge, understanding, develop competencies & skills. It also emphasizes in the structure of teaching, learning and course duration so that it is optimum to earliest entry of students to their lab research phase of the program.

The academic programme in each of the five faculties in which AcSIR offers Ph.D. degrees is administered by a Board of Studies (BoS). The core courses have syllabi that are designed by the faculties in those areas, who have pursued research and taught these courses. Besides this, in order to get the most out of the expertise of the faculty members and their research experience in learning by students, some flexibility is given to the instructors in each course so that they can introduce a few special topics of their choice, making the course unique. Advanced courses are normally given by the faculty members in their own area of expertise. Each AcSIR Academic Centre has its area of specialization and expertise.

General Objectives of the course is that after successfully going through it, students will be able to understand the methods and techniques, developing knowledge and competencies, to be helpful in their research plans ahead in his/her selected field of research. Also, to support the students to understand the nature of problems faced during the Ph.D. period, develop suitable interdisciplinary scientific methods through some innovative remedies and learn to solve them.

Identical titles with identical contents listed across the faculty of Studies were pruned and only one is listed under the most relevant faculty with course serial no.

Course Requirements
For Completion of PhD Program

Minimum credits required to be successfully completed: 18 credits

Distribution of the 18 credits:

- Course 1: Total credits: 6 (consisting of two courses as under)
    - Research Methodology: 4 credits
    - Research Publication and Ethics: 2 credits
- Course 2: Total credits: 2 (consisting of one or two courses)
    - Inter-disciplinary/ Cross-disciplinary Course: 2 credits (either two courses of 1 credit each OR one course of 2 credits, to be opted from the list of offered courses)
- Course 3: Total credits: 6 (consisting of two or three courses)
    - Advanced Course: 6 credits (either two courses of 3 credit each OR three courses of 2 credits each, to be opted from the list of offered courses within Institute; restrictions of exclusion may apply when opted across Institutes)
- Course 4: Total credits: 4
    - Societal Program: Problem Understanding and Analysis: 4 credits (Group activity of upto five Team members from within Institute or across Institutes), no restriction of Faculty of Study, discipline of an AcSIR student.

How to read Course Codes: Every Advanced Course in AcSIR has a unique course code. A code can be understood as under:

AcSIR- 01- XX YY- 001

Two numbers identify AcSIR centres code:

Code	Lab Name
1	CBRI, Roorkee
2	IGIB, New Delhi
3	CCMB, Hyderabad
4	CDRI, Lucknow
5	CECRI, Karaikudi
6	CEERI, Pilani
8	CFTRI, Mysuru
9	CGCRI, Kolkata
10	CIMAP, Lucknow
11	CLRI, Chennai
12	CMERI, Durgapur
14	CRRI, New Delhi
15	CSIO, Chandigarh
16	CSMCRI, Bhavnagar
17	IICB, Kolkata
18	IICT, Hyderabad
19	IIP, Dehradun
20	IMTECH, Chandigarh
22	IITR, Lucknow
24	NAL, Bengaluru
25	NBRI, Lucknow
26	NCL, Pune
27	NEERI, Nagpur
28	NGRI, Hyderabad
29	NIO, Goa
30	NISTADS, New Delhi
31	NML, Jamshedpur
32	NPL, New Delhi
33	IHBT, Palampur
35	AMPRI, Bhopal
36	IMMT, Bhubaneswar
37	IIIM, Jammu
38	NEIST, Jorhat
39	NIIST, Trivendrum
41	SERC, Chennai
42	NISCAIR, New Delhi
43	CIMFR, Dhanbad
44	URDIP, Pune
45	4PI, Bengaluru
61	PHFI-IIPH-Delhi
62	PHFI-IIPH-Hyderabad
63	LVPEI, Hyderabad
64	BSIP, Lucknow
65	NIMR, New Delhi
66	IASST, Guwahati

These letters show the Faculty of Study i.e. XX can be:

BS: for Biological Sciences

CS: for Chemical Sciences

PS: for Physical Sciences

ES: for Engineering Sciences

MIS: for Mathematical & Information Sciences

Two letter shows course type i.e. YY can be:

RM: for Research Methodology

RP: for Research Publication and Ethics

ID: for Inter-disciplinary/ cross-disciplinary Learning

AD: for Advanced

SP: for Societal Program

A serial number for course to distinguish

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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Advanced Courses and Syllabus

Course contents

33.	**38**	CSIR-NEIST	40	574
34.	**39**	CSIR-NIIST	11	617
35.	**41**	CSIR-SERC	08	629
36.	**42**	CSIR-NISCAIR	07	638
37.	**43**	CSIR-CIMFR	18	646
38.	**44**	CSIR-URDIP	09	666
39.	**45**	CSIR-4PI	12	676
40.	**64**	DST-BSIP	12	689
41.	**66**	DST-IASST	31	702

01	CSIR-CBRI	3	Advanced Course

Faculty of Study	Course Code	Course Title
Chemical Sciences	AcSIR-01-CS-AD-001	Advanced Instruments in Materials Research
Chemical Sciences	AcSIR-01-CS-AD-002	Frontiers in Building Materials
Chemical Sciences	AcSIR-01-CS-AD-003	Advanced Environmental Analysis & Management
Chemical Sciences	AcSIR-01-CS-AD-004	Introduction to Polymer Materials
Chemical Sciences	AcSIR-01-CS-AD-005	Plastics and Composites
Chemical Sciences	AcSIR-01-CS-AD-006	Geopolymers
Chemical Sciences	AcSIR-01-CS-AD-007	Nanotechnology and Analytical Techniques
Engineering Sciences	AcSIR-01-ES-AD-001	Wind Effects on Building Structures (WEBS)
Engineering Sciences	AcSIR-01-ES-AD-002	Structural Response Control for Seismic Protection
Engineering Sciences	AcSIR-01-ES-AD-003	Continuum Mechanics & Finite Element Analysis
Engineering Sciences	AcSIR-01-ES-AD-004	Corrosion Control in Reinforced Concrete Structures
Engineering Sciences	AcSIR-01-ES-AD-005	Applied Soil Mechanics
Engineering Sciences	AcSIR-01-ES-AD-006	Fundamentals of Structural Engineering
Engineering Sciences	AcSIR-01-ES-AD-007	Fundamentals of Soil Mechanics
Engineering Sciences	AcSIR-01-ES-AD-008	Re-Engineering of Structures

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Faculty of Study	Course Code	Course Title
Engineering Sciences	AcSIR-01-ES-AD-009	Optimization Techniques
Engineering Sciences	AcSIR-01-ES-AD-010	Advanced Structural Mechanics
Physical Sciences	AcSIR-01-PS-AD-001	Fundamentals of Engineering Geology
Physical Sciences	AcSIR-01-PS-AD-002	Rock Mechanics
Physical Sciences	AcSIR-01-PS-AD-003	Advanced Seismology
Physical Sciences	AcSIR-01-PS-AD-004	Landslide Disaster Mitigation
Physical Sciences	AcSIR-01-PS-AD-005	Advanced Refrigeration Systems & Design
Physical Sciences	AcSIR-01-PS-AD-006	Building Physics
Physical Sciences	AcSIR-01-PS-AD-007	Solar Energy Utilisation in Buildings

AcSIR Academic Centre Code: 01

CSIR-Central Building Research Institute	**CSIR-CBRI**

Course 3 : Advanced Course **Chemical Sciences** **Total Credits 6**

Title:		Course Code	Credits
	Advanced Instruments in Materials Research	**AcSIR-01-CS-AD-001**	**2**

Principles and instrumentation of advanced equipments such as thermal analyzer (DMA, TMA, DSC, TGA etc.), Rheometer, Microscopes (SEM, TEM, ESCA, image analyzer and AFM), Dilatometry, Flammability tests (Cone calorimeter, burning test apparatus etc.), IR Spectroscopy, Thermal conductivity apparatus etc. Accelerated exposure test (Humidity chamber, UV chamber etc.), Interpretation of instrumental data.

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AcSIR Academic Centre Code: 01	
CSIR-Central Building Research Institute	CSIR-CBRI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Frontiers in Building Materials	AcSIR-01-CS-AD-002	2

Building stone, Bricks, Lime, Cement & Concrete, Aggregate, Water, Ferrous Materials, Non-Ferrous Materials, Paints, Asphalt, Bitumen, Gypsum, Adhesive, Sealants, Advanced Materials(e.g.: Nanomaterials etc.). Physio-chemical Analysis of Building Materials and their Engineering Properties.

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AcSIR Academic Centre Code: 01

CSIR-Central Building Research Institute	CSIR-CBRI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Advanced Environmental Analysis & Management	Course Code	Credits
		AcSIR-01-CS-AD-003	2

Materials: Building Stone, Bricks, Lime, Cement & Concrete, Aggregate, Water, Ferrous Materials, Non-Ferrous Materials, Paints, Asphalt, Bitumen, Gypsum,
Adhesive, Sealants, Advanced Materials etc. Physio-chemical Analysis, Engineering properties. Environmental Science: Air Pollution, Water Pollution, Monitoring and remedial measures, Environmental Audit and Environmental Impact Assessment Waste management: Industrial Solid waste, Municipal waste, Hazardous waste and Analysis and Utilization / Management,Advanced Instrumentation Analysis: Powder X-ray Diffraction, Electron Microscopy, X-ray Fluorescence, Inductive Couple Plasma, Thermal Analysis, Spectroscopy.

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AcSIR Academic Centre Code: 01

CSIR-Central Building Research Institute	**CSIR-CBRI**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:		Course Code	Credits
	Introduction to Polymer Materials	**AcSIR-01-CS-AD-004**	**2**

Basic concepts: Polymer raw materials, Polymerization principles and processes, Thermoplastic and thermosetting polymers, Characterization of polymers/plastics,
Polymer modification, Introductory concepts on biodegradable polymers, Polymer degradation, High temperature polymers, Nano polymers, Self-cleaning polymer materials, Recycled polymers etc.

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AcSIR Academic Centre Code: 01	
CSIR-Central Building Research Institute	**CSIR-CBRI**

Course 3 : Advanced Course	**Chemical Sciences**		**Total Credits 6**
Title: Plastics and Composites		**Course Code**	**Credits**
		AcSIR-01-CS-AD-005	**2**

Polymer blends, Filled plastics, Fire retardant polymers and methods of imparting fire retardancy, Polymer matrix composites, Sandwich composites, Lignocellulosic fibres and their composites, Composite processing, Fire hazards and toxicity, Polymers and plastics in building construction.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 01

CSIR-Central Building Research Institute **CSIR-CBRI**

Course 3 : Advanced Course **Chemical Sciences** **Total Credits 6**

Title:	Course Code	Credits
Geopolymers	**AcSIR-01-CS-AD-006**	**2**

Raw materials, Synthesis and characterization of geopolymers, Activation chemistry and compositional effect, Durability in chemical environments,
Application of geopolymer in building construction (concrete, coatings, bricks etc.), Processing of fly ash and its pozzolanic reactivity for use in cementitious materials.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 01

CSIR-Central Building Research Institute	**CSIR-CBRI**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	**Nanotechnology and Analytical Techniques**	**Course Code**	**Credits**
		AcSIR-01-CS-AD-007	**2**

Introduction, General considerations, definitions, consequences of size reduction, Properties: structural, thermodynamic, optical, electrical and magnetic properties, Methods of synthesis, Surface modifications, factors governing the stability and assembly, Characterization of Nanomaterials-XRD, UV-Vis, FTIR, Microscopy, XPS, Applications of Nanomaterials

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AcSIR Academic Centre Code: 01			
CSIR-Central Building Research Institute			**CSIR-CBRI**
Course 3 : Advanced Course	**Engineering Sciences**		**Total Credits 6**
Title: Wind Effects on Building Structures (WEBS)		**Course Code**	**Credits**
		AcSIR-01-ES-AD-001	**3**

Introduction to wind engineering, wind climate and wind structure. Structure of turbulence, probabilistic distribution of wind, extreme wind events. Aerodynamics of bluff bodies, vortex shedding and associated unsteady along and across wind forces. Analytical procedures for along wind and across wind forces. Computational aspects of wind flow around buildings. Wind interference effects. Wind Tunnel Testing and its salient features. Wind effects on buildings, Performance of existing buildings and case studies. Codal provisions- Wind resistant design of buildings, glass panels of doors, windows and facades. Introduction to International Codes. Risk, hazard and vulnerability analysis of wind sensitive structures.

AcSIR Academic Centre Code: 01

CSIR-Central Building Research Institute	**CSIR-CBRI**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:	**Structural Response Control for Seismic Protection**	**Course Code**	**Credits**
		AcSIR-01-ES-AD-002	**3**

Theory of Vibration Isolation: Theory of vibration isolation, Principle of base isolation, Components of base isolatio, Advantages and limitations, Linear theory of base isolation-Applications.
Isolation Devices: Different isolation devices-Modeling of isolation device, Design of isolated devices, Stability of isolation devices, Application of devices to buildings.
Energy dissipation devices: Metallic Yield dampers, Friction dampers, Viscoelastic dampers, Tuned mass dampers, Tuned liquid dampers, Shape memory alloy dampers, Application to buildings.
Structural Control: Introduction to control theories; Strategies, Active Control, Passive control, Hybrid control-Semi-active control.
Case Studies.

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AcSIR Academic Centre Code: 01

CSIR-Central Building Research Institute	**CSIR-CBRI**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:	**Continuum Mechanics & Finite Element Analysis**	**Course Code**	**Credits**
		AcSIR-01-ES-AD-003	**3**

Continuum Mechanics: Introduction, Vectors and Tensors, Analysis of Strains, large deformations and finite strains, Eulerian Langrangian and Almansi, Green's and Cauchy's strain tensors, Compatibility equations, elastic stress strain equations, generalized Hooke's Law, Material Yield Criteria-Von-mises, Tresca, Mohr-Coloumb, Drucker-Prager etc.

Finite-Element Analysis - Finite element technique, discretization, energy and variational approaches, basic theory, displacement, force and hybrid models, shape function, use of isoparametric elements, convergence criteria, numerical intergration, element formulations, 2-D elements, plate bending elements, introduction to 3-D elements, shell elements , interface elements ,boundary elements, infinite elements. Application to non-linear problems; special topics. Usage of commercial packages.

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AcSIR Academic Centre Code: 01

CSIR-Central Building Research Institute	**CSIR-CBRI**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:		**Course Code**	**Credits**
	Corrosion Control in Reinforced Concrete Structures	**AcSIR-01-ES-AD-004**	**3**

Deterioration of concrete structures: Constituent materials, microstructures, mix design for durability, permeability, carbonation, chloride penetration, corrosion damage, sulphate attack, alkali-silica reaction, other chemical attacks, influence of types of cement on corrosion.

Basics of Corrosion: Introduction to corrosion process, forms of corrosion, steel corrosion in concrete, corrosion rate measurement instruments.

Condition assessment and corrosion monitoring of reinforced concrete structures: condition survey, nondestructive testing (NDT), measurement of half cell potential, resistivity and corrosion rate, permanent corrosion monitoring systems.

Repair principles, materials and corrosion control measures: Patches, overlay, repair mortars, sprayed concrete, FRP wrapping, corrosion, inhibitors, surface coatings and cathodic protection.

Corrosion rate measurements in laboratory – NDT and corrosion survey techniques at site – Surface coatings acceptance tests – Cathodic Protection.

AcSIR Academic Centre Code: 01

CSIR-Central Building Research Institute	CSIR-CBRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Applied Soil Mechanics	AcSIR-01-ES-AD-005	3

Design of innovative foundation in soft soil, Slope stability analysis and control measures design including seismic effect, Embankment design, Dam foundation design, Liquefaction Potential and mitigation Study, Conventional foundation design including seismic effect, Design of foundations for vibration control, Design of R.E. retaining wall with seismicity, Solution of foundation problem by Beams on elastic medium, Support system design for excavation, Design of foundation in Expansive soil and control measures, Design of foundation in liquefiable soil, Rock anchor design, Seepage problem under earth structures.

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AcSIR Academic Centre Code: 01			
CSIR-Central Building Research Institute			**CSIR-CBRI**
Course 3 : Advanced Course	**Engineering Sciences**		**Total Credits 6**
Title: Fundamentals of Structural Engineering		**Course Code**	**Credits**
		AcSIR-01-ES-AD-006	**3**

Introduction, Structural systems, Determinate & Indeterminate structural forms , Different principles for analysis of structural systems, Loading on structural systems.
Concept of Matrix method of structural analysis: 1D, 2D & 3D forms, Other analysis methodologies. Concept in structural designs – concrete & steel as structural material – Basics of design processes; Effects of different kinds of loads on structural systems and consequences on the design process.

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AcSIR Academic Centre Code: 01

CSIR-Central Building Research Institute **CSIR-CBRI**

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:		Course Code	Credits
	Fundamentals of Soil Mechanics	**AcSIR-01-ES-AD-007**	**3**

Introduction to Soil and Soil Mechanics: Formation of soil, Types of soil, Phase diagram, Index properties & its determination, Soil classification, Permeability of soils & its determination, Effective stress concept, compaction,one dimensional compression, magnitude of settlement, oedometer test, shear strength of soil, failure criterion, measurement of shear strength-drainage conditions and strength parameters, Boussinesq equation, New Mark's influence Chart - approximate stress computation-Westargaard's equation, different types of earth pressure, theories of earth pressure, determination of earth pressure, infinite &finite slopes, different approach of stability analysis.
Foundation Engineering: Introduction, functions, types, capacity from various theory and load test, settlement, IS codal provision.

Design Stabilization: Introduction, needs, principles, Different stabilizer, Essential properties of stabilizer, Methods of applications-effect of stabilizer on engineering properties of soil-design.

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AcSIR Academic Centre Code: 01			
CSIR-Central Building Research Institute			CSIR-CBRI
Course 3 : Advanced Course	Engineering Sciences		Total Credits 6
Title: Re-Engineering of Structures		Course Code	Credits
		AcSIR-01-ES-AD-008	3

Introduction, Structural behaviour of multi-storeyed and Industrial buildings, Various design loads, combinations and behaviour for each component, Characteristics of commonly used materials in engineered/non-engineered construction, Different types of concrete & its properties, Influence of concrete properties on serviceability and durability, Assessment of structural adequacy against different loading systems, Techniques of in-situ evaluation of material properties, Design for strengthening of existing structures, Repair Strategies, Materials for Repair, Different techniques and application of repair measures for building components, Modelling of strengthening techniques Case studies.

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AcSIR Academic Centre Code: 01

CSIR-Central Building Research Institute CSIR-CBRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:		Course Code	Credits
	Optimization Techniques	AcSIR-01-ES-AD-009	3

To impart knowledge about the techniques that are adopted for optimising different design aspects related to building

Introduction

Types of optimization schemes

Linear Optimization techniques

Stochastic Programming etc.

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AcSIR Academic Centre Code: 01

CSIR-Central Building Research Institute	CSIR-CBRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title: Advanced Structural Mechanics	Course Code	Credits
	AcSIR-01-ES-AD-010	3

Fundamentals of structural mechanics: Definition of stress, strain, constitutive relationships, Strain Energy principles, Navier-Bernoulli elementary bending theory of beams, Flexural and shear stresses. Concept of shear center, Deep Beams.

Torsion: St Venant torsion and distortion, Computer methods of structural analysis: Introduction to stiffness and flexibility methods. Matrix methods of structural analysis. Strain energy methods of deriving the stiffness matrix. Analysis of redundant structures. Special structures, Introduction to structural stability, Stability of structural systems. Euler buckling loads and approximate methods of critical load evaluation.

Mechanics of thin plates: Thin plate theory, Imposition of boundary conditions, Kirchoff shear and corner lift up of rectangular plates. Methods of Navier and Levy solutions.

Mechanics of Shells: Types of shells, Shells of translation and rotation. Membrane theory of shells. Cylindrical and spherical shells.

References:

1. Crandall, S. H. An Introduction to Mechanics of Solids. Tata McGraw-Hill Education, 2012.
2. Popov E. P. Engineering Mechanics of Solids, Prentice Hall, 1998
3. Timoshenko, S. P., and Woinowsky-Krieger, S. Theory of Plates and Shells. McGraw-Hill, 2010

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AcSIR Academic Centre Code: 01

CSIR-Central Building Research Institute | CSIR-CBRI

Course 3 : Advanced Course | Physical Sciences | Total Credits 6

Title:	Course Code	Credits
Fundamentals of Engineering Geology	AcSIR-01-PS-AD-001	3

Rocks and Structures: Rocks & rock masses, Structural geology- Joints & discontinuities, Folds & faults, Effect of discontinuities on slope stability, Structural geology in engineering construction, Earth processes - Weathering.
Elementary rock mechanics & soil mechanics: Rock mass classification, Engineering properties of rocks, Rocks as engineering materials, Engineering classification of soils, Index properties, Shear parameters.
Geological invesitigations in civil engineering: Remote sensing & GIS for civil engineering projects, Engineering geology in planning, Design and construction of engineering structures - Dams, Tunnels, Buildings, Roads.
Geophysical methods: Seismic and electrical methods for civil engineering investigations.
Landslides: Landslide types & processes, Causes, Investigation and analysis, Remedial measures
Geohydrology: Hydrologic cycle- Precipitation, Runoff, Infiltration, Ground water flow, Surface and subsurface exploration of groundwater- Drilling and construction of wells, Pumping tests and evaluation of aquifer parameters.

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AcSIR Academic Centre Code: 01

CSIR-Central Building Research Institute	CSIR-CBRI

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Rock Mechanics	AcSIR-01-PS-AD-002	3

To study the behaviour of rock at site under different stress conditions and to assess its properties in field and in the laboratory as well.
Introduction to rock mechanics, Rocks, Rock structures and their importance.
Surface and subsurface investigations. Engineering rock mass classifications & their application. Physico-mechanical properties of rocks.
Stresses in elastic and plastic ground conditions. Excavation Methods. Support design and instrumentation in tunnels and slopes, Problems and their remedies in rock engineering. Application of rock mechanics.

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AcSIR Academic Centre Code: 01

CSIR-Central Building Research Institute — CSIR-CBRI

Course 3 : Advanced Course — Physical Sciences — Total Credits 6

Title:	Course Code	Credits
Advanced Seismology	AcSIR-01-PS-AD-003	3

To impart concepts on the basic aspects of seismic waves, their propagation, related instrumentation and consequences on the design of buildings

Science of earthquakes, Seismic waves, Magnitude & intensity, Earthquake source mechanism, Seismic instrumentation, Seismic zoning map, Site response studies, Source and path effect, Seismic hazard analysis, Risk and estimation, Seismic micro-zonation, Earthquake prediction studies, Seismic alert systems.

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AcSIR Academic Centre Code: 01

CSIR-Central Building Research Institute	**CSIR-CBRI**

Course 3 : Advanced Course	**Physical Sciences**	**Total Credits 6**

Title:	**Course Code**	**Credits**
Landslide Disaster Mitigation	**AcSIR-01-PS-AD-004**	**3**

Study on landslide to understand its behaviour, design of slope and control measure design. Introduction: Landslide types and processes; Application of remote sensing and GIS in landslide studies, Landslide hazard and risk assessment, Landslide instrumentation, SMR & slope stability assessment, Landslide control measures, Landslide case studies.

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AcSIR Academic Centre Code: 01			
CSIR-Central Building Research Institute			**CSIR-CBRI**
Course 3 : Advanced Course	**Physical Sciences**		**Total Credits 6**
Title: Advanced Refrigeration Systems & Design		**Course Code**	**Credits**
		AcSIR-01-PS-AD-005	**3**

Introduction: History of Refrigeration and Air-Conditioning Systems. Heat Exchanger Devices: Definition and Working Principle of Different Heat Exchange Devices.
Vapor Compression cycle: Performance Analysis of the Vapor Compression Cycle, Components. Cascade System and its Application, Dry Ice System.
Sorption system: Simple liquid-Ammonia and Water-Lithium Bromide System, Advanced Sorption Systems. Psychrometric chart: Construction of chart, comfort zone for human body, effective parameters. Load Calculations: Cooling Load Calculation, Heating Load Calculations, Humidification/Dehumidification Equipments and Year Around Air-Conditioner, Design of Air Conditioning Ducts.

References:
1. C.P. Arora, Refrigeration and Air-conditioning, Tata McGraw-Hi1 1-2009
2. F.C. Mcquiston, J.D. Parker and J.D. Spitler Mcquiston, "Ventilating and Air Conditioning: Analysis and Design", Wiley, 201 1
3. P.N. Ananthanarayanan, "Basic Refrigeration and Air Conditioning", Tata McGraw-Hill, 2013

AcSIR Academic Centre Code: 01	
CSIR-Central Building Research Institute	**CSIR-CBRI**

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Building Physics	**AcSIR-01-PS-AD-006**	**3**

Introduction: Building Physics, Definitions, Importance of Building Physics, History of Building Physics.
Heat Transfer through Building: Conduction, Fourier's Law, First Law, Second law, Steady State: One dimension: flat assemblies, Two Dimension: Cylinder symmetric, Two and Three Dimensions: Thermal Bridges.
Convection: Heat Exchange at a Surface, Convective Heat Transfer, Calculating The Convective Surface
Film Coefficient: Flat Assemblies, Cavities and Pipes.
Radiation: Absorption, Reflection and Transmission, Radiant Exchange between two Surfaces, Grey Body, Colored Body
Mass Transfer: Air Transfer, Moisture Transfer, Vapor Transfer, Combined Air-Vapor-Heat Transfer

References:
1. Ir. H.S.L.C. Hens, "Building Physics, Heat, Air and Moisture: Fundamentals and Engineering Methods with Examples and Exercises", Wiley, 2017
2. M.G. Davies, "Building Heat Transfer" Wilay, 2004
3. M. Kutz, "Heat Transfer Calculations", Tata Macgraw Hill, 2004
4. S. Carlucci, "Thermal Comfort Assessment of Buildings", Springer, 2013

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 01

CSIR-Central Building Research Institute | CSIR-CBRI

Course 3 : Advanced Course | Physical Sciences | Total Credits 6

Title:	Course Code	Credits
Solar Energy Utilisation in Buildings	AcSIR-01-PS-AD-007	3

Introduction: Sun, Solar path, Radiation pattern.
Measurement: Solar Radiation and Sunshine.
Solar thermal applications: Liquid Flat-Plat Collectors and its performance analysis, Solar air heaters and its performance analysis, Concentrating collectors, Thermal energy storage: sensible heat storage, latent heat storage and thermo-chemical heat storage, other methods to utilization of solar energy:
Other techniques: photovoltaic conversion, solar chimney, solar pond, wind energy, biomass energy, wave energy and ocean energy economic analysis of solar systems

References:
1. J. Twidell and T. Weir, "Renewable Energy Resources", CRC Press, 2015
2. B.H. Khan, "Non-Conventional Energy Resources", Tata McGraw-Hill, 2009
3. M. Patel, "Wind and Solar Systems", CRC Press, 2011

02	CSIR-IGIB	3	Advanced Course

Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-02-BS-AD-001	Ayurgenomics
Biological Sciences	AcSIR-02-BS-AD-002	Genome Design Principles
Biological Sciences	AcSIR-02-BS-AD-003	Molecular & Cellular Mechanisms of Defense
Biological Sciences	AcSIR-02-BS-AD-004	Programming for Biologists
Biological Sciences	AcSIR-02-BS-AD-005	Space and Time in Biological Systems
Biological Sciences	AcSIR-02-BS-AD-006	Stems Cells and Regenerative Medicine

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 02	
CSIR-Institute of Genomics and Integrative Biology	CSIR-IGIB

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title: Ayurgenomics	Course Code	Credits
	AcSIR-02-BS-AD-001	2

Ayurgenomics approach for understanding health-disease transitions and mechanisms of disease, Disease gene network and disease-phenotype de-convolution through Ayurgenomics approach, Therapeutic aspects of Ayurveda with respect to pharmacological and life style interventions: Contempory relevance of practice and science, Novel insights into mechanisms of disease and drug action through integration of therapeutic aspects of Ayurveda with modern biology and genomics

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 02

CSIR-Institute of Genomics and Integrative Biology CSIR-IGIB

Course 3 : Advanced Course Biological Sciences Total Credits 6

Title:	Course Code	Credits
Genome Design Principles	AcSIR-02-BS-AD-002	2

An overview of the science of genomics and the changing paradigm in genetics and biology; Introduction to human genome project and the learning from it, Variability in the human genome, methodologies and its role in health and disease, Functional annotations of the human genome, Abundance and role of noncoding rna in the human genome, modelling and corrections using genome edting tools6. chromatin folding and epigenetics.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 02	
CSIR-Institute of Genomics and Integrative Biology	CSIR-IGIB

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Molecular & Cellular Mechanisms of Defense	Course Code	Credits
		AcSIR-02-BS-AD-003	2

Self versus non-self, innate and adaptive immunity,the immunologist's toolbox, inflammation and immune response in infection and complex disorders-cellular and molecular basis.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 02			
CSIR-Institute of Genomics and Integrative Biology			**CSIR-IGIB**
Course 3 : Advanced Course	**Biological Sciences**		**Total Credits 6**
Title: Programming for Biologists		**Course Code**	**Credits**
		AcSIR-02-BS-AD-004	**2**

Basics of programming work environment, basics of matrix algebra, matrix and vector operations, concepts of algorithms, file handling and introduction to data types, basic programming,high through put data handling, statistical curation of data, data clustering using multiple techniques, the different scales of time in biology, how time is defined at the organismal and cellular level, how tme delays and periodocity is generated in biological systems, how do network motifs regulate biological processes.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 02

CSIR-Institute of Genomics and Integrative Biology CSIR-IGIB

Course 3 : Advanced Course Biological Sciences Total Credits 6

Title:	Course Code	Credits
Space and Time in Biological Systems	AcSIR-02-BS-AD-005	2

About science and practice of ayurveda, ayurveda for predicitive, preventive, personalised, participatory and promotive medicine(p5 medicine), contempopary P4 medicine: approach and challenges, ayurgenomics: an intergactive approach for P4 medicine, introduction to teh TRISUTRA framework of ayurveda in the perspective of systems biology and networks medicine, concept of Tridosha the common organising principle of Ayurveda:link b/w internal and external environment & role in health, disease and human individuality, multiscalar systems biology:resonance with Tridosha at different functional hierarchies from genotype to phenotype, Mechanotransduction in biological systems: resonance with principles and applicationof Trisutra Ayurveda, Human individuality and concept of prakriti, Prakriti development and infuencing factors: parallels with prevailing concepts and molecular mechanisms, Phenome Stratification: methods of prakriti evaluation by Ayurveda and modern objective parameters, Applications of Ayurveda's prakriti principles and stratification methods in understanding variability in response to external environment, disease susceptibility, progression and therapeutic management, Molecular correlates of Tridosha and prakriti: examples from earlier studies,

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AcSIR Academic Centre Code: 02

CSIR-Institute of Genomics and Integrative Biology CSIR-IGIB

Course 3 : Advanced Course Biological Sciences Total Credits 6

Title:	Course Code	Credits
Stems Cells and Regenerative Medicine	AcSIR-02-BS-AD-006	2

The course will discuss 1.stem cells and pluripotent cells 2.regeneration in highly regenerative organisms 3.Organ regeneration where it happens in humans 4.organ regeneration, making it happen where it doesn't in human. The course will discuss each of these aspects through papers and latest advance in each area and what it teaches us about regeneration in general.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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03 CSIR-CCMB 3 *Advanced Course*

Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-03-BS-AD-001	Cell Biology
Biological Sciences	AcSIR-03-BS-AD-002	Developmental Biology
Biological Sciences	AcSIR-03-BS-AD-003	Biology of Inheritance
Biological Sciences	AcSIR-03-BS-AD-004	Disease Biology and Immunity
Biological Sciences	AcSIR-03-BS-AD-005	Ecology and Conservation
Biological Sciences	AcSIR-03-BS-AD-006	Gene Regulation and Genome Organization

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 03		
CSIR-Centre for Cellular and Molecular Biology		CSIR-CCMB
Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title: Cell Biology	Course Code	Credits
	AcSIR-03-BS-AD-001	2

Cell cycle and Cytoskeleton, Cell organization, protein sorting and vesicle trafficking, protein quality control through UPR and degradation, Cell death and division, Differentiation, Migration and Adhesion and Methods in cell biology, Signal transduction.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 03

CSIR-Centre for Cellular and Molecular Biology	CSIR-CCMB

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Developmental Biology	Course Code	Credits
		AcSIR-03-BS-AD-002	2

Introduction about Developmental biology, common terms used in the field, tools and techniques used in developmental biology. Basic concepts of development I and II (model systems: Drosophila melanogaster and mouse), Maternal effect genes, Establishment of body plan (Morphogen gradient, Pattern formation, segmentation, axis formation, metamorphosis), Early development in model organisms: frog/fish, birds, Mammalian development: Concepts of potency and its gradual loss during development. Maternal control of early mammalian embryos, zygotic genome activation. First and second cell fate decision and establishment mammalian blastocyst. Implantation, post implantation development and gastrulation. Development of germ layers and germline development. Synthetic developmental biology: Basic concepts of synthetic developmental biology. Lineage memory and its manipulation during self-organisation. Future potential of synthetic developmental biology. Basics of brain development (model systems: Drosophila melanogaster and mouse). Neural lineage establishment, neural tube formation, neural patterning, neurogenesis, neuron differentiation and migration, myelination, synapse formation. Derivatives of mesoderm – paraxial, intermediate and lateral plate mesoderm, heart development. Developmental biology and medicine, Medical embryology, teratology, developmental disorders and syndromes and therapies. Regeneration: Concepts of evolution of regeneration. Models and mechanisms of regeneration.

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AcSIR Academic Centre Code: 03

CSIR-Centre for Cellular and Molecular Biology CSIR-CCMB

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Biology of Inheritance	AcSIR-03-BS-AD-003	2

Prokaryotic genetics: Mutations, Mutagenesis and DNA repair mechanisms, Mechanisms of gene transfer in bacteria, Concepts in mutant analysis-suppressors, synthetic lethals and their uses, Use of transposable elements in mutagenesis, Bacterial gene regulation. Horizontal gene transfer in bacteria-mechanisms and implications Eukaryotic genetics: Introduction to Yeast –life cycle and genetic manipulations, Mating type switching in Yeast, Plant Genetics- Mendelian and non-Mendelian inheritance, Epigenetics of plants- Introduction, examples and applications, Components of epigenetics-DNA methylation, non-coding RNA and histones, Mapping mutations using genome sequencing- rice as a case study, Bayesian methods of risk assessment, Consanguinity in humans and model genetic systems, Segregation distortion and meiotic drive.

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AcSIR Academic Centre Code: 03	
CSIR-Centre for Cellular and Molecular Biology	CSIR-CCMB

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Disease Biology and Immunity	**AcSIR-03-BS-AD-004**	**2**

Biology of infection: Bacterial Pathogenesis: Introduction to Bacterial Pathogens, Bacterial Virulence Mechanisms, Mycobacterial Pathogenesis. Pathogenesis of Parasites: Introduction to Parasite Biology, Pathogenesis of Malaria, Immune Evasion Mechanisms, Challenges to combat parasitic diseases. Viral Pathogenesis: Introduction to Virology and Molecular Mechanisms of Viral Infections. Genomics and genetic diseases: Overview of Human Genome Project; update on HGP; 1000 Genome Project; HapMap data; methods for genome analysis; different DNA sequencing methods, including next generation sequencing. Molecular basis of disease - from simple disease to complex disease, autosomal, X-linked and Y-linked diseases. Change in pattern of different types of analysis to understand genetic basis of disease; including candidate genes approach, GWAS analysis, gene-gene interaction, gene-environment interaction, fetal programming and epigenetics. Mitochondrial genome, mitochondrial dysfunction and disease, different methods for understanding the cellular, histological and genetic basis of mitochondrial disorders, applications of mitochondrial genomic variations – from forensics to evolution. Origin, evolution and migration of modern human, role of India in early human migration, genetic diversity in India and its implications in health and diseases. DNA fingerprinting, evolution of DNA fingerprinting techniques, applications of DNA fingerprinting in medico-legal and forensics, including wildlife forensics. Nervous system and neuropsychiatric disorders: Overview of the Nervous System and functioning of Neurons: Structural or anatomical level, cellular level, molecular level Techniques and tools in understanding Brain and Behaviour at system level. Circuit level approach to understand Brain and Behaviour. Chemosensory circuit (perception of odor and pheromones), Reward circuit (Addiction and Depression & related Mood Disorders) Environmental perturbations affecting Brain and Behaviour (how environment affects the gene functions and brain and behaviour via epigenetic or chromatin remodeling mechanisms; early circuit development and maturation and implications to pervasive CNS disorders in adulthood). Biology of Neurodegeneration and Repair: Adult Neurogenesis, Neural Progenitor or Stem cells. Learning and memory Circuit: Cognitive disorders and mental retardation. Protein folding and Human health: Introduction: Protein folding in the tube, Protein folding in the crowded environment of cell. Protein misfolding and aggregation, different kind of aggregations: Theory and experiments, loss of function/gain of function, Cellular adaptation to protein aggregation - stress response pathways, Mechanism of protein aggregation in the cell - phase separation concept, theory and experiments. Protein aggregation and proteostasis - protein quality control, functional aggregation, protein misfolding diseases. Protein-misfolding diseases - challenges and opportunities, disease models, mechanisms, therapeutics. Aging and protein misfolding - functional collapse or cellular protection, Stem cells in protein misfolding diseases. Immunology: Organization of the immune system, Lymphocyte development, Innate and a

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Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Ecology and Conservation	AcSIR-03-BS-AD-005	2

Key words: Species diversity theory; measurement of species diversity; niche concept; species interactions; community assembly; dispersal; patterns in endemism; adaptation; phylogeny; population genetics. Biological communities comprising of several species are organized in some predictable ways. This allows measurement of species diversity and using it as a parameter of interest to look at responses to various perturbations. The factors underlying the organisation of biological communities are key to understanding the functional role of a species, and all of species diversity. Therefore, the interactions between species and species assembly are phenomena that are still being investigated. These form the basis for the science of conservation biology. Biogeographic patterns are often non random and thereby, an explanation that drives the pattern is of interest to biologists. Vicariance and dispersal are two broad processes that drive biogeographic patterns. However, with our increasing knowledge about different species, explanations for biogeographic patterns have become complex. The utility of biogeography is in prioritizing areas for conservation and understanding earth's processes that have played a role in shaping the biological diversity. Natural selection has revolutionized our understanding of 'life on earth'. The journey in time made towards understanding causality of 'variation' has led to development of evolutionary biology. This field of biology integrates adaptations in an organism (phenotype) to the shifts that are made in the allele frequencies in their population. The factors that enhance fitness of an organism through modifications in their behaviour and life history strategies are crucial to expanding our understanding of evolutionary biology. Species interactions overview competition, predation, facilitation...implications for community assembly Lotka-Voltera population models Niche and neutral perspectives in community assembly Intra- vs. interspecific interactions (stabilizing and equalizing mechanisms) Functional traits and community assembly. Biodiversity and ecosystem function. Introduction to the theory of natural selection. Microevolution and macroevolution. Modes of speciation, biogeography, diversification patterns and processes. Introduction to conservation biology, biodiversity concept, measurement and challenge, biodiversity values, economics of biodiversity, loss of biodiversity, problems of habitat loss, Isolation, and fragmentation, conservation management of biodiversity. Protecting species- In situ and ex situ conservation and re-introduction; assisted reproductive technologies, genome resource banking, conservation genetics, measuring genetic diversity in plants and animals, species recovery program. Invasive Species – invasive species biology; islands systems and impact of invasives; control and mitigation of invasive species impacts. Climate Change – Effects on the physical environment and biodiversity; tropical biodiversity under global warming; effects on biotic interactions; indirect threats to biodiversity from climate change. Extinctions and the practice of preventing them – Why extinctions are alarming? What are the rates of extinction? Extinction proneness; future extinctions and how could they be prevented.

AcSIR Academic Centre Code: 03	
CSIR-Centre for Cellular and Molecular Biology	**CSIR-CCMB**

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Gene Regulation and Genome Organization	Course Code	Credits
		AcSIR-03-BS-AD-006	2

Overview of genomes: The new science of genomics - major questions and potentials The rest and the most of the genome - search of function. Packaging of genome: Structural and functional domains in genome, Chromosome territories, Nuclear architecture and genomic packaging. Epigenetic regulation: Chromosomal position effect and heterochromatin, Structural basis of epigenetic cellular memory Coordinated regulation of gene clusters. The cell biology of the genome, nuclear-cytoplasmic communication: Mapping structural and functional compartments of the nucleus, Nucleolus, Nuclear Pore, Establishing temporal and spatial location Visualizing nuclear events, Nuclear Matrix, Interchromatin granule compartments, Mechanical signalling to chromatin, Chromatin and nuclear lamina, Transnuclear connections to cytoskeleton and adhesion complexes. Overview of the epigenetic mechanisms of gene regulation: Chromatin remodeling, ATP dependent remodeling, Histone modifications and histone code, Histone variants. Chromatin modifications and mechanism of their action: Chromatin and genome stability, Crosstalk between cell signalling pathways and epigenetic machinery, Methods in chromatin biology. Transcriptional Regulation: Regulation of Transcription Initiation by RNA Polymerase II, Pre-initiation complex assembly and regulation, Suppression of pervasive transcription, Methods for studying (regulators of) transcription initiation, RNA Polymerase II Transcription Elongation Control, Control of transcriptional pausing and termination, Measuring transcription elongation dynamics, Transcription-coupled processes, Post-transcriptional life of mRNA: Association of transcribing mRNAs with various RNA binding proteins, mRNA export to cytoplasm: Various pathways, Localized Translation: Methods to identify mRNA localization, Regulation of protein translation, Translation Initiation in Eukaryotes, Global and Specific regulation, 5’ and 3’ UTRs and their significance, Major pathways regulating translation, Capped and uncapped translations, Bicistronic reporter vectors, Cytoplasmic vs ER translation and protein targeting, RNA granules (SG, PB), unloading of ribosomes and flow of mRNA between ribosomes and RNA granules, Tools to study translation regulation, Metabolic labeling, Polysome Analysis and profiling, Ribosome profiling.

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Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-04-BS-AD-001	Animal Models in Biomedical Research
Biological Sciences	AcSIR-04-BS-AD-002	Approaches to Drug Delivery
Biological Sciences	AcSIR-04-BS-AD-003	Biology and Therapeutics of Life Style and CNS Disorders
Biological Sciences	AcSIR-04-BS-AD-004	Biology of Macromolecules
Biological Sciences	AcSIR-04-BS-AD-005	Cancer Biology
Biological Sciences	AcSIR-04-BS-AD-006	Cell Signaling
Biological Sciences	AcSIR-04-BS-AD-007	Microbial Pathogenesis
Biological Sciences	AcSIR-04-BS-AD-008	Molecular & Cellular Biology
Biological Sciences	AcSIR-04-BS-AD-009	Molecular and Cellular Mechanism of Defence
Biological Sciences	AcSIR-04-BS-AD-010	Molecular Therapeutics
Biological Sciences	AcSIR-04-BS-AD-011	Plant Secondary metabolites and Their in vitro Biosynthesis through Plant Tissue Culture
Biological Sciences	AcSIR-04-BS-AD-012	Plant Taxonomy, Biodiversity, Conservation, Ethnobotany and Pharmacognocy
Chemical Sciences	AcSIR-04-CS-AD-001	Advanced Organic Chemistry
Chemical Sciences	AcSIR-04-CS-AD-002	Chemistry of Natural Products
Chemical Sciences	AcSIR-04-CS-AD-003	Synthetic Methods for Organic Chemists

04 CSIR-CDRI 3 *Advanced Course*

Faculty of Study	Course Code	Course Title
Chemical Sciences	AcSIR-04-CS-AD-004	Organic Spectroscopy Applications
Chemical Sciences	AcSIR-04-CS-AD-005	Chemistry and Biology of Heterocycles
Chemical Sciences	AcSIR-04-CS-AD-006	Natural Products and Drug Discovery

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AcSIR Academic Centre Code: 04

CSIR-Central Drug Research Institute	CSIR-CDRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title: Animal Models in Biomedical Research	Course Code	Credits
	AcSIR-04-BS-AD-001	2

Principles and fundamentals of Plant taxonomy; classification of angiosperms; International Code of Introduction to model systems, Origins of Animal Experimentations, Laws, regulations and policies affecting the use of Laboratory animals, Brief account of biology and diseases of commonly used Rodent models (Mouse, Rat, Hamster, Guinea pigs, Gerbils and Mastomys), Brief account of biology and diseases of different Non-Rodent models (Rabbit, Dog, nonhuman primates), Laboratory Animal Biosecurity (Prevention, containing and eradication) Planning and Execution of Animal Experiments, Common Zoonotic Diseases and Prevention. Genetic manipulations and Transgenesis: Principles and methods, Transgenic and Knockout Models for specific diseases. Genetic Monitoring of Experimental Animals. Alternative Models (cell based, Yeast, Drosophila, C. elegans, Zebrafish), advantages and disadvantages. Animal handling, care and Laboratory animal Techniques (practicals).

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AcSIR Academic Centre Code: 04			
CSIR-Central Drug Research Institute			**CSIR-CDRI**
Course 3 : Advanced Course	**Biological Sciences**		**Total Credits 6**

Title:		Course Code	Credits
	Approaches to Drug Delivery	**AcSIR-04-BS-AD-002**	**2**

Conventional dosage forms- for per-oral and parenteral drug delivery, Analytical approaches and method development for pharmaceutical analysis, Storage stability under ICH and Schedule Y regimes, Controlled release- Principles and strategies, Oral controlled release systems, Targeted drug delivery with special reference to colloidal particles. Cutaneous and Transdermal drug delivery, Delivery of drugs by Pulmonary route, Microparticles and nanoparticles for drug delivery, Strategies for the delivery of biomacromolecules. Liposomes as drug delivery vehicles, BCS system and applications of micro emulsions for delivery of poorly soluble drugs. Laboratory Work, Matrix-controlled release tablet , Adhesive-dispersion transdermal, Drug powder for inhalation, Development of nanosuspension

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AcSIR Academic Centre Code: 04

CSIR-Central Drug Research Institute	**CSIR-CDRI**

Course 3 : Advanced Course	**Biological Sciences**	**Total Credits 6**

Title:	**Biology and Therapeutics of Life Style and CNS Disorders**	**Course Code**	**Credits**
		AcSIR-04-BS-AD-003	**2**

Concept and introduction to Biology and Therapeutics of Life Style Disorders, Introduction to General Pharmacology (Basic concepts and Terminologies; Pharmacokinetics), Introduction to General Pharmacology (Pharmacogenomics and adverse reactions), Immunopharmacology; Immune regulation of metabolic syndrome, Immunopharmacology Lab work, Energy metabolism, Obesity and Diabetes (pathophysiology and therapeutics), Biology of Inflammation and inflammatory disorders (pathophysiology and therapeutics), Introduction to disorders affecting cardiovascular system, (pathophysiology and therapeutics of cardiac myopathies), Introduction to disorders affecting cardiovascular system (pathophysiology and therapeutics of hypertension), Introduction to disorders affecting cardiovascular system (pathophysiology and therapeutics of atherosclerosis and thrombosis) Role of non-coding RNA in cardio-metabolic diseases Introduction to disorders affecting cardiovascular system (pathophysiology and therapeutics of cardiac failure), Cardiovascular system (CVS) Lab work Lab work of Diabetes and Inflammation, Basic Understanding of Neurotransmission and Neurotransmitters, Etiology and Pathogenesis of Neurodegenerative disorders, Etiology and Pathogenesis of Psychiatric disorders, Targets and Therapeutic of Neurodegenerative disorders, Targets and Therapeutic of Psychiatric disorders, Recent Updates in animal models of Neurodegenerative disorders, Recent Updates in animal models of Psychiatric disorders, Targets and Therapeutics in Traumatic Brain Injury, Etiology and Pathogenesis of Neurovascular disorders, Epigenetic mechanisms of CNS Disorders

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AcSIR Academic Centre Code: 04

CSIR-Central Drug Research Institute	CSIR-CDRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Biology of Macromolecules	Course Code	Credits
		AcSIR-04-BS-AD-004	2

Introduction to Primary and secondary structures of proteins and nucleic acids; hydrogen bonding, ionic and hydrophobic interactions. Amino Acids and Proteins, Peptide backbone, side chains, polarity, Absorbance, Single letter codes, etc. Protein Structure: Primary, secondary, tertiary and quaternary structure, covalent modifications of the polypeptide chain, Forces that determines protein structure, Structural motifs in regulatory proteins: DNA-binding proteins, Zinc finger motif, Helix T urn Helix motif Basic Leucine Zipper motifs. Tools: Databank of protein sequences (SWISS-PROT), Basics of protein sequence alignment , Protein Regulation, Enzymes I: Mechanism of Catalysis , Enzymes II: Kinetics & Regulation, Protein Methods: Protein separation and purification Methods, Protein Function Analysis, The Life Cycle of a Protein: Folding to Destruction (Proteasomes and Unbiquitination), Practical Training to protein separation/detection using Western blotting , Introduction to Proteomics and its advantages over genomics, 1D and 2D Gel Electrophoresis: pI, Isoelectric focusing, 2 dimensional gel, Gel Staining methods and analysis, Protein spot/Band processing for Mass spectrometric analysis, Introduction to Mass spectrometers such as MALDI-TOF/TOF and electrospray mass spectrometer. Spectral Peak Annotation and Database search, Shotgun Proteomics, Protein quantification using Mass spectrometry: ITRAQ, ICAT and SILAC, Practical Training for 1D and 2 D gel electrophoresis and subsequent Mass Spectrometric analysis of processed protein spot, Optical spectroscopy: Photons, chromophores, transition dipole moments, absorbance. Circular Dichroism, Fluorescence and surface plasmon resonance. Particles in a field: Applications of MS for complex proteins, electrophoresis and sedimentation. X-ray diffraction: Overview of theory. Scattering from a periodic lattice, reciprocal space, and symmetry. Phase problem, Patterson functions, molecular replacement, model building and refinement. Nuclear magnetic resonance: overview and practical aspects. Nuclear spin and coupling interactions, multi-dimensional experiments, determination of protein and nucleic acid structures, protein folding, dynamics, SAR by NMR. Cryo-EM: Applications of Cryo-EM on the architecture of molecular machines, organelles and organisms. Bioinformatics: 3D structure modeling, visualization softwares, homology modeling, similarity searches, sequence alignment.

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CSIR-Central Drug Research Institute	CSIR-CDRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:		Course Code	Credits
	Cancer Biology	AcSIR-04-BS-AD-005	2

Cancer: The nature of cancer and class organization Hall Marks of Cancer: Evasion of Apoptosis, Limitless replicative potential, Sustained Angiogenesis, Inflammation, Cancer: The Key Players (Carcinogens, tumor virology, oncogenes tumor suppressor genes, cell cycle regulation), Hypoxia and Angiogenesis in cancer, Metabolism and cancer, MicroRNAs and cancer, Stem Cells and Cancer, Chemoresistance & Radioresistance in Cancer, Experimental approaches to understanding the origins, diagnosis, and treatment of cancer. Recent advances in the field and future prospects.

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AcSIR Academic Centre Code: 04

CSIR-Central Drug Research Institute	CSIR-CDRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Cell Signaling	Course Code	Credits
		AcSIR-04-BS-AD-006	2

Principles of Cell Signaling and Biological Consequences Introduction: Overview of Pathways and Networks and GPCR Signalling, G Protein–Coupled Receptors, G Protein Effectors, Ligand-Gated Ion Channels, Regulation of Ion Channels by G Proteins, Protein Kinases,Protein Phosphatases, Ras-MAPK Pathways, Growth Factor and Receptor Tyrosine Kinases Cytokine Receptors and Jak-STAT Signaling Nuclear Transactivators and Repressors Nuclear receptors, Chromatin Remodeling, Regulation of Complexes by Cytoskeletal Elements: Integrins as Force Transducers Linking Mechanical Stimuli and Biochemical Signals, Apoptosis, MicroRNA.

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AcSIR Academic Centre Code: 04			
CSIR-Central Drug Research Institute			**CSIR-CDRI**
Course 3 : Advanced Course	**Biological Sciences**		**Total Credits 6**

Title:		Course Code	Credits
	Microbial Pathogenesis	**AcSIR-04-BS-AD-007**	**2**

Clinical spectrum of AIDS, Dengue, Tuberculosis, Malaria & Kala-azar, (Lectures in reference to Clinical symptoms, Diagnosis, Prophylaxis and Treatments), Cellular and Host tropisms of Organisms and Pathological changes (Lectures in reference to molecular bases of survival of the organisms in the hosts), Metabolic and Enzymatic Pathways, (Lectures based on the molecules involved in virulence, diagnosis and drug targets), Mechanism of Actions of Drugs and Drug Resistance (Lectures highlighting present drugs, SDR, MDR, XDR and role of Hosts) Delineations of Genomes and Proteomes of HIV, Plasmodium, L. donovani and M. tuberculosis, (Lectures based on Identification of important molecules involved in patho-biology of organisms, future drugs and Immunogens), Laboratory Work: Culture of micro-organisms in laboratory and Infections in vivo and in ex vivo.

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AcSIR Academic Centre Code: 04

CSIR-Central Drug Research Institute CSIR-CDRI

Course 3 : Advanced Course Biological Sciences Total Credits 6

Title:	Molecular & Cellular Biology	Course Code	Credits
		AcSIR-04-BS-AD-008	2

Nuclear ultrastructure, chromatin network and spatial organization in the nucleus, DNA Replication (Origin recognition and initiation of DNA replication, mechanisms of replication, analyzing DNA replication origins and mechanisms), Transcriptional regulation, (The transcription initiation complex: components, transcription factor, recruitment and regulation, regulatory DNA elements), Chromatin organization in prokaryotes and eukaryotes, chromatin assembly/disassembly and transcriptional control, epigenetic control of cancer, Protein translation, post-translational modifications, retro transport. Organelle targeting and cellular transport of proteins, Transport across membranes and signal transduction, Ligand receptors, ion channels, signal transduction pathways Calcium signalling, Molecular and cellular evolution Abiogenesis, mechanisms of evolution (random mutation, natural selection, genetic drift, endosymbiosis and current controversies, Cell cycle regulation and apoptosis, Maintenance and transition of the phases of the cell cycle, pathways of programmed cell death, Molecular processes in development, Gradients and cascades in embryo development.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 04

CSIR-Central Drug Research Institute	CSIR-CDRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Molecular and Cellular Mechanism of Defence	**AcSIR-04-BS-AD-009**	**2**

Cells and tissues of the immune system, Innate immunity, Effectors of adaptive immunity, Antigen and antibody, Complement system and inflammatory reaction, Major Histocompatibility Complex, Antigen processing, presentation Cytokines, chemokines and leukocyte trafficking, Immunobiology of the pulmonary system, Immune tolerance and autoimmunity, Immunobiology of Malaria, Pathology of Malaria, Immunobiology of Leishmania, Pathology of Leishmania, Immunobiology of Filaria, Pathology of Filaria, Immune Cell signaling of Leishmaniasis, Vaccines

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 04	
CSIR-Central Drug Research Institute	CSIR-CDRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Molecular Therapeutics	AcSIR-04-BS-AD-010	2

Introduction to General Pharmacology Molecular Mechanisms of Drug Action Adverse Drug Reactions and Side effects Molecular Pharmacokinetics and Pharmacodynamics Safety Pharmacology Clinical Trial Pharmacovigilance Biotherapeutics Laboratory Work

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 04		

CSIR-Central Drug Research Institute	CSIR-CDRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title: Plant Secondary metabolites and Their in vitro Biosynthesis through Plant Tissue Culture	Course Code	Credits
	AcSIR-04-BS-AD-011	2

Plant secondary metabolites: classification, plant environment interaction and its production, role of these metabolites in drug development, Plant tissue culture: history, concepts, vocabulary, terminology, types and applications, General methods and laboratory organisation of plant tissue culture; types and constituents of plant tissue culture media, Microproprogation: principles, types, method and application; somatic embryogenesis, Production of medicinally important secondary metabolites by callus/cell suspension/hairy root cultures. Optimization of physical/chemical factors, precursor-feeding and elicitation for enhanced production, Transgenic plants: methods and advances in producing transgenics, selection, identification, molecular analysis for confirmation; biotransformation using cell/hairy root cultures for generating pharmaceutical lead molecules; approaches of engineering metabolic pathways in heterologous systems.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 04	
CSIR-Central Drug Research Institute	**CSIR-CDRI**

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Plant Taxonomy, Biodiversity, Conservation, Ethnobotany and Pharmacognocy	**AcSIR-04-BS-AD-012**	**2**

Principles and fundamentals of Plant taxonomy; classification of angiosperms; International Code of Botanical Nomenclature; concept of plant taxa, plant nomenclature and plant identification; modern trends in taxonomy, speciation in plants, Role of herbaria, botanical gardens and taxonomic literature for plant identification; methods and techniques of plant collection, processing and herbarium preparation, Molecularsystematics: concepts and applications, molecular markers in plant systematic, procedures for collecting and sampling of plant materials, molecular phylogenetics. Floristic diversity: scope and perspective; species distribution and endemism; hotspots and mega-diversity; threats of plant diversity and assessment of plants as per IUCN recommendations; conservation of threatened plants: in situ and ex situ; types of protected area, role of Biosphere Reserve, National Parks, Wild Life Sanctuaries and Sacred Grooves in biodiversity conservation, National Biological Diversity Act and biopiracy, Bio prospection: principle, techniques and applications, Ethnobotany: definition and scope; interdisciplinary nature of Ethnobotany and its role in drug development, Pharmacognosy: role in Indian Pharmacopeia, development of quality control parameters for evaluation of crude drug samples/ herbal drug formulation/ adulteration and substitutions.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 04		

CSIR-Central Drug Research Institute	CSIR-CDRI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Advanced Organic Chemistry	Course Code	Credits
		AcSIR-04-CS-AD-001	2

Resolutions of mixture of enantiomers, Diastereoselective and enantioselective syntheses (reagent controlled, catalyst controlled, substrate controlled), Conformational analysis and conformational effect on reactivity, Asymmetric oxidation and reduction, Methods of asymmetric synthesis and their application in total synthesis, reaction mechanism, Advanced catalysts and ligand systems for the C-C and C-X bond formations, Retrosynthetic analysis, photochemistry, pericyclic reactions, oxidation-reduction reactions, Organocatalysis, Principle and Classification, Antibody catalyzed reaction, Enamine catalysis and iminium catalysts, Bronsted acid and Bronsted base catalysts, Hybrid Organocatalysts and application in total synthesis of natural products, Metal catalysis, Importance in biological processes, Transition and Coinage metal catalyzed reactions, Application in total synthesis of natural products, Advances in Name Reactions and Reagents,metathesis reactions.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 04	
CSIR-Central Drug Research Institute	CSIR-CDRI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Chemistry of Natural Products	AcSIR-04-CS-AD-002	2

Introduction to the chemical diversity and biological activity of natural products, Biosynthesis of natural products derived from Acetate, Mevalonate, Deoxyxylulose ,Phosphate and Shikimate Pathways, Construction mechanism of natural products, Recent development in natural products isolation and characterization, Biomimetic organic synthesis, Total synthesis of bioactive natural products, Natural products as tools to understand biological processes.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

CSIR-Central Drug Research Institute	CSIR-CDRI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title: Synthetic Methods for Organic Chemists	Course Code	Credits
	AcSIR-04-CS-AD-003	2

Formation of carbon-carbon bond employing various kinds of organometallic reagents, C-C double bonds through different reactions, oxidation, reduction through various kinds of reagents, functional group interconversion, by substitution including protection and deprotection, alkylation of enolates, and other carbon nucleophiles, reaction of carbon nucleophiles with carbonyl compounds, electrophilic addition to C-C multiple bonds, reactions of C-C multiple bonds, Retrosynthesis, disconnection, synthons, linear and convergent synthesis, umpolung of reactivity and protecting groups. Introduction to green chemistry (Concept of Atom Economy), Principles, plans and benefit, Tools of green chemistry, Name reactions using green chemistry concept.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 04		
CSIR-Central Drug Research Institute		CSIR-CDRI
Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Organic Spectroscopy Applications	AcSIR-04-CS-AD-004	2

Mass spectroscopy, IR spectroscopy, Proton magnetic resonance spectroscopy, Structural assignment by employing NMR techniques, Proton NMR, Carbon-13 NMR spectroscopy, Introduction COSY, HSQC, HMBC, NOESY, ROESY, Structural elucidation using 2D-NMR methods.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 04			
CSIR-Central Drug Research Institute			CSIR-CDRI
Course 3 : Advanced Course	Chemical Sciences		Total Credits 6
Title: Chemistry and Biology of Heterocycles		Course Code	Credits
		AcSIR-04-CS-AD-005	2

Privileged heterocycles, Electronic properties, reactivity (electrophilicity and nucleophilicity), Synthetic methodologies, Biological properties of Natural products and drug candidates, Biosynthesis, Dimeric compounds and related stereochemistry.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 04

CSIR-Central Drug Research Institute | CSIR-CDRI

Course 3 : Advanced Course | Chemical Sciences | Total Credits 6

Title:	Course Code	Credits
Natural Products and Drug Discovery	AcSIR-04-CS-AD-006	2

Natural products: Importance, lead, clinical trials in drug discovery research, Case studies of marketed natural product drugs, Synthetic Biology and Genetic engineering in the production of natural product, A brief overview of drug discovery approach, Cause of diseases, Target identification, Target validation, Modeling, Synthesis and SAR, Drug Delivery, Clinical Trials, Etiology, pathogenesis, prevention, drug targets and chemotherapy, drug resistance and remedies of tropical infectious diseases, Etiology and remedies of diseases developed through metabolic disorders.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

05 CSIR-CECRI 3 *Advanced Course*

Faculty of Study	Course Code	Course Title
Chemical Sciences	AcSIR-05-CS-AD-001	Electrochemical Remediation
Chemical Sciences	AcSIR-05-CS-AD-002	Functional Materials
Engineering Sciences	AcSIR-05-ES-AD-001	Environmental Engineering
Engineering Sciences	AcSIR-05-ES-AD-002	Electrochemical Technology
Engineering Sciences	AcSIR-05-ES-AD-003	Electrochemical Power Sources
Physical Sciences	AcSIR-05-PS-AD-001	Advanced Material Characterization Techniques
Physical Sciences	AcSIR-05-PS-AD-002	Advanced Corrosion Technology
Physical Sciences	AcSIR-05-PS-AD-003	Advanced Electrochemistry
Physical Sciences	AcSIR-05-PS-AD-004	Modelling & Simulation in Electrochemistry

AcSIR Academic Centre Code: 05

CSIR-Central Electro Chemical Research Institute	CSIR-CECRI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Electrochemical Remediation	AcSIR-05-CS-AD-001	2

Overview of electrochemical remediation technologies- electro chemical transport and transformation – basics – electrokinetic (Ek) removal of chlorinated organic compounds – lasagna technology – remediation of heavy metals and other inorganic pollutants – Ek removal of nitrate and fluoride – Ek remediation of mixed metal contaminants – Electrochemical reduction of carbondioxide into fuels-Mechanistic studies-Electrocarboxylation of aromatic compounds-influence of different electrode materials.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 05	
CSIR-Central Electro Chemical Research Institute	CSIR-CECRI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Functional Materials	AcSIR-05-CS-AD-002	2

Introduction - surface properties and functionalization - nanomaterials – design of functional materials – characterization techniques – functional materials for energy applications – biomaterials - materials for solar energy - magnetic materials– thermoelectric materials - smart materials - organic materials for electronics application - computational materials science - modelling of nanomaterials -electronic and band structures.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 05

CSIR-Central Electro Chemical Research Institute CSIR-CECRI

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title: Environmental Engineering	Course Code	Credits
	AcSIR-05-ES-AD-001	2

Environmental chemistry- atmospheric chemistry,environmental chemicals; Environmental Microbiology - classification and characteristics of Microorganismsmicrobes and nutrient cycles-pathogens in wastewater Microbiology of biological treatment processes aerobic and anaerobic, a-oxidation, (3-oxidation, nitrification and denitrification, eutrophication. Factors influencing toxicity. Effects - acute, chronic, concentration response relationships. Test organisms - toxicity testing, Bioconcentration-Bioaccumulation, Biomagnifications.Bioassay, biomonitoring, bioleaching.

Pollution in waste water - physical and chemicaltreatment of water and waste water- Biological treatment of water and wastewater-sludge treatment and disposal. Airpollution and control-solid and hazardous waste management-waste characterization and waste reduction.

Industrial wastewater management, treatment & disposal-Industrial pollution prevention & waste minimization-Wastewater reuse and residual management- heavy metal removal-aerobic and anaerobic biological treatment -chemical oxidationozonation-photocatalysis-carbon adsorption-wet air oxidation.

Nanoporous materials their synthesis/preparation and structure, post-synthetic modification, characterization and use in various applications like adsorption/separation, catalysis etc,Adsorption and desorption isotherms.

Advanced treatment process- role of electro chemistry in water and waste water treatment.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

CSIR-Central Electro Chemical Research Institute	CSIR-CECRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Electrochemical Technology	AcSIR-05-ES-AD-002	2

Electrochemical process engineering and optimization of electrochemical parameters technologies on electrochemicals including processes developed at CSIR-CECRI metal finishing technologies - corrosion control processes - electrometallurgy includes aqueous - non aqueous and high temperature metallurgical processes.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 05

CSIR-Central Electro Chemical Research Institute	CSIR-CECRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Electrochemical Power Sources	Course Code	Credits
		AcSIR-05-ES-AD-003	2

Energy scenario, necessity of electrochemical power sources, classification of electrochemical energy systems, batteries (primary and secondary batteries) fuel cells, supercapacitors and flow batteries; Thermodynamic- electrode potentials, theoretical cell voltage, theoretical/practical capacity, C-rate, cycle-life; electrochemical processes and electrode kinetics; overview of characterization techniques; materials, significances and challenges for batteries, flow batteries and supercapacitor; recent research and development of various energy storage and conversion devices along with modern technologies, challenges and prospects.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Advanced Material Characterization Techniques	Course Code	Credits
		AcSIR-05-PS-AD-001	2

Optical Microscopy, Electron microscopy: TEM, HRTEM, SEM, STEM, EDX, FIB, Ebeam lithography, Scanning probe microscopy: AFM, STM, MFM, confocal, etc, Raman spectroscopy/microscopy, Thermal analysis techniques, Magnetic measurements, Electrical measurements, Spectroscopic ellipsometry.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 05			
CSIR-Central Electro Chemical Research Institute			**CSIR-CECRI**
Course 3 : Advanced Course	**Physical Sciences**		**Total Credits 6**

Title:	Course Code	Credits
Advanced Corrosion Technology	**AcSIR-05-PS-AD-002**	**2**

Functional Coatings: Types and application, Cathodic protection (CP), Electrochemical theory of cathodic protection-design, Reinforcement corrosion environmental conditions, Transport mechanisms, Admixtures to concrete, Coatings to concrete surface, High performance concrete, Corrosion resistant rebars, Smart and greener concrete, Nano composite materials for construction industries, Flow and biocorrosion, Fluid flow fields, Flow corrosion testing methods, Bacterial enumeration mechanism, Microbial corrosion on active/passive alloys, Selection of biocides/inhibitors against microbiologically influenced corrosion (MIC), Relationship between CP and MIC.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 05

CSIR-Central Electro Chemical Research Institute	CSIR-CECRI

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Advanced Electrochemistry	Course Code	Credits
		AcSIR-05-PS-AD-003	2

Basic electrochemistry concepts, Ideally polarizable and non-polarizable electrodes, Reference electrodes, Electrified interfaces, Interface vs. Interphase, Electrical double layer, Helmholtz-Gouy-Chapman model, Stern theory, Electrode capacitance, Adsorption phenomena at electrodes, Potential of zero charge, Electro-capillary curves, Lippmann equation. Electrochemical thermodynamics, Kinetics of electron transfer, Overpotential, Exchange current density, Butler-Volmer equation- Derivation and approximations, Tafel equation, Standard electrode potential, Potentiometry, Nernst equation, Modes of mass transfer, Diffusion, Faraday's laws, Faradaic vs. non-Faradaic processes, Electrolysis, Electrode position. Electrochemical techniques, Voltammetry, Reversible and irreversible reactions, Amperometry, Oculometry, Chrono-amperometry, Chrono-potentiometry, Rotating electrodes (RDE & RRDE), Impedance spectroscopy, Equivalent circuits, AC. Thin layer cells, Spectroelectrochemistry-Applications, Microelectrodes, Scanning electrochemical microscopy and Electrochemical instrumentation, Simple circuits and feedback loops.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 05			
CSIR-Central Electro Chemical Research Institute			CSIR-CECRI
Course 3 : Advanced Course	Physical Sciences		Total Credits 6

Title: Modelling & Simulation in Electrochemistry	Course Code	Credits
	AcSIR-05-PS-AD-004	2

Atomic level modeling, Periodic boundary conditions, Pair potentials embedded atom method, Potentials for covalent solids and semiconductors, Basic statistical and thermodynamical concept, Monte Carlo simulations , Molecular dynamics simulations, Quantum mechanical modelling, Hartree-Fock and density functional theory, Ab initio electronic structure calculations. Analytical models of polymer elecirolyte membrane fuel cells and direct methanol fuel cells, Modeling charge transport, Mass transport, Heat transport, Proton exchange membrane, Gas diffusion layer, Catalyst layer, Modeling fuel cells, Microfuel cells, Fuel cell stacks, Fuel cell systems design, Model validation, Modeling batteries.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

06 CSIR-CEERI

3 *Advanced Course*

Faculty of Study	Course Code	Course Title
Engineering Sciences	AcSIR-06-ES-AD-001	Cyber Physical Systems Design Practices
Engineering Sciences	AcSIR-06-ES-AD-002	Design and Simulation of Microwave Devices
Engineering Sciences	AcSIR-06-ES-AD-003	Design of Smart Sensors and Devices
Engineering Sciences	AcSIR-06-ES-AD-004	Advanced Microwave Materials and Their Applications
Engineering Sciences	AcSIR-06-ES-AD-005	Advanced Communication Systems
Engineering Sciences	AcSIR-06-ES-AD-006	Micro-Sensors and Actuators: Design and Fabrication
Engineering Sciences	AcSIR-06-ES-AD-007	Advanced Packaging Technologies
Engineering Sciences	AcSIR-06-ES-AD-008	Advanced Machine Learning and Applications
Engineering Sciences	AcSIR-06-ES-AD-009	High-Power Microwave Devices and Fabrications
Engineering Sciences	AcSIR-06-ES-AD-010	Micro-and Nano Technology and Applications

AcSIR Academic Centre Code: 06		
CSIR-Central Electronics Engineering Research Institute		**CSIR-CEERI**
Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Cyber Physical Systems Design Practices	**AcSIR-06-ES-AD-001**	**3**

System Engineering Fundamentals: Specification requirements and Elaboration, Conceptual Design, System Engineering Management, Design Thinking, Technology Reediness Level, (TRL) Audit, TRL Translation, TRA/ TRL assessment report for a live project specific to Cyber Physical System Area.

Practical CPS design: Discussion about the CPS practical design, implementation, testing and verification methods,CPS case studies.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 06

CSIR-Central Electronics Engineering Research Institute	**CSIR-CEERI**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:	**Design and Simulation of Microwave Devices**	**Course Code**	**Credits**
		AcSIR-06-ES-AD-002	**3**

Study, Design and analysis of different components for: Electron beam generation, Electron beam and RF interaction, Electron beam collection, In and out coupling of RF etc. Introduction to design of components used in 5G communication: Simulation/modelling of electron beam optics; Study, modelling and analysis of convergent and gyrating electron beam for medium to high power vacuum microwave devices; Simulation/ modelling of interaction structure: Study, modelling and analysis of interaction structures for high efficiency, high power, high frequency, high linearity; Simulation/ modelling of coupling system: Study, modelling and analysis of coupling system for high power, wideband and high frequency devices.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 06

CSIR-Central Electronics Engineering Research Institute CSIR-CEERI

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Course Code	Credits
Design of Smart Sensors and Devices	AcSIR-06-ES-AD-003	3

MEMS Accelerometer, MEMS Acoustic Sensor, Ion-Sensitive Field-Effect Transistors, RF-MEMS switches flexible micro-patterned tactile sensor, UV-LED devices for optimization of epitaxial structure, InGaN/GaN blue/ green laser, nano-structured plasmonic-based colour filters, LTCC-based micro-hotplates; Design: Literature surve, Design of smart sensor or device; Simulation: Implementation of the design on software; Results and analysis; Case Study: Design and simulation of smart device based on given parameters.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 06	
CSIR-Central Electronics Engineering Research Institute	CSIR-CEERI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Advanced Microwave Materials and Their Applications	Course Code	Credits
		AcSIR-06-ES-AD-004	3

Advanced vacuum-grade materials for high power microwave devices including (isotropic, homogeneous materials) lightweight magnetic materials, thermally conducting insulating materials. Review of Maxwell equations, introduction to metamaterials and effective medium concept, physics of negative permeability and permittivity. Physics of photonic band gap structure, FSS, dispersion engineering manipulation of light wave, surface plasmon, super lens, metamaterial microwave antennas and absorbers. Metamaterial assistance of antennas, metamaterial assistance of interaction structures of microwave tubes, interaction of metamaterial with moving electron, overview of metamaterial fabrication.

Module 1: (1 credit)
Advanced vacuum-grade materials for high power microwave devices including (isotropic, homogeneous materials) lightweight magnetic materials, thermally conducting insulating materials
Module 2: (1 credit)
Review of Maxwell equations, introduction to metamaterials and effective medium concept, physics of negative permeability and permittivity. Physics of photonic band gap structure, FSS, dispersion engineering manipulation of light wave, surface plasmon,
Module 3: (1 credit)
super lens, metamaterial microwave antennas and absorbers. Metamaterial assistance of antennas, metamaterial assistance of interaction structures of microwave tubes, interaction of metamaterial with moving electron, overview of metamaterial fabrication.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 06

CSIR-Central Electronics Engineering Research Institute CSIR-CEERI

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Course Code	Credits
Advanced Communication Systems	AcSIR-06-ES-AD-005	3

Review of analog and digital communication systems; Digital modulation Schemes; Optimum Receivers for AWGN Channels; Carrier and Symbol Synchronization; Multicarrier Modulation Techniques; Cognitive Radio and Spectrum Sensing Techniques; Theory and basic concepts in application of wireless communication systems 5G,Wireless Local Area (WLAN), BLE4.0/5; and Wireless Personal Area (WPAN) Networks; Application and design and implementation issues and solutions including hardware-software co-design for Software Defined Radio, software defined networking, Tactile radios, vehicular communication networks; Design of Physical layer digital baseband modules for multi-protocol standards. The study of data networking will include multiple access, reliable packet transmission, MAC and Routing and protocols. Implementation issues and system level analysis.

Module 1: Design (1 credit)
- Literature survey
- Design of smart sensor or device.

Module 2: Simulation (1 credit)
- Implementation of the design on software
- Results and analysis

Module 3: Case Study (1 credit)
- Design and simulation of smart device based on given parameters.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 06	
CSIR-Central Electronics Engineering Research Institute	CSIR-CEERI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title: Micro-Sensors and Actuators: Design and Fabrication	Course Code	Credits
	AcSIR-06-ES-AD-006	2

Unit processes in fabrication of IC/MEMS, fundamentals of MEMS, sensing principles, actuation mechanisms, case studies.

Module 1: Unit Processes in Fabrication of IC
Crystal growth techniques, wafer preparation and shaping, chemical cleaning, thermal oxidation, thermal diffusion, ion implantation, photolithography
Module 2: Unit Processes in Fabrication of IC/MEMS
Thin film deposition, etching (wet and dry), surface and bulk micro-machining, LIGA, wafer bonding.
Module 3: Fundamentals of MEMS Design and Sensing Principles
Introduction to MEMS, fundamentals of solid mechanics, mechanics of beam and diaphragm, air damping, sensing principles (piezoresistive sensing, capacitive sensing, piezoelectric sensing, resonant sensing, thermoelectric sensing, magnetic sensing).
Module 4: Actuation Mechanisms and Case Studies
Actuation mechanisms (capacitive actuation, piezoelectric actuation, thermo-mechanical actuation, thermo-electric, magnetic actuation), case-studies.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 06

CSIR-Central Electronics Engineering Research Institute	CSIR-CEERI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title: Advanced Packaging Technologies	Course Code	Credits
	AcSIR-06-ES-AD-007	2

Importance of packaging, Issues related to parasitics, Bonding and encapsulation techniques, Hermetic and vacuum sealing, flip-chip bonding, High density packaging, System-in-package (SiP), 3D packaging, Reliability of packages, LTCC Technology for MCM/MSTM, Case studies of customized packaging of MEMS inertial sensors (i) Accelerometer (ii) Gyroscope and (iii) Magnetometer; Packaging of MEMS pressure sensors and pressure sensor module with ASIC; Packaging of FET based pH sensors-ISFET and EGFET devices using reverse dam-and-fill technique; Integrated packaging of LTCC micro-hotplates for sensor applications, Interconnection techniques of micro-hotplates, characterization and reliability testing of micro-hotplates packaging; Integrated packaging of electro-chemical sensors using alumina and LTCC technology.

Module 1:
Advanced Packaging Techniques: Overview
Low Temperature Co-fired Ceramic (LTCC) Technology for Customized Packaging
Module 2:
Customized Packaging of MEMS Devices and Microsensors
Integrated Packaging Approach for LTCC Based Thick Film Devices

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 06			
CSIR-Central Electronics Engineering Research Institute			CSIR-CEERI
Course 3 : Advanced Course	Engineering Sciences		Total Credits 6
Title: Advanced Machine Learning and Applications		Course Code	Credits
		AcSIR-06-ES-AD-008	2

Introduction to Machine Learning and Kernel Techniques; Probabilistic Graphical Model; Basics of Reinforcement Learning; Semi-supervised Learning and Transfer Learning; Introduction to Deep Networks; Auto-encoders for Representation Learning and MLP Initialization; Stacked, Sparse and Denoising Auto-encoders; Introduction to Convolutional Neural Network (CNN); Convolutional Auto-encoders and Deep CNN for Classification; Structured Probabilistic Models for Deep Learning; Monte Carlo Methods; Deep Generative Models: Boltzman Machines, Deep Belief Networks, Deep Boltzman Machines, Convolutional Boltzman Machines; Recurrent Neural Networks: LSTM & CNN-LSTM; Generative Adversial Network (GAN) and its Variants.

Module 1: Introductory Machine Learning Techniques (1 credit)
Introduction to Machine Learning and Kernel Techniques; Probabilistic Graphical Model; Basics of Reinforcement Learning; Semi-supervised Learning and Transfer Learning; Introduction to Deep Networks; Auto-encoders for Representation Learning and MLP Initialization; Stacked, Sparse and Denoising Auto-encoders; Introduction to Convolutional Neural Network (CNN);
Module 2: Advanced Machine Learning Techniques (1 credit)
Convolutional Auto-encoders and Deep CNN for Classification; Structured Probabilistic Models for Deep Learning; Monte Carlo Methods; Deep Generative Models: Boltzman Machines, Deep Belief Networks, Deep Boltzman Machines, Convolutional Boltzman Machines; Recurrent Neural Networks: LSTM & CNN-LSTM; Generative Adversial Network (GAN) and its Variants.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

CSIR-Central Electronics Engineering Research Institute	CSIR-CEERI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	High-Power Microwave Devices and Fabrications	Course Code	Credits
		AcSIR-06-ES-AD-009	2

Fundamentals of Microwave Tubes Development: Suitable materials, mechanical design and fabrication of components and their qualification criteria, chemical cleaning and electroplating processes, heat treatment, Fabrication/ development techniques; joining techniques for metal-metal, metal-ceramic, metal-glass etc, jigs and fixtures for the development of assemblies/ sub-assemblies. brazing, furnace brazing, induction heater brazing, TIG Welding, torch welding, spot welding. Leak detection techniques and leak detector and leak detection principle. Vacuum processing along with cathode breakdown and cathode activation. Packaging. Vacuum Technology: Generation and measurements of vacuum, Fundamentals of electron emission, types of electron emission, temperature limited and space charge limited emission. Mechanical Fabrication: Fundamental of Engineering drawings. Mechanical fabrication Techniques and machines, dimensional tolerances in fabrication. Qualification of Mechanical parts; tools and techniques.

Module 1: Fundamentals of Microwave Tubes Development (1 credit)
Process and technology.
Module 2: Vacuum Technology and Mechanical Fabrication (1 credit)
Vacuum technology and mechanical engineering

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 06	
CSIR-Central Electronics Engineering Research Institute	CSIR-CEERI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title: Micro-and Nano Technology and Applications	Course Code	Credits
	AcSIR-06-ES-AD-010	2

Introduction to unit processes (cleaning, oxidation, lithography, etching, and deposition), low-dimensional structures (quantum well, quantum wire, quantum dot), quantum confinement, nano-scale properties, fabrication of nanostructures (ALD, CVD, and PLD), synthesis of nanomaterials via chemical route, advanced lithography techniques (Deep-UV, extreme-UV, e-beam, dip-pen, NIL), characterization of nano-materials and structures (TEM, FESEM, Auger, Raman), fabrication of nano-electronic devices (nano-wire FET, ISFET, CNTFET) and their characterization, introduction to bio-chemical sensors, geometrical structures for bio-chemical sensors; Applications of micro- and nano-electronic devices.

Module 1: Introduction to Nanotechnology
Introduction to unit processes (cleaning, oxidation, lithography, etching, and deposition), low-dimensional structures (quantum well, quantum wire, quantum dot), quantum confinement, nano-scale properties, fabrication of nanostructures (ALD, CVD, and PLD), synthesis of nanomaterials via chemical route
Module 2: Advanced lithography techniques and material characterization
Advanced lithography techniques (Deep-UV, extreme-UV, e-beam, dip-pen, NIL), characterization of nano-materials and structures (TEM, FESEM, Auger, Raman)
Module 3: Introduction to nano-electronic devices and nano-biosensors
Fabrication of nano-electronic devices (nano-wire FET, ISFET, CNTFET) and their characterization, introduction to bio-chemical sensors, geometrical structures for bio-chemical sensors; Applications of micro- and nano-electronic devices.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-08-BS-AD-001	Advances in Food Biotechnology
Biological Sciences	AcSIR-08-BS-AD-002	Food Chemistry
Biological Sciences	AcSIR-08-BS-AD-003	Food Components and Its Metabolism
Biological Sciences	AcSIR-08-BS-AD-004	Food Packaging and Sensory Science
Biological Sciences	AcSIR-08-BS-AD-005	Food Saftey and Regulation
Biological Sciences	AcSIR-08-BS-AD-006	Food -Value Metabolites
Biological Sciences	AcSIR-08-BS-AD-007	Functional Food and Nutrigenomics
Biological Sciences	AcSIR-08-BS-AD-008	Technology of Foods
Chemical Sciences	AcSIR-08-CS-AD-001	Chemistry of Foods
Chemical Sciences	AcSIR-08-CS-AD-002	Organic Reaction Mechanisms
Chemical Sciences	AcSIR-08-CS-AD-003	Food Technology
Chemical Sciences	AcSIR-08-CS-AD-004	Chemistry of Heterocycles and Reactive Intermediates
Chemical Sciences	AcSIR-08-CS-AD-005	Advances Inorganic chemistry
Chemical Sciences	AcSIR-08-CS-AD-006	Chemistry of Spices, Plantation Crops, Flavours & Condiments
Chemical Sciences	AcSIR-08-CS-AD-007	Analytical Chemistry and Quality Control in Food Systems

Faculty of Study	Course Code	Course Title
Chemical Sciences	AcSIR-08-CS-AD-008	Packaging & Sensory Studies of Food
Chemical Sciences	AcSIR-08-CS-AD-009	Stability of Food Components
Chemical Sciences	AcSIR-08-CS-AD-010	Natural Products
Engineering Sciences	AcSIR-08-ES-AD-001	Food Process Engineering
Engineering Sciences	AcSIR-08-ES-AD-002	Food Safety and Regulation
Engineering Sciences	AcSIR-08-ES-AD-003	Advanced Separation: Theory & Technologies
Engineering Sciences	AcSIR-08-ES-AD-004	Packaging Technology
Engineering Sciences	AcSIR-08-ES-AD-005	Industrial Plant Design and Management
Engineering Sciences	AcSIR-08-ES-AD-006	Advances in Drying Technology
Engineering Sciences	AcSIR-08-ES-AD-007	Modeling and Simulation in Food Processing
Engineering Sciences	AcSIR-08-ES-AD-008	Process Technology of Cereals and Pulses
Engineering Sciences	AcSIR-08-ES-AD-009	Technology of Fruits and Vegetables Processing

AcSIR Academic Centre Code: 08

CSIR-Central Food Technological Research Institute	CSIR-CFTRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Advances in Food Biotechnology	Course Code	Credits
		AcSIR-08-BS-AD-001	2

Basic concepts and food applications; Natural food colours and flavours. Recombinant DNA technology and genetic manipulation; Genetically modified organisms/foods – basic concepts and methods to achieve & identify target genes. Safety and applicability of modified foods and food ingredients. Biotechnology approaches (enzymes/proteins & effective processing parameters) towards reducing/ modifying anti- nutritional factors in foods and food ingredients. Food Nano biotechnology. Natural food colours and flavours production through biotechnological methods. Fermentation technology, Biotechnological approaches in valorization of food waste. Recent trends in Food Biotechnology (Lab meat, Crispr’d foods etc.)

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Food Chemistry	AcSIR-08-BS-AD-002	3

Introduction to chemistry of foods: Composition and factors affecting the composition of foods, proximate composition of foods. Carbohydrates: Monosaccharides, disaccharides and trisaccharides, their occurrence and classification; isomerism in hexoses, sugar derivatives; caramelization. Chemistry of cellulose, starches and other polysaccharides; starch enzymes; gel formation and starch retrogradation; pectic substances: their occurrence, structure, properties and use in foods. Chemistry of amino acids and proteins: Classification of proteins, chemical and physical properties of proteins, structure of proteins and techniques used in elucidation of protein structure; forces involved in protein conformation, functional properties of proteins in foods, hydrolysis of proteins, major food proteins and their sources; changes in proteins during processing; determination of proteins. Oils and fats: Chemistry, occurrence, classification and composition; physical and chemical properties of fats, rancidity and flavour reversion, refining of oils and fats, fat hydrolysis and interesterification, hydrogenation, shortenings and spreads. Emulsions: definition, surface activity, surface films, theory of emulsions, properties and types of emulsions, emulsifying agents.Vitamins: Chemistry and changes during processing.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 08

CSIR-Central Food Technological Research Institute	CSIR-CFTRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title: Food Components and Its Metabolism	Course Code	Credits
	AcSIR-08-BS-AD-003	2

Macro- and Micro-components of food. Metabolism of carbohydrate, protein and fats. Vitamins and Minerals and their metabolism.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 08

CSIR-Central Food Technological Research Institute	CSIR-CFTRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Food Packaging and Sensory Science	AcSIR-08-BS-AD-004	2

Introduction to Paper, Glass & Metal Packaging, Identification of plastic packaging materials - Overall migration & specific migration tests for packaging materials, water vapour and gas transmission rates of packaging materials, Determination of shelf life of packaged foods, Packaging Waste Management. Introduction to sensory science perception. Requisites of sensory panel, consumer test ranking and Hedonic data analysis. Physical and chemical sensory scores – quantitative descriptive analysis; Food flavourings; Taints and off-flavours; Instrumental analysis of food flavours; Texture and colour measurements; Packaging materials and their interactions with food constituents; Instrumental and statistical methods in sensory analysis.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 08

CSIR-Central Food Technological Research Institute	CSIR-CFTRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Food Saftey and Regulation	AcSIR-08-BS-AD-005	2

Microbial contaminants: Spoilage and pathogenic bacteria and fungi : microbial toxins limiting factors for survival/growth of pathogenic and spoilage microorganism. Other food contaminants- heavy metals and residues of pesticides and antibiotics. Food regulation – national and international: quality system in food chain-ISO 9001, 14001, 17025 and 22000. HACCP implementation: Food safety toxicology: OECD Guidelines on Toxicity of food, Assessment of genotoxicity, teratogenicity, carcinogenicity, hepatotoxicity, nephrotoxicity, pulmonary toxicity, immunotoxicity, endocrine and reproductive toxicity etc.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 08

CSIR-Central Food Technological Research Institute **CSIR-CFTRI**

Course 3 : Advanced Course **Biological Sciences** **Total Credits 6**

Title:	Course Code	Credits
Food -Value Metabolites	**AcSIR-08-BS-AD-006**	**2**

Introduction to plant Metabolites, secondary metabolite, e.g. pigments, pheromones, antibiotics, alkaloids from spice and plantation products such as major spices such Turmeric, Ginger, Pepper, cumin, tea, coffee etc. , Separation and their extraction of secondary metabolite, characterization of these metabolites by various analytical tools, preparation and formulations of secondary metabolites for functional foods, nanoencapsulations of metabolite, methods for encapsulation preparation, characterization, properties and stability study of nanoencapsulations and to assess their biological activities.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 08	
CSIR-Central Food Technological Research Institute	CSIR-CFTRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Functional Food and Nutrigenomics	AcSIR-08-BS-AD-007	3

Nutraceuticals: Definition, terminologies and scope. Plant, animal (marine & sea foods) and microbial based nutraceuticals and their characteristics. Structure-function relationship of defined and characterized nutraceuticals; from plants, vegetables, fruits, animals, pulses and grains; effect of food processing parameters on defined nutraceuticals. Dietary Supplements: Definition, characteristics and scope; Status in selected countries across the globe; Intake of dietary supplements and positive health benefits; Performance and functionality; Interaction with one or more functions of human health; Technological suitability of supplements in food processing. Functional Foods: Definition and applicability; basis to identify functional components in varied sources. Characterization of bio-actives from edible sources with defined functional attributes and elucidation of their structure - function relationship. Benefits of identified functional attributes in food ingredients and prepared foods. Legal requirements and regulations for functional food. Effect of food processing parameters on defined functional attributes. Functional food development and commercialization in food products. Nutrigenomics: Fundamentals of Nutrigenomics and Nutriepigenomics. Interaction of genome and Nutrition. Nutrigenomics in various diseases.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

CSIR-Central Food Technological Research Institute	CSIR-CFTRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Technology of Foods	Course Code	Credits
		AcSIR-08-BS-AD-008	3

Cereal, Millet and Oilseeds Oil Seed Chemistry: Introduction to wheat chemistry and baking technology. Composition and functionality of wheat flour components. Technology of wheat based snack foods, principles of manufacture, quality criteria and shelf-life. Chemical composition of Rice, distribution of nutrients and effect of processing. Physical properties of paddy and rice, density, porosity, angle of response. Physicochemical properties of rice, viscosity, gelatinization, gel consistency, solid loss, water uptake and volume expansion. Chemical, technological and nutritional aspects of sorghum and other millets. Cereal and millet based nutritious foods. Solvent extraction, super critical extraction of oil seeds. Utilization of oilseeds and cakes for infant foods, weaning foods and supplementary food formulations. Anti nutritional factors and their removal. Nutritional quality. Functional and nutritional properties of oil seed proteins. Technology of vegetable protein isolates. Spices, Tea, Coffee, Cocoa and Cashew nuts: Production, processing, chemical composition, properties, special attributes. Flavouring components, their extraction, evaluation, quality control and standards. Specifications for spices and spice products. Formation of flavours in foods. Technology, isolation and identification of flavouring materials. Synthetic flavouring agents and problems relating to their incorporation in foods. Methodology of flavour evaluation. Standards and specifications for flavours. Manufacture and quality control of carbonated beverages. Production, processing and chemistry of tea manufacture. Tea products such as soluble tea, tea concentrate, decaffeinated tea and flavoured tea. Production, processing, roasting and brewing of coffee. Soluble coffee manufacture. Chemistry, standards and specifications of coffee. Other coffee products and coffee substitutes - monsooned coffee, decaffeinated coffee, coffee brew concentrate and chicory. Production, processing and chemical composition of cocoa products and quality standards. Chemistry and technology of cashew nut. Animal products: Animal production, feeds and raising of animals. Abattoir designs and slaughter methods. Meat animals - stunning methods, ante- and post-. mortem inspection and carcass evaluation. Post-mortem biochemical changes in meat, fish and poultry. Meat speciation. Nutritive value of meat and fish, chemical composition, amino acids, fatty acids, omega-3 fatty acids, vitamins, minerals and trace elements. Cholesterol in meat, fish, poultry and eggs. Electrical stimulation and biochemical changes in muscle, muscle structure and meat enzymes. Quality of meat, fish and poultry. Meat tenderisation. Meat emulsions, sausage and comminuted meat products. Minced fish technology and surimi. Spoilage characteristics of meat, fish and poultry. Meat hygiene. Egg structure, composition, egg powder and egg-based products. Cured meat products, fermented meat and fish products, shelf stable products, restructured meats, traditional meat, fish and poultry products. Packaging of meat, fish and poultry products.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 08

CSIR-Central Food Technological Research Institute	CSIR-CFTRI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Chemistry of Foods	AcSIR-08-CS-AD-001	3

g in food molecules, water activity. Gels, emulsions and their importance. Reactions of carbohydrates, mutarotation, formation of glycosides, caramelization and Maillard reaction. Protein chemistry, reactions of proteins, acid hydrolysis, racemization, acylation and homocysteine. Enzymes in foods; protease, glycosidase and lipases. Lipids; glycerol and triacyl glycerols, sn-numbering. Cholesterol, di and monoglycerides. Reactions of lipids, fractionation, inter-esterification, saponification, hydrogenation and lipid oxidation. Flavours: Essential oils, carvone, spearmint, citrus oil, thyme, thymol. Food colours: Natural colours in foods/synthetic colours. Food Toxicology: Toxins in foods/ naturally occurring toxins. Vitamins: Fat/water soluble vitamins. Food protectants and infestation control; fumigation, bio-pesticides, organophosphorus pesticides.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 08

CSIR-Central Food Technological Research Institute	CSIR-CFTRI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Organic Reaction Mechanisms	Course Code	Credits
		AcSIR-08-CS-AD-002	3

Basics, The concept of Aromaticity, Name reactions, Reactive intermediates: Formation, stability, structures and reactivity of carbocation, carbanion, carbene, radicals, benzyne, nitrene, Types of mechanism: classification, limitations examples of aliphatic nucleophilic substitution – aliphatic electrophilic substitution - aromatic nucleophilic substitution - aromatic electrophilic substitution - types of radical reactions - molecular rearrangements oxidation and reduction; Electrophilic reactions- Friedel-Crafts reaction, Reimer-Tiemann reaction, Beckmann rearrangements; nucleophilic reactions- aldol condensation, Perkin reaction, benzoin condensation free radical reaction-halogenation of alkane, addition of HBr on alkene in presence of peroxide, allylic halogenation using N-Bromo Succinamide (NBS), thermal halogenation of alkene CH3-CH=CH2.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 08

CSIR-Central Food Technological Research Institute	**CSIR-CFTRI**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	**Food Technology**	**Course Code**	**Credits**
		AcSIR-08-CS-AD-003	**3**

Cereal & Oil Seed Chemistry Introduction to wheat chemistry and baking technology. Composition and functionality of wheat flour components. Technology of wheat based snack foods, principles of manufacture, quality criteria and shelf-life. Chemical composition of Rice, distribution of nutrients and effect of processing. Physical properties of paddy and rice, density, porosity, angle of response. Physicochemical properties of rice, viscosity, gelatinization, gel consistency, solid loss, water uptake and volume expansion. Solvent extraction, super critical extraction of oil seeds. Utilization of oilseeds and cakes for infant foods, weaning foods and supplementary food formulations. Anti-nutritional factors and their removal. Nutritional quality. Functional and nutritional properties of oil seed proteins. Technology of vegetable protein isolates. Spices & Plantation Crops Production, processing, chemical composition, properties, special attributes. Flavouring components, their extraction, evaluation, quality control and standards. Specifications for spices and spice products. Formation of flavours in foods. Technology, isolation and identification of flavouring materials. Synthetic flavouring agents and problems relating to their incorporation in foods. Methodology of flavour evaluation. Standards and specifications for flavours. Manufacture and quality control of carbonated beverages. Production, processing and chemistry of tea, coffee & cocoa. Tea products such as soluble tea, tea concentrate, decaffeinated tea and flavoured tea. Roasting and brewing of coffee, soluble coffee. Standards and specifications of coffee. Coffee products and substitutes - monsooned coffee, decaffeinated coffee, coffee brew concentrate and chicory. Chemical composition of cocoa products and quality standards. Chemistry and technology of cashew nut.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 08

CSIR-Central Food Technological Research Institute	**CSIR-CFTRI**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Chemistry of Heterocycles and Reactive Intermediates	**AcSIR-08-CS-AD-004**	**3**

Heterocycles, Electronic properties, reactivity (electrophilicity and nucleophilicity), Synthetic methodologies, Biological properties of heterocycles and drug candidates, Biosynthesis of heterocycles and related stereochemistry. Formation of carbon-carbon bond employing various kinds of organometallic reagents, C-C double bonds through different reactions, oxidation, reduction through various kinds of reagents, functional group interconversion by substitution including protection and deprotection, alkylation of enolates, and other carbon nucleophiles, reaction of carbon nucleophiles with carbonyl compounds, electrophilic addition to C-C multiple bonds, Retrosynthesis, synthons, linear and convergent synthesis, umpolung of reactivity.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 08

CSIR-Central Food Technological Research Institute CSIR-CFTRI

Course 3 : Advanced Course Chemical Sciences Total Credits 6

Title:	Advances Inorganic chemistry	Course Code	Credits
		AcSIR-08-CS-AD-005	2

Structure and Bonding in Inorganic Compounds, Chemistry of Coordiration Compounds, Symmetry in Chemistry & Group Theory, Main group chemistry, Organometallic chemistry, Electronic Spectra of Transition Metal Compounds, Magneto Chemistry, Metal Cluster Compounds, Inorganic Reaction Mechanism, Electron Transfer Reactions in Metal Complexes, Bioinorganic Chemistry (Metalloenzymes, Metal complexes as oxygen carriers, Photosynthesis), Metal Complexes in Medicinal Chemistry, Catalysis by inorganic complexes.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

CSIR-Central Food Technological Research Institute	CSIR-CFTRI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Chemistry of Spices, Plantation Crops, Flavours & Condiments	AcSIR-08-CS-AD-006	2

Major spices (ginger, pepper, chilli, turmeric), leafy spices (coriander, mint, curry leaves) minor/ seed spices (cardamom, coriander, cumin, clove, cinnamon), condiments, tea, coffee. Chemistry, physicochemical properties, processing and technology, proximate analysis, Analytical techniques (chromatographic and spectroscopic) value addition, by-products, oleoresins, primary metabolites, nutraceuticals, biomolecules, characterisation and functional foods.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 08

CSIR-Central Food Technological Research Institute	**CSIR-CFTRI**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Analytical Chemistry and Quality Control in Food Systems	**AcSIR-08-CS-AD-007**	**2**

Composition of foods, proximate analysis, physicochemical analysis, quality evaluation, microbial assay, shelf life analysis. Advanced analytical tools; electron microscopy (SEM, TEM, AFM), X-ray diffraction (crystal & powder) and quantitative analysis (AAS, CHN, ICP). Identification and quantification of bisphenol A from polycarbonate bottles; aldehydes, phthalates & monomers from PET bottles.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 08

CSIR-Central Food Technological Research Institute	CSIR-CFTRI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title: Packaging & Sensory Studies of Food	Course Code	Credits
	AcSIR-08-CS-AD-008	2

Fundamentals of food packaging, properties and manufacturing of paper, glass, metal and polymer packaging materials; polyethylene, polypropylene, polystyrene, polyvinyl chloride, polyethylene terephthalate, polycarbonate, recycling symbols, migration in food packaging and protocols as per BIS, determination of shelf life of packaged foods. Introduction to sensory science, sensory panel, consumer test ranking, Hedonic data analysis, e-nose, e-tongue. Physical and chemical sensory scores – quantitative descriptive analysis; Food flavourings; Taints and off-flavours; Instrumental analysis of food flavours; Texture and colour measurements; Instrumental and statistical methods in sensory analysis.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 08

CSIR-Central Food Technological Research Institute	**CSIR-CFTRI**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	**Course Code**	**Credits**
Stability of Food Components	**AcSIR-08-CS-AD-009**	**2**

Introduction to secondary metabolites, e.g. pigments, antibiotics, alkaloids from spice and plantation products; Separation and extraction of secondary metabolites, characterization by various analytical tools, preparation and formulations of functional foods, Encapsulation methods (Micro & Nano), characterization, properties and stability studies of encapsulated materials and evaluation of biological activities.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 08			
CSIR-Central Food Technological Research Institute			CSIR-CFTRI
Course 3 : Advanced Course	Chemical Sciences		Total Credits 6
Title: Natural Products		Course Code	Credits
		AcSIR-08-CS-AD-010	2

Classification, nomenclature and synthesis of Alkaloids, Terpenoids and Steroids such as pinene, camphor, cadinene, α-vetivone, Hirsutene and Abietic acid (Terpenoids); Cholesterol, Testosterone and Androsterone (Steroids). Isolation and characterization, elucidation of structure-property relationships. Biosynthesis of steroids, terpenoids, fatty acids, alkaloids and natural products.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 08

CSIR-Central Food Technological Research Institute	CSIR-CFTRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Food Process Engineering	Course Code	Credits
		AcSIR-08-ES-AD-001	3

Flow of fluids - properties of liquids, Newtonian liquids, Bernoulli equation, energy equation for steady flow of fluids, Heads, flow measurements, viscosity, non-Newtonian fluids, Heat transfer Thermal properties of food, Conduction, convection, radiation with examples, Steady state and Unsteady heat transfer, Heat exchanger, Microwave heating, Refrigeration and Freezing of Foods- Pressure -Enthalpy Chart, Vapour-Compression refrigeration, freezing time prediction, Plank's equation, Evaporation Evaporators type, Single and multiple effect evaporators, Mass transfer Diffusion process, steady and unsteady state mass transfer, mass transfer in packaging materials, Membrane Separation - Ultrafiltration membrane system, reverse osmosis, types, membrane performance, applications, Basics of food dehydration - Water activity, various dehydration systems/types, drying rate curves, drying time prediction, mass and energy balance with respect to dehydration, Introduction to High Pressure Processing of foods, Extrusion technology of food materials.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 08

CSIR-Central Food Technological Research Institute — CSIR-CFTRI

Course 3 : Advanced Course — Engineering Sciences — Total Credits 6

Title:	Course Code	Credits
Food Safety and Regulation	AcSIR-08-ES-AD-002	3

Microbial contaminants - spoilage & pathogenic bacteria and fungi; Microbial toxins; Limiting factors for survival/growth of pathogenic and spoilage microorganisms; Other food contaminants - heavy metals and residues of pesticides & antibiotics; Food regulations - national and international; Quality systems in food chain - ISO 9001, 14001, 17025 and 22000. HACCP implementation, FSSAI, Sanitation in food processing, CODEX, GMP, BIS, AGMARK, HALAL etc., Nanosensors for food safety.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 08

CSIR-Central Food Technological Research Institute CSIR-CFTRI

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Course Code	Credits
Advanced Separation: Theory & Technologies	AcSIR-08-ES-AD-003	3

Mass transfer applications to separations, unit operations in separation: membrane separation, centrifugation, demixing, adsorption, distillation etc, fundamentals of separation equipment design.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

Course 3 : Advanced Course **Engineering Sciences** **Total Credits 6**

Title:	Course Code	Credits
Packaging Technology	**AcSIR-08-ES-AD-004**	**3**

Packaging technology and its importance to food processing and preservation. Packaging systems, chemical and physical testings for packaging materials. Types of packaging materials - paper boards, bags, pouches, plastic films, aluminum foils, metalized films, laminations and coextruded films, tin plate, aluminum cans and composite cans, glass containers, rigid plastic containers, collapsible tubes, corrugated fiber board boxes and miscellaneous containers. Aseptic packaging and retort pouches. Sensory evaluation of foods.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 08	
CSIR-Central Food Technological Research Institute	CSIR-CFTRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Industrial Plant Design and Management	Course Code	Credits
		AcSIR-08-ES-AD-005	2

Overall design considerations; General Design considerations - health and safety hazards, Environmental protection, Plant location, layout, operation and control; Process design and development -batch vs continuous, types of process designs, process flow diagrams (P&ID); Flow sheeting and tools for design; Analysis of cost estimation - cash flow, capital investment, estimations of revenue and product cost, cash flow patterns and taxes, profitability; Optimum design strategies - Linear programming, Breakeven charts; Equipment Design and cost -Heat equipment, Separation equipment.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

CSIR-Central Food Technological Research Institute	CSIR-CFTRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Advances in Drying Technology	Course Code	Credits
		AcSIR-08-ES-AD-006	2

Introduction to drying: theory of drying and principles, types of dryers and selection of drying methods, spray drying and its applications. Innovative drying methods in food processing: infrared drying, microwave drying, radio frequency drying, superheated steam drying and Spray freeze drying. Application of drying methods in micro and nanoencapsulation processes, Computational Fluid Dynamics and Finite Element Modelling of drying process.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 08

CSIR-Central Food Technological Research Institute	CSIR-CFTRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:		Course Code	Credits
	Modeling and Simulation in Food Processing	AcSIR-08-ES-AD-007	2

Models and modeling, Role of modeling in food science and technology, Kinetic modeling, Modeling heat and mass transfer, Empirical approaches, Applications of modeling, Computational approaches for simulation.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 08	
CSIR-Central Food Technological Research Institute	CSIR-CFTRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Process Technology of Cereals and Pulses	Course Code	Credits
		AcSIR-08-ES-AD-008	2

Characteristics of wheat & its milled products - physical, chemical and rheological; Influence of ingredients, processing conditions and additives on quality attributes of bakery products; Physical & chemical characteristics of rice and rice based processed products; Cooking quality of rice; Parboiling of paddy; Processed products of maize, sorghum and finger millet; Processing of pulses including cooking quality; Oilseeds as source of edible protein and oil; Extraction methods for edible oil - ghanni, expeller and solvent; Processing of oilseeds for protein concentrates and isolates.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 08

CSIR-Central Food Technological Research Institute CSIR-CFTRI

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Course Code	Credits
Technology of Fruits and Vegetables Processing	AcSIR-08-ES-AD-009	2

Maturity indices in fruits and vegetables; Postharvest spoilage -microbiological and physiological; wax coating; fruit ripening; Measurement of texture & colour in fruits and vegetables; Canning of fruits and vegetables; Preparation of fruit juices/beverages - RTS, squashes, syrups, lime juice cordial; Tomato based juice, puree, paste, ketchup and soup; Fruit juice concentrates and powders; Fruit & vegetable based pickles; Preserves and candies; commercial cold storages and supply chain management.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

09 CSIR-CGCRI

3 *Advanced Course*

Faculty of Study	Course Code	Course Title
Engineering Sciences	AcSIR-09-ES-AD-001	Advanced Glass Science and Technology
Engineering Sciences	AcSIR-09-ES-AD-002	Ceramic Based Membrane Separation Technology
Engineering Sciences	AcSIR-09-ES-AD-003	Electronic Ceramics
Engineering Sciences	AcSIR-09-ES-AD-004	Nanostructured Photonic and Optical Materials
Engineering Sciences	AcSIR-09-ES-AD-005	Processing of Glass and Ceramics
Engineering Sciences	AcSIR-09-ES-AD-006	Material Characterization
Engineering Sciences	AcSIR-09-ES-AD-007	Functional Coatings and Nanomaterials
Engineering Sciences	AcSIR-09-ES-AD-008	Bioceramics and Biomaterials Science and Engineering
Engineering Sciences	AcSIR-09-ES-AD-009	Refractory Technology and Applications
Engineering Sciences	AcSIR-09-ES-AD-010	Mechanical Behaviour of Ceramics and other Engineering Materials

AcSIR Academic Centre Code: 09			
CSIR-Central Glass & Ceramic Research Institute			**CSIR-CGCRI**
Course 3 : Advanced Course	**Engineering Sciences**		**Total Credits 6**
Title: Advanced Glass Science and Technology		**Course Code**	**Credits**
		AcSIR-09-ES-AD-001	**3**

Glass structures, Raman and infrared spectroscopy and transmission and scanning electron microscopy Glass preparation Fabrication and characterization of optical fibres, optical and ophthalmic glass, photonic glass, laser glass, graded Index glass, photosensitive, photochromic glass, Glasses for biomedical and nuclear applications, Specialty materials like ultra-low expansion glass-ceramics, machinable glass-ceramics, semiconductor and nanometal doped glasses Specialty materials like ultra-low expansion glass-ceramics, machinable glass-ceramics, semiconductor and nanometal doped glasses Glasses for biomedical and nuclear applications. Specialty materials like ultra-low expansion glass-ceramics, machinable glass-ceramics, semiconductor and nanometal doped glasses.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 09

CSIR-Central Glass & Ceramic Research Institute	**CSIR-CGCRI**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:		Course Code	Credits
	Ceramic Based Membrane Separation Technology	**AcSIR-09-ES-AD-002**	**3**

Fundamentals of membrane based separation for different Liquid and gas separation including hot gas filtration. Design fabrication and performance studies of ceramic based Membrane for Membrane Distillation, Membrane contactor, Membrane reactor in energy and environmental application. Membrane application for harvesting energy from sustainable source.

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AcSIR Academic Centre Code: 09

CSIR-Central Glass & Ceramic Research Institute CSIR-CGCRI

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Course Code	Credits
Electronic Ceramics	AcSIR-09-ES-AD-003	3

Fundamentals of dielectrics, insulators, packaging and substrate materials; Fabrication and characterization of capacitors and ferroelectrics, pyroelectrics, piezoelectrics, and smart materials; Properties and applications of sensors, actuators, varistors, electronically conducting ceramics, ionically conducting ceramics and ceramic superconductors

Basics of magnetic ceramics, storage and spintronics; Introduction to electrooptic ceramics and plasmonics and "nano'-impact in electronic ceramics.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 09

CSIR-Central Glass & Ceramic Research Institute **CSIR-CGCRI**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**	
Title: Nanostructured Photonic and Optical Materials		**Course Code**	**Credits**
		AcSIR-09-ES-AD-004	**3**

Electromagnetic theory of interaction of light with matter, polarization and diffraction of light, Raleigh scattering, Mie scattering, Brillouin and Raman scattering, optical absorption and emission spectroscopy, opticalcoherence, stimulated emission, laser, basic properties of highly transparent glasses.

Nano-materials and nanostructure optics, basic concepts of plasmonics , electromagnetics of metals and metalnano composites, surface plasmon polariton, different coupling schemes, plasmon waveguide and band gap structure.

Spectroscopy and sensing, metamaterial and negative index at optical frequencies, super lensing and imaging.

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AcSIR Academic Centre Code: 09		

CSIR-Central Glass & Ceramic Research Institute	CSIR-CGCRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Processing of Glass and Ceramics	Course Code	Credits
		AcSIR-09-ES-AD-005	3

Glassy state and viscosity, commercial glasses, glass forming materials, glass melting furnaces, refining processes of glass melt, Annealing, tempering andtoughening chemical strengthening defects in glass; industrial glass processes, Manufacture of glass fiber, ceramization of glass, machinable and bioactive glass-ceramics, optical and special glassesSynthesis of ceramic precursors, packing of ceramic powders, rheological properties of ceramic suspension, ceramic forming processes, forming defects. Thermal processes in ceramics, polymorphic transformation in ceramics, sintering, hot pressing, cooling of ceramic wares, microwave, laser and plasma assisted processing of ceramics, rapid prototyping, processing machines and furnaces.

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AcSIR Academic Centre Code: 09

CSIR-Central Glass & Ceramic Research Institute **CSIR-CGCRI**

Course 3 : Advanced Course **Engineering Sciences** **Total Credits 6**

Title:	Course Code	Credits
Material Characterization	**AcSIR-09-ES-AD-006**	**3**

- X-ray Diffraction basics, structure factor, reitveld refinement, quantitative phase analysis
- Optical Microscopy
- Transmission Electron Microscopy
- Scanning Electron Microscopy
- Mechanical Property characterization
- Atomic absorption spectroscopy and ICP-AES
- EPR and NMR spectroscopy
- X-ray fluorescence spectroscopy
- EPMA, EDS, WDS
- Electron Energy loss spectroscopy
- Secondary ion mass spectrometry (SIMS),
- X-ray photoelectron spectroscopy and Auger electron spectroscopy
- UV-VIS spectrophotometry,
- FTIR spectroscopy, Raman spectroscopy, Ellipsometry

A. Text books on X-ray diffraction and Small Angle X-ray Scattering:

1. X-ray diffraction. Its theory and applications, Author: S. K. Chatterjee, Publishers: Prentice Hall of India, New Delhi
2. Elements of X-ray diffraction, Author: B. D. Cullity, Publishers: Reading, MA, Addison-Wesley Publishing Co.
3. X-ray Diffraction, Author: B. E. Warren, Publishers: Reading, MA, AddisonWesley Publishing Co.
4. Structure Determination by X-ray Crystallography, Mark Ladd and Rex Palmer, Publisher: Kluwer Academic/Plenum
5. Small Angle Scattering, A. Guinier and G. Fournet, Publisher: Wiley, New York
6. Small Angle Scattering, O. Glatter and O. Kratky, Publisher: Academy, London

B. Text books on optical and electron microscopy:

1. “Fundamentals of Light Microscopy and electronic imaging”, Douglas B. Murphy
2. “Transmission Electron Microscopy: A Textbook for Materials Science” (4 Vol.)

AcSIR Academic Centre Code: 09

CSIR-Central Glass & Ceramic Research Institute	CSIR-CGCRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Functional Coatings and Nanomaterials	Course Code	Credits
		AcSIR-09-ES-AD-007	3

Part-I: Introduction to functional coatings, their deposition techniques and properties, applications (2 Credits)

☐ Basic elements of coatings: Theory and mechanism (mechanical anchoring, monolayer on monolayer formation, chemical compound formation, diffusion and pseudo diffusion) of adherence/adhesion (basic adhesion, total force of adhesion etc.) of coatings ; Surface and interface and their importance on coating properties ; Determination of qualitative and quantative adhesion of coatings (such as Scotchtape test, Benjamin and Weaver method etc.); Types of coatings based on organic, inorganic and organic-inorganic materials ; Metal oxide based coatings (dielectric such as SiO2, ZrO2; semiconducting like ZnO, In2O3, TiO2; conducting e.g. ITO, IZO) ; Defects of coatings (atomic scale defects e.g. point defects, dislocation lines and defects in macroscopic scale like polishing scratches, pores, grinding scratches, crystallite boundaries, fused particles, surface warp); Surface cleaning processes ; Patterning of coating surface (1D/2D pattern by soft lithography); Deposition techniques (sol-gel, spray pyrolysis, chemical/physical vapour deposition thermal and plasma spraying and electroplating) ; Varieties of functional coatings (antireflection, high reflection, colour coatings, waveguiding, anti-scratch, anti-corrosion, antibactial/antimicrobial, hydrophobic and hydrophilic coatings etc.); Properties of functional coatings (like optical, electrical, optoelectronic, thermal, mechanical, etc.) and applications (waveguide sensing, transparent conducting electrode, low emissivity coating, energy saving coatings, etc.)

Part-2: Fundamentals of nanomaterials and their fabrication strategy, graphene and zeolite based nanomaterials and their properties, applications, challenges and future prospect (1 Credit): Definition and types of nanomaterials ; Fabrication processes (top down and bottom-up) including wet chemical / sol-gel, solvothermal, sonochemical, microwave, emulsion, evaporation induced self-assembly; Graphene and its compounds; Advantages of graphene; Graphene based metal oxide and organic-inorganic hybrid nanomaterials ; Zeolite based nanomaterials (ZBN, low silica and high silica based zeolites, zeolites from industrial waste and agro-waste materials) ; Surface, microstructural and optical properties of ZBN ; Catalytic, liquid and gas separation, energy and environmental applications

1. “Coatings on Glass”, H. K. Pulker, Elsevier, Oxford, 1994
2. “Functional Coatings”, Swapan Kumar Ghosh (Ed.), Wiley, Weinheim, 2006
3. “Physics of Thin Films”, Georg Hass and Rudolf E. Thun (Eds.), Volume 2, Academic Press, New York, 1964
4. “Sol-Gel Coatings on Titanium”, Laurent-Dominique Piveteau, Springer, Cambridge, 2001
5. “Functional Coatings”, Volkmar Stenzel and Nadine Rehfeld, Vincentz Network, 2011
6. “Nanomaterials: An introduction to synthesis, properties and applications” Dieter Vollath, 2
nd
Edition, 2009, Wiley-VCH Verleg GmbH & Co.
7. “Sol-Gel Science: The Physics and Chemistry of Sol-Gel Processing”, C. Jeffrey Brinker, George W. Scherer, Academic Press Inc., 1990, UK.

AcSIR Academic Centre Code: 09

CSIR-Central Glass & Ceramic Research Institute	**CSIR-CGCRI**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:	**Bioceramics and Biomaterials Science and Engineering**	**Course Code**	**Credits**
		AcSIR-09-ES-AD-008	**3**

Basics of human physiology; Materials in medical devices; historical background; govt. regulations; materials aspects/requirements of human body; classification of biomaterials; natural/synthetic biomaterials; biocompatibility/mechanical requirements; structure and properties of biomaterials; tissue-materials interactions; hard tissue replacements; soft tissue replacements; semiconductor materials, Preparation, processing and characterization techniques of different bio-materials, implants and devices; Physical and mechanical properties of bio-ceramics and other biomaterials, Surface modification of biomaterials for improved biocompatibility/bioactivity, etc.; Invitro and invivo evaluation of bio-ceramics and implants,
Basicsof bio-glass, composition, characterization and application areas, Applications of bioceramics as bone graft materials, hip-implant, dental implant, drug delivery devices and tissueengineered materials with some case studies,Introduction to Stem Cell, Tissue Engineering and Regenerative Medicine

1. Biomaterials science : an introduction to materials in medicine / edited by Buddy D. Ratner ... [et al.].– 2nd ed.
2. An Introduction to Bioceramics, edited by L. L. Hench and J. Wilson, World Scientific.
Structural Biomaterials, by J. Vincent, Princeton University Press.
3. J. Black and G. Hastings, Handbook of Biomaterial Properties, Chapman and Hall, London, U.K.
4. J. Park and R. S. Lakes, Biomaterials : An introduction, 3rd. ed, ISBN: 978-0-378-37879-4, Springers, New York.
5. Biomaterials: An Introduction, Ed. Joon Bu Park, R. S, Lakes, Springers, ISBN0387378790, 9780387378794.
6. Bio-Ceramics : Materials and Applications, Pub: American Ceramic Society, 2000.
7. Biomaterials in Orthopaedics, (multi-authored), Informa Health Care, 2003.
8. Introduction to dental materials, R. V. Noort, Elsevier Health Sciences, 2002.
9. Polymeric Biomaterials, S. Dumitriu, CRC Press, 2001.
10. Biomaterials Science & Tissue Engineering: Principles and Methods, BikramjitBasu, Cambridge

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AcSIR Academic Centre Code: 09

CSIR-Central Glass & Ceramic Research Institute | CSIR-CGCRI

Course 3 : Advanced Course | Engineering Sciences | Total Credits 6

Title:	Course Code	Credits
Refractory Technology and Applications	AcSIR-09-ES-AD-009	3

Monolithics refractories(castables, plastic, ramming mass, gunning mixes, refractory mortar), advantage of monolithic refractories over shaped refractories andapplication technique. Their manufacturing methods, bond system and properties.

Structure property correlation of refractory. Melt corrosion of refractories.Carbon containing refractories (MgO-C, Al2O3-C, MgAl2O4-C,Al2O3-MgO-C and Al2O3-SiCC and Al2O3-MgO-C), MgAl2O4 containing refractories and oxide-nonoxide composite refractoriesfor various steel and other high temperature applications.Synthetic refractory raw materials. Refractory waste utilisation/recycling.

Applications of refractories in blast furnace, LD converter, coke oven,basic oxygen furnace, electric arc furnace, induction furnace, ladles, continuous casting of steel. Refractory application in non-ferrous, cement, glass industries and high temperature processing industries.

☐ Monolithic Refractories: A Comprehensive Handbook – Subrata Banerjee (WileyAmerican Ceramic Society)

 Refractory Castable Engineering, FIRE Compendium Series Vol. 1 - Ana Paula da Luz, Mariana A.L. Braulio and Victor C. Pandolfelli (GöllerVerlag GmbH, Germany)

 Refractory Material Selection for Steelmaking - Thomas Vert(Wiley-American Ceramic Society)

 Refractories: Production and Properties - J. H. Chester

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AcSIR Academic Centre Code: 09

CSIR-Central Glass & Ceramic Research Institute CSIR-CGCRI

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Course Code	Credits
Mechanical Behaviour of Ceramics and other Engineering Materials	AcSIR-09-ES-AD-010	3

Stress and Strain, Types of Mechanical Behaviour of Materials, Elasticity, Plasticity, Fracture Mechanics, Strengthening Mechanism of Materials, Mechanical Behaviour of Materials under High Temperature and Cyclic Loading, Testing of Mechanical Behaviour of Materials

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Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-10-BS-AD-001	Advanced Bioinformatics
Biological Sciences	AcSIR-10-BS-AD-002	Advances in Plant-Microbe Interactions and Disease Management
Biological Sciences	AcSIR-10-BS-AD-003	Biology of Diseases
Biological Sciences	AcSIR-10-BS-AD-004	Current Breeding Approaches in Plants
Biological Sciences	AcSIR-10-BS-AD-005	Fundamentals of Pharmacology, Toxicology and Pharmaceutical Sciences
Biological Sciences	AcSIR-10-BS-AD-006	Genome Editing and Application
Biological Sciences	AcSIR-10-BS-AD-007	Genomics and System Biology
Biological Sciences	AcSIR-10-BS-AD-008	Management of Problematic Soils
Biological Sciences	AcSIR-10-BS-AD-009	Plant Secondary Metabolism
Biological Sciences	AcSIR-10-BS-AD-010	Principle of Crop Production
Biological Sciences	AcSIR-10-BS-AD-011	Principles of Plant Breeding
Chemical Sciences	AcSIR-10-CS-AD-001	Chromatographic Separation and Characterization of Natural Products
Chemical Sciences	AcSIR-10-CS-AD-002	Frontiers in Synthetic Chemistry: Basic Principles and Name Reactions
Chemical Sciences	AcSIR-10-CS-AD-003	Reagents in Organic Synthesis
Chemical Sciences	AcSIR-10-CS-AD-004	Frontiers in Organic Spectroscopy and structure elucidation

10	CSIR-CIMAP	3	Advanced Course

Faculty of Study	Course Code	Course Title
Chemical Sciences	AcSIR-10-CS-AD-005	QA/QC and Regulatory Updates on MAPs and Their Derived Products
Chemical Sciences	AcSIR-10-CS-AD-006	Frontiers in Nanomaterial and Nanoscience
Chemical Sciences	AcSIR-10-CS-AD-007	Advances in Essential Oil Chemistry and Analysis
Chemical Sciences	AcSIR-10-CS-AD-008	Advances in Catalysis in Chemical Transformations

AcSIR Academic Centre Code: 10			
CSIR-Central Institute of Medicinal and Aromatic Plants			**CSIR-CIMAP**
Course 3 : Advanced Course	**Biological Sciences**		**Total Credits 6**
Title: Advanced Bioinformatics		**Course Code**	**Credits**
		AcSIR-10-BS-AD-001	**3**

Basic principles of computing in bioinformatics, structural bioinformatics, comparative genomics, functional genomics, drug designing, Cheminformatics, algorithm of sequence alignment, probability and statistics, modeling and mathematical techniques, artificial intelligence and machine learning, supervised & unsupervised learning, linear regression, classification, re-sampling methods, linear model selection and regularization, data mining beyond linearity, tree-based methods, ,support vector machines, k-means clustering, hierarchical clustering & principal component analysis, introduction to R, Python & other advance programming languages.

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CSIR-Central Institute of Medicinal and Aromatic Plants	CSIR-CIMAP

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Advances in Plant-Microbe Interactions and Disease Management	Course Code	Credits
		AcSIR-10-BS-AD-002	3

Principles and overview Biological control of plant pest/pathogens; Bio-control agents (antagonists, arbuscular mycorrhizae, actinomycetes, Entomopathogenic Nematodes (EPN) etc.) and their application; Natural products for Antimicrobial and nematicidal activities; Disease resistant plant/crop development; Bio-formulations; Organic cultivation of Medicinal and Aromatic Plants; Induced Systemic Resistance; Integrated disease management strategies; GMOs and GM crops for disease management; PR proteins, elicitors defense strategies, Plant resistance against pest/pathogens, pathogen-derived resistance in plants against virus; R-gene expression and transcription profiling.

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AcSIR Academic Centre Code: 10

CSIR-Central Institute of Medicinal and Aromatic Plants	CSIR-CIMAP

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title: Biology of Diseases	Course Code	Credits
	AcSIR-10-BS-AD-003	3

Introduction to microorganisms, types of infection, development and manifestation, defense against infection, prevention of infections, resistance in infectious organisms; Classification of antimicrobial agents; Mechanism of antimicrobial agents, mechanism of drug resistance, strategies for combating drug resistance. Activated innate and adapted immune responses; Pathobiology of inflammation, inflammatory reactions in infectious and non-infectious disease conditions; autoimmune disorders.

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AcSIR Academic Centre Code: 10

CSIR-Central Institute of Medicinal and Aromatic Plants	CSIR-CIMAP

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Current Breeding Approaches in Plants	Course Code	Credits
		AcSIR-10-BS-AD-004	3

Theory: Breeding methods with self pollinated crops (pure line breeding and mass selection, pedigree method, bulk population and back cross breeding, multiline, population breeding approach (diallel selective mating), rapid isolation of homozygous lines, Hybrid varieties - male sterilities) Breeding methods with cross pollinated crops (Selection in cross pollinated crops, Hybrid varieties, Recurrent selection, Synthetic and composites varieties). Principles & methods of breeding for resistance to diseases & pests, herbicides pollutants and adverse climatic conditions. Polyploidy in plant breeding; Aneuploidy (nullisomics, monosomics, trisomics, monoploids and haploids), autoplyploidy, allopolyploidy. Classical examples: evolution of bread wheat, tobacco, cotton, amphidiploids in Brassica species. Biotechnology in plant breeding, tissue and cell culture, genetic engineering, embryo culture, anther and pollen culture somatic hybridization, molecular markers. Consequences of inter-specific and distant hybridization. Mutation breeding. Introduction and techniques in molecular breeding; Morphological and Molecular markers, QTL analysis; Application of molecular breeding in plants; Development of mapping populations; Molecular mapping and gene tagging of important traits; Marker-assisted selection; Gene pyramiding. Practical: Floral biology in self and cross pollinating plant species, selfing, crossing and maintenance of cross pollinating populations with special reference to breeding work in medicinal and aromatic plants. Estimation of oil content and secondary metabolites in major medicinal and aromatic plants.

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CSIR-Central Institute of Medicinal and Aromatic Plants	CSIR-CIMAP

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Fundamentals of Pharmacology, Toxicology and Pharmaceutical Sciences	AcSIR-10-BS-AD-005	3

General pharmacology, drug receptor interactions, in-vitro and in-vivo bioassays in drug discovery and development. General toxicology, adverse drug reaction, drug safety profiling and regulatory toxicology. Introduction to pharmaceutical dosage forms, Conventional methods for drug delivery, Novel Drug Delivery Systems (NDDS).

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AcSIR Academic Centre Code: 10

CSIR-Central Institute of Medicinal and Aromatic Plants	CSIR-CIMAP

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:		Course Code	Credits
	Genome Editing and Application	AcSIR-10-BS-AD-006	3

Basic concept on genes and genomes; gene knock-down, knock-out and knock-in strategies; Approaches for directed genome modification; genome editing tools: TILLING; homologous recombination, Zinc Finger Nuclease, TALENs, CRISPR-Cas; Designing of modules and delivery systems for genome editing, screening and selection of edited organisms; Applications of genome editing tools in healthcare, crop improvement and metabolite production.

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Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Genomics and System Biology	AcSIR-10-BS-AD-007	3

Introduction to genomics and system biology: central dogma of life, genomes and genes, genome organization and synteny, gene expression and functional genomics; High-throughput approaches: transcriptome, proteome and metabolome, advanced sequencing techniques, DNA Sequence assembly, approaches for directed genome modification; Application of genomics and system biology: gene discovery, genotype designing, crop improvement and drug discovery.

AcSIR Academic Centre Code: 10

CSIR-Central Institute of Medicinal and Aromatic Plants	CSIR-CIMAP

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Management of Problematic Soils	AcSIR-10-BS-AD-008	3

Area and distribution of problem soils - acidic, saline, sodic and physically degraded soils; origin and basic concept of problem soils, and factors responsible; Morphological features of saline, sodic and saline-sodic soils; characterization of salt-affected soils - soluble salts, ESP, pH, physical, chemical and microbiological properties. Acid soils- nature of soil acidity, sources of soil acidity, effect on plant growth, lime requirement; management of acid soils, biological sickness of soils and its management; Management of saline and sodic soils; salt tolerance of crops - mechanism and ratings; monitoring of soil salinity in the field; management principles for sandy, clayey, red lateritic and dry land soils; MAPs cultivation in problem soils; MPAs based cropping pattern for utilizing poor quality ground waters; Quality of irrigation water; management of brackish water for irrigation; salt balance under irrigation; characterization of brackish waters; Salt stress: Meaning of salt stress and its effect on crop growth; salt stress injury and resistance in plants; practical ways to overcome the effect of salt stress through soil and crop manipulations.
Characterization of acid, acid sulphate, salt-affected and calcareous soils; cations (Na+, K+, Ca++ and Mg++) in ground water and soil samples; anions (Cl-, SO4-, CO3- and HCO3-) in ground waters and soil samples; electrical conductivity and gypsum requirement of salt-affected soils; soil pH; Lime requirements of acid soils; salt stress/injury on plants under laboratory conditions; visit to salt-affected/acid soil areas); Instruments used in Soil, Plant and Water Analysis (UV-VIS spectrophotometer, AAS, ICP, Flame photometer); Microbiological analysis of soil (Bacteria, Fungi, Actinomycetes, Total microbial biomass).

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AcSIR Academic Centre Code: 10

CSIR-Central Institute of Medicinal and Aromatic Plants | CSIR-CIMAP

Course 3 : Advanced Course | Biological Sciences | Total Credits 6

Title:	Course Code	Credits
Plant Secondary Metabolism	AcSIR-10-BS-AD-009	3

Basic concept on primary and secondary metabolism, secondary metabolite classes (alkaloids, terpenoids, phenylpropanoids), Biological function, industrial applications; Water absorption and plant nutrition and its effect on metabolisms, Plant photosynthesis and carbon assimilation, secondary metabolite biosynthetic pathways; Carbon fluxes between primary and secondary metabolites in plants. Plant cell, tissue and organ culture, In-vitro secondary metabolite production and biotransformation: production of commercially useful secondary metabolites by callus/ cell suspension/ hairy root cultures Scale up studies using bioreactors for commercial production. Biotransformations using cell/hairy root cultures for generating pharmaceutical molecules. Metabolic engineering/synthetic biology for secondary metabolic pathway modulation: proposes and potentials. Recent approaches of engineering metabolic pathways in heterologous systems (plants, microbes and insect cell lines).

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AcSIR Academic Centre Code: 10

CSIR-Central Institute of Medicinal and Aromatic Plants	CSIR-CIMAP

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Principle of Crop Production	AcSIR-10-BS-AD-010	3

Theory Part-I: Principles of crop production; Crop plants in relation to environment; G x E interaction; Factors determining crop distribution; Agroclimatic zones of India; Agronomic practices and crop productivity; Principles of weed control, crop-weed competition; herbicides-formulation, classification, selectivity and mode of action; Zero/minimum tillage; Allelopathy in agriculture; Soil-water-plant relationship; Soil water constants; Measurement of soil moisture; methods of scheduling irrigation; Methods of irrigation, Strategies for minimizing water losses under field conditions; Micro - irrigation system. Dry land agriculture; Soil moisture stress and plant growth; drought resistance in crops; Soil moisture conservation techniques; Cropping system approach for maximizing crop productivity; Concept of crop rotation; Intercropping and multistorey cropping; crop diversification with MAPs; Concept of Precision Farming; Concepts of GIS; Application of Precision Farming in MAPs. Theory Part-II: Soils-their origin, morphology, composition and nature; Physical, chemical and biological properties of soil; Factors and process for soil formation; Classifications of soils; major soils of India; Criteria of essentiality of nutrients, Mineral nutrition of crops, functions of nutrients in plants; Macro- and micro-nutrients in soils fixation, biological and chemical transformation and release of nutrients in soils; Soil fertility evaluation, Manures and fertilizers, Organic farming; Problem soils, salt affected, waterlogged and acid soils; Soil amendments, Quality of irrigation water; Soil organic matter and its dynamics; Instrumental methods of analysis of soils, plant and water; Biological N fixation, Natural P solubilization & fixation.Practical Part-I: Layout preparation; Irrigation method; Soil moisture evaluation; Recording of agro-meteorological observations; Multiplication of MAPs planting/seed material; Nursery raising techniques; Precision farming data recording and interpretation. Practical Part-II: Soil sampling and processing; Soil test procedures (Mechanical and Physico-chemical); Soil Analysis (organic C, P H, Ec, CEC, major, micro and heavy metals); Determination of nutrients (P, K) fixing capacity of soil; Plant sampling, Plant Analysis (for N, P, K, Fe, Cu, Mn, Zn and heavy metals); Water Quality Assessment for Irrigation (PH, EC, SAR, RSC, hardness, B, NO3); Instruments Used in Soil, Plant and Water Analysis (UV-VIS spectrophotometer, AAS, ICP, Flame photometer); Microbiological analysis of soil (Bacteria, Fungi, Actinomycetes, Total microbial biomass).

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 10

CSIR-Central Institute of Medicinal and Aromatic Plants CSIR-CIMAP

Course 3 : Advanced Course Biological Sciences Total Credits 6

Title:	Course Code	Credits
Principles of Plant Breeding	AcSIR-10-BS-AD-011	3

Theory: Evolution, domestication, introduction, centers of origin and gene introgression. Reproductive systems, pollination control and breeding plans. Genetic concepts in breeding self pollinated crops. Selection under self fertilization (Pure line theory). Consequences of hybridization. Inheritance of quantitative traits. Role of genotype and environment in continuous variation. Genetic basis of breeding open pollinated plants. Systems of pollination control. Systems of mating and their consequences. Theory of selection. Responses to selection and genetic organization. Heterosis and inbreeding depression. Designing model cultivar- ideotype concept.Assessment of variability, components of variance, genetic diversity, Correlationship and path coefficient, diallel, line x tester, generation mean, biparental cross analysis, North Carolina design I, II, III, Triple test cross, different models for varietal adaptation. Evaluation, maintenance of varieties, quality seed, seed industry, seed act, seed production, processing, seed testing. IPR, PBR, UPOV conventions and recent developments.Practical: ANOVA, means, variances, partitioning of variances in various models, analysis in NC designs, diallel and line x tester. Estimation of genetic diversity through D2 statistic, correlation, heritability, and genetic advance, stability analysis using different models. Seed testing for germination. Creation and screening plants for biotic and abiotic stress.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 10

CSIR-Central Institute of Medicinal and Aromatic Plants CSIR-CIMAP

Course 3 : Advanced Course Chemical Sciences Total Credits 6

Title:	Course Code	Credits
Chromatographic Separation and Characterization of Natural Products	AcSIR-10-CS-AD-001	3

Extraction and isolation of Plants Secondary Metabolites (PSM); Column chromatographic techniques and various adsorbents used in the purification of PSM; Activity guided fractionation, isolation and characterization of leads from natural products; Principles and applications of Flash, Low pressure, Medium pressure and High pressure liquid chromatography, 13C NMR Spectroscopy; 2D NMR; Structure elucidation of natural products by EI/CI-MS, FAB-MS; Hybrid Instruments for Structure elucidation of natural products by LC-MS and LC-MS/MS; Resolution of enantiomeric mixtures; Separation methods in carbohydrates.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 10

CSIR-Central Institute of Medicinal and Aromatic Plants	**CSIR-CIMAP**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	**Course Code**	**Credits**
Frontiers in Synthetic Chemistry: Basic Principles and Name Reactions	**AcSIR-10-CS-AD-002**	**3**

Aldol type reactions, Arndt-Eistert synthesis, Baeyer-Villiger rear., Barton-Mccombie reaction, Beckman rearrangement, Benzidine rear., Benzilic acid rear., Chichibabin reaction, Dakin reaction, Ene reaction, Favorskii Rearr., Pinacol-pinacolon rear., Fischer Indole synthesis, Friedel-craft reaction, Fries rear., Mannich reaction, McMurry reaction, Sharpless epoxidation, Jacobson epoxidation, Sharpless dihydroxylation, Swern oxidation, Wittig reaction, Wittig rearrangement, Suzuki coupling, Heck Coupling, Buchwald-Hartwig amination, Appel reaction, Mitsunobu reaction etc.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 10			
CSIR-Central Institute of Medicinal and Aromatic Plants			CSIR-CIMAP
Course 3 : Advanced Course	Chemical Sciences		Total Credits 6
Title: Reagents in Organic Synthesis		Course Code	Credits
		AcSIR-10-CS-AD-003	3

Reagents for Oxidation: Jones reagent, Pyridine chlorochromate, Collins reagent, Serette's reagent, Corey's reagent, Selenium dioxide, m-Chloroperbenzoic acid, Swern oxidation, Osmium tetraoxide etc.; Reagents for Reduction: Catalytic hydrogenation, Pd-C, Raney Nickel, Lindlar's catalyst, Wilkinson' catalyst, Sodium borohydride, Lithium aluminium hydride, DiBAL, Sodium cyanoborohydride, Na-NH3, Clemmensen reduction, Wolff-Kishner reduction. Miscellaneous reagents: Diazomethane, poly phosphoric acid, Gilman reagents, Lithium diisopropylamide (LDA), DABCO, Butyl lithium, DCC, EDC, HOBt, Potassium t-butoxide, Phase transfer catalysis, Crown ethers, Baker's yeast, p-TSA, Diazomethane, N-bromo succinimide, PPA, DBU, DDQ, Trifluoroacetic acid etc.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 10

CSIR-Central Institute of Medicinal and Aromatic Plants	**CSIR-CIMAP**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	**Frontiers in Organic Spectroscopy and structure elucidation**	**Course Code**	**Credits**
		AcSIR-10-CS-AD-004	**3**

Application of UV-Vis and IR Spectroscopy in natural products chemistry; Introduction to NMR and NMR Parameters; One Dimensional Experiments: 1H NMR, Carbon-13 NMR and Carbon-13 Editing; Two Dimensional Experiments: Homonuclear Correlations, Heteronuclear Correlations; Principle and Methodology of mass- EI, ESI APCI, APPI etc.; LC-MS/MS: Principles and application in structure elucidation of Natural Products.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

CSIR-Central Institute of Medicinal and Aromatic Plants	CSIR-CIMAP

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
QA/QC and Regulatory Updates on MAPs and Their Derived Products	AcSIR-10-CS-AD-005	3

Chemical analysis of crude drug & finished product, de-replication technique in isolation, impurity profiling, bio-analysis of drug molecules, quality standards, herbals in IP.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 10			
CSIR-Central Institute of Medicinal and Aromatic Plants			CSIR-CIMAP
Course 3 : Advanced Course	Chemical Sciences		Total Credits 6
Title: Frontiers in Nanomaterial and Nanoscience		Course Code	Credits
		AcSIR-10-CS-AD-006	3

Fundamentals of nanomaterials, Classification (zero to two dimensional and assembled nanostructures) and their advantages & disadvantages, Size dependent chemical and physical properties, Synthesis and fabrication, Basic characterization and application of nanomaterials. Basic instrumentation in SEM-EDAX, TEM, zeta analyzer/particle size analyzer and AFM use in nanoscience.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 10			
CSIR-Central Institute of Medicinal and Aromatic Plants			CSIR-CIMAP
Course 3 : Advanced Course	Chemical Sciences		Total Credits 6

Title:	Advances in Essential Oil Chemistry and Analysis	Course Code	Credits
		AcSIR-10-CS-AD-007	3

Headspace Gas chromatography (HS-GC): theory and practice, Chiral Gas Chromatography, Two Dimensional Gas chromatography techniques (GCxGC): theory and practice, Solid-phase micro-extraction (SPME) technique and its application in analysis of flower volatiles, selection of different polarity SPME fibers, enantiomer separation using chiral SPME-GC, SPME-GC-MS and Headspace techniques, 14C dating of natural and petroleum derived aroma chemicals: citral, menthol and vanillin.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 10

CSIR-Central Institute of Medicinal and Aromatic Plants CSIR-CIMAP

Course 3 : Advanced Course Chemical Sciences Total Credits 6

Title:	Course Code	Credits
Advances in Catalysis in Chemical Transformations	AcSIR-10-CS-AD-008	3

Basic principle involves in homogeneous catalysts, structure of solid surfaces, chemisorption and physiosorption, adsorption isotherms, principle of heterogeneous catalysts, preparation and characterization of catalysts, determination of surface area and stability of catalysts, acid-base catalysts, supported metal catalysts and zeolites and their applications, kinetics of calalytic reactions, enhancing the bioactivity through chemical modification, valorization of terpenoids using heterogeneous catalyst, catalysts deactivation/ poisoning and their regeneration, mechanistic investigations using in-situ spectroscopic techniques, Analytical techniques to monitor the progress of the reaction, industrially important green catalysts for oxidation and reduction, lipase induce esterification of important terpene alcohols.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-11-BS-AD-001	Approaches to Drug Delivery
Biological Sciences	AcSIR-11-BS-AD-002	Biochemical Engineering
Biological Sciences	AcSIR-11-BS-AD-003	Bioprocessing and Industrial Fermentation
Biological Sciences	AcSIR-11-BS-AD-004	Cell and Tissue Engineering
Biological Sciences	AcSIR-11-BS-AD-005	Computational Biology
Biological Sciences	AcSIR-11-BS-AD-006	Connective Tissue Biology
Biological Sciences	AcSIR-11-BS-AD-007	Industrial Microbiology and Enzymology
Biological Sciences	AcSIR-11-BS-AD-008	Metabolomics
Biological Sciences	AcSIR-11-BS-AD-009	Nanobiology
Biological Sciences	AcSIR-11-BS-AD-010	Nanomaterial Toxicology
Chemical Sciences	AcSIR-11-CS-AD-001	Supramolecular Chemistry
Chemical Sciences	AcSIR-11-CS-AD-002	Biomaterials for Targeted Therapeutics
Chemical Sciences	AcSIR-11-CS-AD-003	Advanced Organic Chemistry
Chemical Sciences	AcSIR-11-CS-AD-004	Advanced Photochemistry
Chemical Sciences	AcSIR-11-CS-AD-005	Advances in Bioinorganic chemistry

11	CSIR-CLRI	3	Advanced Course

Faculty of Study	Course Code	Course Title
Chemical Sciences	AcSIR-11-CS-AD-006	Advanced Materials Science
Chemical Sciences	AcSIR-11-CS-AD-007	Organic Spectroscopy Applications
Chemical Sciences	AcSIR-11-CS-AD-008	Green Chemistry
Chemical Sciences	AcSIR-11-CS-AD-009	Biophysical Chemistry
Chemical Sciences	AcSIR-11-CS-AD-010	Electronic Structure Theory

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 11

CSIR-Central Leather Research Institute	CSIR-CLRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Approaches to Drug Delivery	Course Code	Credits
		AcSIR-11-BS-AD-001	2

Sustained release drug delivery systems. (SRDDS) Polymers for controlled drug delivery systems Concepts and system design for the rate – controlled drug delivery Parenteral controlled release drug delivery systems Transdermal drug delivery systems (TDDS) Controlled release oral drug delivery systems Targeted drug delivery system.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 11

CSIR-Central Leather Research Institute CSIR-CLRI

Course 3 : Advanced Course Biological Sciences Total Credits 6

Title: Biochemical Engineering	Course Code	Credits
	AcSIR-11-BS-AD-002	2

Basics of Microbiology – Structure of cells, important cell types; Chemicals of life – Sugars, polysaccharides, lipids, nucleotides and nucleic acids, amino acids and proteins; cellular organization. Enzyme kinetics – Michelis-Menten kinetics, substrate activation and inhibition, multiple substrates, temperature and pH effects on enzyme reaction rates; applied enzyme catalysis; enzyme immobilization and kinetics; stoichiometry of cell growth and product formation. Molecular genetics – gene expression, induction and repression, genetic code, protein synthesis; recombinant DNA technology; kinetics of microbial growth, substrate utilization, product formation; sterilization and thermal death kinetics; batch and continuous sterilization; Transport phenomena - Gas liquid mass transfer in cell systems, basic mass transfer rates, measurement of kLa; Heat transfer aspects; Design and analysis of bioreactors, ideal reactors and non-ideal mixing; multiphase bioreactors – CSTR, packed bed, bubble column, etc; animal and plant cell bioreactors; scale up criteria Instrumentation and control – physical and chemical sensors; offline analytical methods; process control; Downstream processing – filtration, centrifugation, sedimentation, extraction, precipitation; chromatography, membrane separations; Bioprocess economics; Biological waste water treatment.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Bioprocessing and Industrial Fermentation	Course Code	Credits
		AcSIR-11-BS-AD-003	2

Industrial microorganisms – Screening, isolation and preservation techniques; Measurement techniques for biomass – qualitative and quantitative; strain improvement /enrichment techniques - wild types, mutation, genetic engineering principles and techniques. Screening of enzymes and metabolites; enzyme assays; Purification methods – ammonium sulphate precipitation, ultrafiltration, aqueous two-phase extraction, spray drying; chromatographic methods – Gas chromatography, Liquid Chromatography, Characterization of enzymes Bioprocessing – Submerged fermentation - Medium preparation and sterilization; inoculum preparation; shake flask culture, ; principles of fermentations at laboratory, pilot scale and commercial scales; factors influencing growth and production; monitoring and control; Solid state fermentation – substrates and inoculum types; critical factors of influence; reactors and scale up; downstream processing; formulations. Industrial fermentations – Single cell protein, enzymes – protease, lipase, tannase, cellulase, etc; organic acids – citric and lactic acids; ethanol, vinegar; secondary metabolites; high value products; food fermentations; enzymes in leather processing. Technology aspects – Costing and economics of bioprocessing; IPR aspects; validation of processes; detailed project report preparation; marketing strategies.

AcSIR Academic Centre Code: 11			
CSIR-Central Leather Research Institute			CSIR-CLRI
Course 3 : Advanced Course	Biological Sciences		Total Credits 6
Title: Cell and Tissue Engineering		Course Code	Credits
		AcSIR-11-BS-AD-004	2

Cell and Tissue culture, Angiogenic factors and growth factors Introduction to Tissue engineering, Artificial skin Embryonic and adult stem cells, Induced pluripotency, Cancer stem cell Stem cell differentiation, Therapeutics prospects, Ethics issues, Implants Basic principle of different types of tools (such as nano-lithography, TEM, AFM and other x-ray base detections techniques) will be discussed and their relevance to biological system characterization. Analytical electron microscopy.

AcSIR Academic Centre Code: 11

CSIR-Central Leather Research Institute **CSIR-CLRI**

Course 3 : Advanced Course	**Biological Sciences**	**Total Credits 6**

Title: Computational Biology	**Course Code**	**Credits**
	AcSIR-11-BS-AD-005	**2**

Concepts in molecular modelling: Introduction to Statistical Mechanics and Classical Mechanics. Molecular mechanics: Potential energy surface, Born-Oppenheimer approximation, Features of molecular mechanics, force fields, Bonds structure and bending angles, Electrostatic Vander Waals and non-bonded interactions, Hydrogen bonding in molecular mechanics, Derivatives of molecular mechanics energy function, Calculating thermodynamic properties using force field for metals and inorganic systems, Application of energy minimization. Molecular dynamics and monte carlo simulation methods: Molecular Dynamics using simple models, Molecular Dynamics with continuous potentials and at constant temperature and pressure, Solvent effect in molecular Dynamics, conformational changes from Molecular Dynamics simulation, Analysis of molecular dynamics trajectory, Normal Model analysis, ANM, GNM, Coarse graining approaches: modeling of protein aggregation. Monte Carlo Method in various ensembles and its applications.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

CSIR-Central Leather Research Institute	CSIR-CLRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Connective Tissue Biology	Course Code	Credits
		AcSIR-11-BS-AD-006	2

Extracellular matrix (ECM) proteins, lipids and glycoproteins, Triple helix structure of collagen, Functions of skin and other connective tissues Types of collagen , Stability, crosslinking and Thermal properties, Biosynthesis of collagen, Matrix metalloproteinases and action on ECM, Biology of wound healing and other disorders.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 11

CSIR-Central Leather Research Institute	CSIR-CLRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title: Industrial Microbiology and Enzymology	Course Code	Credits
	AcSIR-11-BS-AD-007	2

Introduction to Microorganisms, Growth & metabolism: Microbial nutrients and physiology Metabolic pathways and bioconversions: Introduction to Enzymology: Role of microbes in Industrial sector.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Metabolomics	AcSIR-11-BS-AD-008	2

Metabolism and interaction of the metabolome, the genomics, proteomics and the environment; Advantages of studying the metabolome; Application of hypothesis generating studies vs. the use of traditional hypothesis directed research; targeted and non-targeted studies; clinical and environmental case studies; important considerations in studying the metabolome; design and sample preparation; mass spectrometry in metabolomics; data processing and analysis; metabolite identification

AcSIR Academic Centre Code: 11

CSIR-Central Leather Research Institute	**CSIR-CLRI**

Course 3 : Advanced Course	**Biological Sciences**	**Total Credits 6**

Title:	**Nanobiology**	**Course Code**	**Credits**
		AcSIR-11-BS-AD-009	**2**

Nanomaterial synthesis and characterization Incorporation of nanoparticles in biomaterials, Nanoparticles for therapeutic purposes Multifunctional nanocomposites and nanobiocomposites. Characterization of nanoparticles/nanocomposties Use in targeting and imaging

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 11

CSIR-Central Leather Research Institute	CSIR-CLRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Nanomaterial Toxicology	Course Code	Credits
		AcSIR-11-BS-AD-010	2

Basics of nanotechnology Synthesis and characterization of engineered nanomaterials (ENMs) Sol gel, biological and ball milling methods for synthesis of ENMs and characterisation using electron microscopy (TEM, SEM), dynamic light scattering (DLS) and confocal microscopy. Safety assessment of ENMs – methods and challenges Methods for assessment of toxicology of ENMs; preparation of nano-suspensions; exposure paradigm, cellular uptake, absorption and distribution; in silico approaches for macromolecule interaction with ENMs. Mechanism of toxicity of ENMs Effect of size, shape and surface chemistry on cellular responses (oxidative stress, cytotoxicity, genotoxicity, immunotoxicity etc) Ecotoxicity of ENMs Models and methods used for ecotoxicity assessment of ENMs;.life cycle analysis of ENMs. Safe handling of ENMs and their disposal Practical: Preparation of nano-suspensions and their characterization Cellular uptake using flow cytometer Cytotoxicity assessment for ENMs.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 11			
CSIR-Central Leather Research Institute			**CSIR-CLRI**
Course 3 : Advanced Course	**Chemical Sciences**		**Total Credits 6**
Title: Supramolecular Chemistry		**Course Code**	**Credits**
		AcSIR-11-CS-AD-001	**2**

Nature of supramolecular interactions, role of various non-covalent interactions, multiple hydrogen bonding motifs, Stability of H-bonds, Jorgensen model for H-bonding, supramolecular synthons, dimensions of supramolecular chemistry, Janus molecules. Photoresponsive molecules and self-assembly, Molecular recognition, classification of supramolecular host-guest complexes, supramolecular selfassembly, supramolecular polymers, molecular capsules, self- assembled dendrimers, self-assembled nanotubes, low molecular weight organogels. Characterization techniques of self-assemblies,supramolecular sensors.

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Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 11

CSIR-Central Leather Research Institute	**CSIR-CLRI**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	**Biomaterials for Targeted Therapeutics**	**Course Code**	**Credits**
		AcSIR-11-CS-AD-002	**2**

Rational design and engineering of lipid-based targeted drug delivery vehicles and their therapeutic applications - Design of polymeric micelles as nano drug carriers - Design of polymer-based nanometric targeted delivery systems and their therapeutic applications - Set-backs and unmet challenges – Cancer and its Hall Marks - Principles of designing anti-cancer therapeutics – Molecular basis of lung, breast, melanoma and prostate cancers – Rationale for selecting leading pathways in cancer therapy – Nuclear hormone receptors as targets in cancer therapy – Rationale for design of cancer therapy against multiple pathways-Concept of designing hybrid molecules as a dual strategy - Use of nanotechnology in cancer therapy - Concept of cancer stem cells and design of cancer stem cell therapeutics.

AcSIR Academic Centre Code: 11

CSIR-Central Leather Research Institute | CSIR-CLRI

Course 3 : Advanced Course | Chemical Sciences | Total Credits 6

Title: Advanced Organic Chemistry	Course Code	Credits
	AcSIR-11-CS-AD-003	2

Stereochemistry, reaction mechanism, C-C and C-X bond formations, Retrosynthetic analysis, photochemistry, pericyclic reactions, reactive intermediates, Methods of asymmetric synthesis and their application in total synthesis, oxidation-reduction reactions, organocatalysis, metathesis reactions.

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AcSIR Academic Centre Code: 11	
CSIR-Central Leather Research Institute	CSIR-CLRI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Photochemistry	AcSIR-11-CS-AD-004	2

Introduction to photochemistry, excited state processes, fluorescence and phosphorescence, quantum yields, charge-transfer spectra, solvatochromism, photochromism, transient absorption techniques, Luminescence emission lifetimes, two- and multiphoton processes, photoinduced energy and electron transfer, FRET, fluorescence polarization, excimers, exciplexes, delayed fluorescence, Photochemistry of Organic chromophores. Photochemistry in organized and confined media.

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AcSIR Academic Centre Code: 11

CSIR-Central Leather Research Institute	CSIR-CLRI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Advances in Bioinorganic chemistry	AcSIR-11-CS-AD-005	2

Metal ions in biology, structure and function of metallo-proteins and enzymes, Communication role for metals in biology. Heme and non-heme systems with one-, two- or multi-metal, photosynthesis and photosystem II; O2-binding, reduction to O2-, O22-, and O2- species their utilization in hydroxylation and epoxidation; nitrogen fixation, water-oxidation reactions. Synthetic models, Correlation with structure and function of the natural enzymes, design and synthesis, mechanisms. Metal based drugs, Porphyrins, Corrin hydroporphyrins.

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AcSIR Academic Centre Code: 11			
CSIR-Central Leather Research Institute			CSIR-CLRI
Course 3 : Advanced Course	Chemical Sciences		Total Credits 6

Title: Advanced Materials Science	Course Code	Credits
	AcSIR-11-CS-AD-006	2

Crystal systems and space groups, Close packing and various simple structure types like AB, AB2, AB3 and complex structural types ABX3, AB2X4, etc. Factors affecting crystal structures, Common preparative methods; X-ray diffraction and Electron microscopy, Defect structures, colour centers, reciprocal lattices, Properties of solids – Band theory, metals, insulators, semiconductors, dielectric and ferroelectric properties, magnetic properties, optical properties, ionic conduction; structure-processing-property correlations.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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CSIR-Central Leather Research Institute	CSIR-CLRI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Organic Spectroscopy Applications	AcSIR-11-CS-AD-007	2

Mass spectroscopy, IR spectroscopy, Proton magnetic resonance spectroscopy, Structural assignment by employing NMR techniques, Carbon-13 NMR spectroscopy, Introduction COSY, HSQC, HMBC, NOESY, ROESY, Structural elucidation using 2D-NMR methods.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 11			
CSIR-Central Leather Research Institute			CSIR-CLRI
Course 3 : Advanced Course	Chemical Sciences		Total Credits 6

Title:		Course Code	Credits
	Green Chemistry	AcSIR-11-CS-AD-008	2

Green chemistry concepts: Basic understanding, scope and interdisciplinary nature of green chemistry; Environmental factors; Carbon credit, Energy efficiency and atom economy, Catalysis and green chemistry, Alternate reaction media and reaction systems, ionic liquids, supercritical fluids, solventless chemistry.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 11

CSIR-Central Leather Research Institute	**CSIR-CLRI**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Biophysical Chemistry	**AcSIR-11-CS-AD-009**	**2**

The structure of biological macromolecules. Statistical thermodynamics especially applied on biological systems, macromolecules in solution, conformational equilibria, membrane equilibria, ligand binding and cooperativity. Microcalorimetry. Methods to study equilibrium and speed for association-dissociation processes. Membrane proteins and membrane transport. Spectroscopic methods: UV-Vis and fluorescence, EPR, ESR and NMR related to biophysical chemistry. Physical methods for studies of the interaction between biological macromolecules. Transport processes with relevance in biological systems and experimental biophysical chemistry. Determination of functional molecular mass in solution using scattering methods and sedimentation. Molecular dynamics and Monte-Carlo simulation.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 11	
CSIR-Central Leather Research Institute	CSIR-CLRI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Electronic Structure Theory	AcSIR-11-CS-AD-010	2

Post-Hartree-Fock methods: Moller-Plesset perturbation theory (MP2, MP3, and MP4), Configuration Interaction (CI), Coupled-Cluster single double (triple) (CCSD(T))– performance of various methods for the prediction of van der Waal and hydrogen bonding interactions, spectral properties. Density functional theory based methods: Hybrid and Minnesota functional – Application of DFT methods (excitation energy calculations). Density functional methods with Dispersion correction (Grimme's approaches). Car-Parrinello Molecular Dynamics (CPMD) and Born-Oppenheimer Molecular Dynamics (BOMD).

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Faculty of Study	Course Code	Course Title
Chemical Sciences	AcSIR-12-CS-AD-001	Advanced Physical Chemistry
Chemical Sciences	AcSIR-12-CS-AD-002	Advanced Inorganic Chemistry
Chemical Sciences	AcSIR-12-CS-AD-003	Advanced Organic Chemistry
Chemical Sciences	AcSIR-12-CS-AD-004	Advanced Coordination Chemistry
Chemical Sciences	AcSIR-12-CS-AD-005	Advances in Bioinorganic chemistry
Chemical Sciences	AcSIR-12-CS-AD-006	Advanced Materials Science
Chemical Sciences	AcSIR-12-CS-AD-007	Advanced Catalysis
Chemical Sciences	AcSIR-12-CS-AD-008	Advanced Surface Science
Chemical Sciences	AcSIR-12-CS-AD-009	Composite Materials
Chemical Sciences	AcSIR-12-CS-AD-010	Porous Materials
Engineering Sciences	AcSIR-12-ES-AD-001	Advanced Materials
Engineering Sciences	AcSIR-12-ES-AD-002	Advanced Mechanics of Solids
Engineering Sciences	AcSIR-12-ES-AD-003	Analytical Mechanics
Engineering Sciences	AcSIR-12-ES-AD-004	Computational Fluid Flow and Heat Transfer
Engineering Sciences	AcSIR-12-ES-AD-005	Convective Heat and Mass Transfer

Faculty of Study	Course Code	Course Title
Engineering Sciences	AcSIR-12-ES-AD-006	Digital Signal Processing and Applications
Engineering Sciences	AcSIR-12-ES-AD-007	Dynamics and Control of Rigid Body Mechanical Systems
Engineering Sciences	AcSIR-12-ES-AD-008	Electrical and Electronic Circuits and Devices
Engineering Sciences	AcSIR-12-ES-AD-009	Mechanical Vibration
Engineering Sciences	AcSIR-12-ES-AD-010	Mechanics of Composite Materials
Engineering Sciences	AcSIR-12-ES-AD-011	Microcontrollers and Embedded System Design
Engineering Sciences	AcSIR-12-ES-AD-012	Machines and Mechanisms
Engineering Sciences	AcSIR-12-ES-AD-013	Manufacturing Process Modeling
Engineering Sciences	AcSIR-12-ES-AD-014	Optimization Techniques in Engineering
Engineering Sciences	AcSIR-12-ES-AD-015	Robotics
Engineering Sciences	AcSIR-12-ES-AD-016	Wear of Materials and Surface Modification Technologies
Mathematical & Information	AcSIR-12-MIS-AD-001	Mathematics for Engineers
Mathematical & Information	AcSIR-12-MIS-AD-002	Advanced Control System
Mathematical & Information	AcSIR-12-MIS-AD-003	CAD and Computer Graphics
Mathematical & Information	AcSIR-12-MIS-AD-004	Finite Element Methods

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

12 CSIR-CMERI

3 *Advanced Course*

Faculty of Study	Course Code	Course Title
Mathematical & Information	AcSIR-12-MIS-AD-005	A Comprehensive Approach to Computer Vision
Mathematical & Information	AcSIR-12-MIS-AD-006	Machine Learning
Mathematical & Information	AcSIR-12-MIS-AD-007	Computer Programming and Numerical Methods

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute CSIR-CMERI

Course 3 : Advanced Course Chemical Sciences Total Credits 6

Title:	Course Code	Credits
Advanced Physical Chemistry	AcSIR-12-CS-AD-001	2

Thermodynamics and chemical kinetics, Quantum Mechanics, Atomic structure and spectroscopy, Chemical bonding in diatomics, Chemical applications of group theory, Colloids and Surface science, surfactants, Interface and Interfacial properties, Electrochemistry.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute	**CSIR-CMERI**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Advanced Inorganic Chemistry	**AcSIR-12-CS-AD-002**	**2**

Structure & Bonding in Inorganic Compounds, Chemistry of Coordination Compounds, Symmetry in Chemistry & Group Theory, Main group chemistry, Organometallic chemistry, Electronic Spectra of Transition Metal Compounds, Magneto Chemistry, Metal Cluster Compounds, Inorganic Reaction Mechanism, Electron Transfer Reactions in Metal Complexes, Bioinorganic Chemistry (Metalloenzymes, Metal complexes as oxygen carriers, Photosynthesis), Metal Complexes in Medicinal Chemistry, Catalysis by Inorganic Complexes.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 12			
CSIR-Central Mechanical Engineering Research Institute			CSIR-CMERI
Course 3 : Advanced Course	Chemical Sciences		Total Credits 6
Title: Advanced Organic Chemistry		Course Code	Credits
		AcSIR-12-CS-AD-003	2

Stereochemistry, reaction mechanism, C-C and C-X bond formations, Retrosynthetic analysis, photochemistry, pericyclic reactions, reactive intermediates, Methods of asymmetric synthesis and their application in total synthesis, oxidation-reduction reactions, organocatalysis, metathesis reactions.

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AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute	**CSIR-CMERI**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	**Advanced Coordination Chemistry**	**Course Code**	**Credits**
		AcSIR-12-CS-AD-004	**2**

Naming of coordination compounds, classification of ligands, chelate and macrocyclic effect, Theories dealing with the formation of Coordination Compounds, Spectrochemical Series; Splitting of d-orbitals, Jahn–Teller Effect; Stability constants of Transition metal complexes and their determination by Job's Method. Spin–Orbit Coupling, Electronic states and term symbols, Selection rules (Laporte and spin selection rule), Interpretation of electronic spectra of Transition metal complexes, Orgel and Tanabe Sugano diagrams. Charge Transfer spectra, Magnetic Properties of Transition elements, Chemistry of Inner Transition Elements.

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AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute **CSIR-CMERI**

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Advances in Bioinorganic chemistry	Course Code	Credits
		AcSIR-12-CS-AD-005	2

Metal ions in biology, structure and function of metallo-proteins and enzymes, Communication role for metals in biology. Heme and non-heme systems with one-, two- or multi-metal, photosynthesis and photosystem II; O2-binding, reduction to O2-, O22-, and O2- species their utilization in hydroxylation and epoxidation; nitrogen fixation, water-oxidation reactions. Synthetic models, Correlation with structure and function of the natural enzymes, design and synthesis, mechanisms. Metal based drugs, Porphyrins, Corrin hydroporphyrins.

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AcSIR Academic Centre Code: 12	
CSIR-Central Mechanical Engineering Research Institute	CSIR-CMERI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title: Advanced Materials Science	Course Code	Credits
	AcSIR-12-CS-AD-006	2

Crystal systems and space groups, Close packing and various simple structure types like AB, AB2, AB3 and complex structural types ABX3, AB2X4, etc. Factors affecting crystal structures, Common preparative methods; X-ray diffraction and Electron microscopy, Defect structures, colour centers, reciprocal lattices, Properties of solids – Band theory, metals, insulators, semiconductors, dielectric and ferroelectric properties, magnetic properties, optical properties, ionic conduction; structure-processing-property correlations.

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AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute	CSIR-CMERI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Catalysis	AcSIR-12-CS-AD-007	2

Homogeneous and heterogeneous catalysis, adsorption, diffusion, kinetics, equilibrium andrate expressions; chiral catalysis, Surface Science in Catalysis, Catalytic Materials; Supports; Active Components, Classes of reactions and types of reactors; Catalyst preparation methods; Characterization of catalysts; Catalysis in super critical media; Brief introduction of organo and electro-catalysis; Structure-activity-property-stability of catalysts, Catalysts in chemical industry, Catalysis in petroleum refining and petrochemicals; Catalysis in the utilization of renewable feed stocks and concepts of sustainable chemistry.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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CSIR-Central Mechanical Engineering Research Institute	CSIR-CMERI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Surface Science	AcSIR-12-CS-AD-008	2

Introduction to Surface Science - Surface phenomena - Adsorption, Desorption, Adsorption Models, Special properties of surfaces and interfaces, Electronic structure of surfaces, Surface modification and its applications, Nanoscale catalysis and applications, Surface spectroscopy and microscopy tools for nanocatalysis.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute **CSIR-CMERI**

Course 3 : Advanced Course	**Chemical Sciences**		**Total Credits 6**
Title: Composite Materials		**Course Code**	**Credits**
		AcSIR-12-CS-AD-009	**2**

Concept of Composite materials, Various types of composites, Classification based on Matrix Material: Organic Matrix composites, Polymer matrix composites (PMC), Carbon matrix Composites or Carbon-Carbon Composites, Metal matrix composites (MMC), Ceramic matrix composites (CMC); Classification based on reinforcements: Fiber Reinforced Composites, Fiber Reinforced Polymer (FRP) Composites, Laminar Composites, Particulate Composites, Reinforcements/ Fibers, Types of fibres, Multiphase fibers, Polymer matrix composites: Preparation of Molding compounds and prepregs, hand layup method, Autoclave method, Filament winding method, Compression molding, Types of polymer composites: Intercalated, exfoliated and partially exfoliated, Reaction injection molding, Processing and characteristics of nano-composites, hybrid composites, functionally graded composites, smart and functional composites. Characterization of Composite Materials, Mechanical and thermal properties of composites, Processing of Advanced composites, Carbon – Carbon composites, Applications of composites in automobile, energy conversion/storage, hydrogen storage materials/tank.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute	CSIR-CMERI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Porous Materials	Course Code	Credits
		AcSIR-12-CS-AD-010	2

Definitions, Micro-Porous and Mesoporous Solids, Structural Chemistry of Zeolite Framework Types, MOFs, COFs, Synthesis, Structure Determination, Role of the Structure directing Agents, The Chemistry of Microporous Framework Solids, Adsorption and Diffusion, Catalytic Applications, hydrogen storage, separation, CO2 sequestration, sensors.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 12			
CSIR-Central Mechanical Engineering Research Institute			CSIR-CMERI
Course 3 : Advanced Course	Engineering Sciences		Total Credits 6
Title: Advanced Materials		Course Code	Credits
		AcSIR-12-ES-AD-001	3

Basics: Mechanics of materials, mechanical properties, dislocation theory, mechanical testing methods, creep and relaxation behaviour of common engineering materials;
Advanced materials: Polymers, conductive polymers, ceramics, composites, nano-composites, smart materials, high temperature materials, bearing materials, materials for sensors and actuators; Material characterization: Optical and X-ray spectroscopy, diffraction methods (X-ray diffraction, Crystallographic texture measurements, electron microscopy (SEM, TEM, EBSD, etc.), Atomic probe micro analysis (AFM), Thermo gravity analysis; Future Trends, Applications, Tutorial and Laboratory.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute	**CSIR-CMERI**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:	**Advanced Mechanics of Solids**	**Course Code**	**Credits**
		AcSIR-12-ES-AD-002	**3**

Stress; Stress tensor, stress transformation, principal stresses. Equilibrium. Strain; Linear strain components, Compatibility. Constitutive Relations; Isotropic and orthotropic materials, Failure Theories. Two dimensional elasticity; Mohr’s Circle. Polar coordinates. Airy’s Stress Function for simple systems. Stress concentration factors. Stresses in pressure vessels and rotating discs. Torsion of bars of various sections. Beam bending; Deflections. Three Moment equation. Unsymmetric bending, bending stress and shear and shear center. Variational principles; Equilibrium-Virtual work and the Principle of Stationary Potential Energy, Compatibility-Principle of Stationary Complementary Energy, Castigliano’s Theorems, Applications. Elastic Stability; Euler’s Bucking Load for columns. Energy methods, Stability of simple frames.

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AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute	CSIR-CMERI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Analytical Mechanics	Course Code	Credits
		AcSIR-12-ES-AD-003	3

Optimum Path: Fermat's Principle, Brachistochrone Problem. Calculus of Variation in Mechanics for Conservative Systems. Degrees of Freedom and the Configuration Space. The Concept of Functionals and their Variations. Virtual work, the varied path. Hamilton's Principle of Stationary Action, Lagrange's Equations of Motion. Applications of Lagrange's Equations: Equations of motion of multi-degree of freedom systems. Vibrations of discrete systems (of lumped masses) and continuous elastic systems. Lagrange Multipliers for Constrained Systems, Applications. Hamiltonian Mechanics: The Legendre Transformations, Hamilton's Canonical Equations of Motion, Applications. Accelerating /rotating reference frames. Dynamics of rotation of rigid bodies. Central force systems; Motion of satellites.

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AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute | CSIR-CMERI

Course 3 : Advanced Course | Engineering Sciences | Total Credits 6

Title:	Course Code	Credits
Computational Fluid Flow and Heat Transfer	AcSIR-12-ES-AD-004	3

Discretization procedure in Finite-difference and Finite-volume methods. Fundamentals of Fluid Flow Modelling. Staggered and Collocated grids. Explicit methods: MAC, SMAC methods for solving Navier-Stokes and Energy equations. Implicit Methods: SIMPLE and SIMPLER. Pressure Solvers: conjugate gradient method, strongly Implicit procedure. Grid-Generation: Algebraic, Transfinite, Poisson equation methods. Finite-volume based Navier-Stokes solution on arbitrary geometry using non-orthogonal grids. Introduction to Turbulence modelling (two equation models).

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AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute **CSIR-CMERI**

Course 3 : Advanced Course **Engineering Sciences** **Total Credits 6**

Title:	Course Code	Credits
Convective Heat and Mass Transfer	**AcSIR-12-ES-AD-005**	**3**

Conservation equations, boundary layers, free convection, forced convection. Heat transfer in laminar and turbulent, internal as well as external flows, mixed convection. Combined convection and radiation. Boiling and Condensation. Molecular diffusion in fluids, mass transfer coefficient. Simultaneous heat and mass transfer; Applications.

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AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute **CSIR-CMERI**

Course 3 : Advanced Course	**Engineering Sciences**		**Total Credits 6**
Title: Digital Signal Processing and Applications		**Course Code**	**Credits**
		AcSIR-12-ES-AD-006	**3**

Elements of analog and digital signal processing, Advantages of Digital over Analog, Sampling Theorem.
Discrete Time Signals & Systems: Classification, Analysis of LT Systems, of LTI system, Response to Arbitrary Inputs, Causality & Stability, Correlation, Convolution, Finite & Infinite Impulse Response, Recursive & Non-Recursive Systems, Difference Equations.
Z-Transform: Definition, Properties, Inverse-Z and Analysis in Z-domain.
Fourier Analysis: Continuous & Discrete-Time Fourier Series, Power density spectrum, Fourier transform, Frequency-domain characteristics of LTI systems, DFT & properties, Linear filtering using DFT, Frequency analysis using DFT, Understanding FFT.
Digital filter design: Characteristics and design of filters, Future trends, Applications, tutorial and hands-on training.

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CSIR-Central Mechanical Engineering Research Institute	CSIR-CMERI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Dynamics and Control of Rigid Body Mechanical Systems	AcSIR-12-ES-AD-007	3

Fundamental concepts and assumptions; Basic terminologies; Reference frame and coordinate systems; Kinematics of rigid bodies; Rotation and Translation; Rotation matrix and homogeneous transformation matrix; Euler's theorem and Chasles theorem; Generalized Coordinates, Degrees-of-freedom, Motion constraints – holonomic and non-holonomic; Rolling bodies; Forces and Moments in a rigid body system; Physical forces, conservative and non-conservative; Inertial forces and concept of inertia; Parallel axis theorem and principal moments of inertia; Inertia ellipsoid; Energy in a rigid body system, work-energy principles and energy methods; Principles of analytical dynamics; Principle of Stationary Action; Generalized forces; Lagrangian and Hamiltonian, D'Alemberts Principle, Euler-Lagrange equations as necessary condition for stationary action; Derivations of equations of motion of rigid body mechanical systems; Structure of equations of motion of a rigid body mechanical system; Forward dynamics and Inverse dynamics; Constraint equations and Constraint forces. Discussion on selected case studies.

Dynamics of linear systems and dynamic response; Transfer functions; Block diagrams; Controllability, Observability; Detectability, Minimal Realization, Concept of poles and zeros, Equilibrium points; Frequency domain analysis; Root locus and Bode analysis; ; Design of controller using pole placement, State space description, PID control, Feedback controller, Concept of Stability, Estimator design; Fundamentals of optimal control. Study of control system on selected case studies.

Introduction to Digital control; Effect of sampling; Linear difference equations and discrete transfer function; z-Transforms; Sampled-data systems; Delays; Notions of digital controller designs; Notion of optimal estimation and Kalman Filter; Quantization effect;

Introduction to Non-linear control; Linearization concept; Input-output Feedback Linearization; Energy methods and Lyapunov Stability Theory; Concept of Adaptive Controller/Sliding mode control; Discussion of selected case studies.

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Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 12		
CSIR-Central Mechanical Engineering Research Institute		**CSIR-CMERI**
Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Electrical and Electronic Circuits and Devices	**AcSIR-12-ES-AD-008**	**3**

Electric Circuits and Components; Network Theorems: Thevenin, Norton, Superposition, Maximum Power Transfer; Circuit Analysis, Transformer, Impedance Matching, Grounding and Electrical Interference, Electrical Safety; Semiconductor Electronics: Diodes and its application; Operation, characteristics : Three terminal devices –- BJT, JFET, MOSFET; Four terminal devices- SCR, Diac, Triac; Amplifiers using BJT, FET; Operational amplifiers; Modern devices: CMOS, MESFET, MODFET, HBT; Computing: Number, system and code conversion, Logic gates, Boolean algebra; Combinational / Sequential Logic circuits – Latch, RS-, JK-, T-, D-, Flip flops, Buffer Register;
Counters, Shift registers. Decoder, Encoder, MUX, DMUX, RAM, ROM, PROM, EPROM, EEPROM; Programmable logic devices.

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AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute CSIR-CMERI

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Course Code	Credits
Mechanical Vibration	AcSIR-12-ES-AD-009	3

Free vibrations and response of single-degree-of-freedom systems to harmonic, periodic and general excitations, Energy dissipation and damping, Duhamel's Convolution Integral for response to general time varying excitation.
Multi-Degree-of-Freedom Systems; Lagrange's Equations. Free Vibration- The Eigenvalue Problem, Orthogonality of Modal Vectors, Dynamic response by Modal Analysis. Rayleigh's Quotient.
Distributed Systems; Exact solutions of free and forced vibrations of bars and beams (axial, torsional and bending). Modal shapes and natural frequencies of continuous systems, Systems with lumped masses, Rayleigh's Principle.
Approximate Methods; Transfer Matrix Methods, Holzer's Method for Torsional Vibration, Myklestad's Method for bending vibration, Dunkerley's Method, Modal Superposition Methods.

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AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute | CSIR-CMERI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Mechanics of Composite Materials	AcSIR-12-ES-AD-010	3

Introduction to Composite Materials, Classification of composites; Fibres and matrices; Manufacturing, mechanical properties and applications of composites. Stress strain relationships for a unidirectional / bidirectional lamina; strengths, thermal and moisture expansion coefficients. Determination of physical and engineering properties of a unidirectional lamina from the individual properties of the fibre and the matrix, fibre volume fraction, and fibre packing. Determination of the elastic stiffnesses and mechanical loads on laminate based on the values of individual laminae and the stacking sequence. Failure Criteria for a unidirectional composite lamina and a laminate; Design of laminated composite and other issues.

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AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute CSIR-CMERI

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Course Code	Credits
Microcontrollers and Embedded System Design	AcSIR-12-ES-AD-011	3

Introduction to embedded systems and architecture, System design using specification and modeling tools; Overview of embedded computing platforms; Microprocessors, Microcontrollers, DSP's and SoC's, Hardware – Software design and partitioning; Design issues, consideration and trade–offs: Performance memory, power, timing, cost, and development time. Memory hierarchy, System Interfaces and Communication with peripheral units, timers counters, Introduction to Real-time system and Real-time Scheduling; Real – time software development: High level languages and Programming issues, Systems performance: Networked embedded systems; Future Trends, Applications, Tutorial and Laboratory.

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CSIR-Central Mechanical Engineering Research Institute **CSIR-CMERI**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:	**Course Code**	**Credits**
Machines and Mechanisms	**AcSIR-12-ES-AD-012**	**3**

Rotation and Plane motion of a rigid body; Kinematic Pairs, Chains, Diagrams. Four Link Planar Mechanisms and their Inversions; Grubler's criterion and Grashof's criterion; Analysis of planar mechanisms – Graphical and Analytical methods; Synthesis of planar mechanisms – Motion, Path and Function generation problems - Graphical and Analytical approaches; Introduction to Machine Elements – Cams, Gears, Brakes, Clutches etc; Cams – classification of cams and followers, nomenclature, description and analysis of follower motion, pressure angle. Determination of basic dimensions, Synthesis of cam profiles – Graphical and Analytical methods; Gears – terminology, fundamental law of gearing, involute profile. Interference and undercutting, Simple, Compound and Epicyclic gear trains.

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AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute — CSIR-CMERI

Course 3 : Advanced Course — Engineering Sciences — Total Credits 6

Title:	Course Code	Credits
Manufacturing Process Modeling	AcSIR-12-ES-AD-013	3

Brief overview of common manufacturing processes; Introduction to numerical methods (working principle, merits-demerits and applications): FDM, FVM, FEM; Introduction to statistical process modelling and analysis; Transport phenomena during solidification – its implication in casting and welding: governing equations, discretization and solution technique; Analytical method to solve the heat conduction equation applied to thermal processes like welding and surface hardening; Different analysis techniques of metal forming processes: slab analysis of rolling process, slip line analysis of punching, FE analysis of thermal forming; Analytical modelling of orthogonal machining; Application of numerical modelling techniques to powder metallurgy.

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AcSIR Academic Centre Code: 12		
CSIR-Central Mechanical Engineering Research Institute		**CSIR-CMERI**
Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Optimization Techniques in Engineering	**AcSIR-12-ES-AD-014**	**3**

Classical optimization methods, unconstrained minimization, univariate, conjugate direction, gradient and variable metric methods, constrained minimization, feasible direction and projections. multi-objective optimization, classical methods for solving multi-objective optimization, genetic algorithms (GAs), multi-objective GAs, engineering applications.

CSIR-Central Mechanical Engineering Research Institute	CSIR-CMERI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Robotics	AcSIR-12-ES-AD-015	3

Robotics introduction, classification and components. Rigid body transformation in R3, Homogeneous representation, Denavit-Hertenberg representation. Forward and Inverse kinematics; Redundant and Non-redundant robots; Differential kinematics, velocities, and their transformations; Geometric and analytical Jacobians; Manipulability, Isotropy and Workspace analysis; Manipulator statics, Velocity-force duality, Recursive computation of velocities and accelerations, Manipulator dynamics -Newton-Euler and Euler-Lagrange; Equation of motion. Path planning in joint and task space, Obstacle avoidance and optimal planning, Review of robot control methods. Optimization in robotics, Human-robot interaction, Joint and link flexibilities, Walking machines and exoskeletons, Robot hand and multi-fingered grasp, Manipulation and control, Tendon driven manipulator.

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AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute	CSIR-CMERI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Wear of Materials and Surface Modification Technologies	Course Code	Credits
		AcSIR-12-ES-AD-016	3

Surfaces and Substrates: Surface topography, physico-chemical aspects of solid surfaces, and importance of substrate.

Friction and Wear: Laws of friction, mechanisms of friction, stick slip, Abrasive wear, Adhesive wear, Erosion, Corrosive wear, Fatigue wear, Delamination of wear, and Fretting wear.

Applications: Wear Behavior of Engineering Materials, Metallic materials, Ceramics, Polymers and Industrial applications.

Surface Modification Techniques: Electro deposition, Plasma spray, Physical vapour deposition, Chemical vapour deposition, Sol-gel coatings and Spin coating methods.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 12	
CSIR-Central Mechanical Engineering Research Institute	CSIR-CMERI

Course 3 : Advanced Course	Mathematical & Information Sciences	Total Credits 6

Title:		Course Code	Credits
	Mathematics for Engineers	AcSIR-12-MIS-AD-001	3

Linear algebra: Linear independence, Orthogonality, Vector Spaces and their bases and dimensions, Gram-Schmidt method for orthogonal basis set, Orthogonal projections. Matrices, Solution methods for linear simultaneous equations, Eigenvalue problem.

Vector analysis: Vector differentiation, Applications, Vector operators: Grad, Div and Curl. Vector integration & related integral theorems, Applications. Cylindrical and spherical Co-ordinate systems.

Differential equations: Linear ODEs of first and second orders, Linear second order equations, Applications. Laplace transform, Applications. Fourier series and applications. Partial differential equations of first and second orders. Laplace and wave equations.

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AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute CSIR-CMERI

Course 3 : Advanced Course Mathematical & Information Sciences Total Credits 6

Title:		Course Code	Credits
	Advanced Control System	AcSIR-12-MIS-AD-002	3

Introduction and Motivation: Role of Controls in Mechatronics, Mathematical Preliminaries, Review of classical control concepts, Root locus technique; Frequency response analysis, Bode Plot, Design of PID Controller, Controller tuning.

State space design: Modeling of physical systems, Concepts of state, State-space, Representation of Linear system, Controllability and Observability, Stabilizability and Delectability, Observer design.

Advance controller design: Kalman Filters as dynamic system state Observers, Notion of nonlinear control, Basics of nonlinear control, Nonlinear control methods, Feedback linearization (input-state & input-output linearization),Fundamentals of Lyapunov Stability Theory (Autonomous Systems), Advanced Stability Theory (Non-autonomous Systems), Robust Outer Loop Controller, Sliding Mode Controller Design.

Practicals:

Hands on experience with MATLAB / SIMULINK model development,

Verification of control performance using P/PI/PID controllers,

Case studies on nonlinear controller development,

Hands-on experience with application of different nonlinear control systems.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute CSIR-CMERI

Course 3 : Advanced Course Mathematical & Information Sciences Total Credits 6

Title:	Course Code	Credits
CAD and Computer Graphics	AcSIR-12-MIS-AD-003	3

Genesis of CAD, Simulation & visualization, , Concepts of CAE and Virtual prototyping, Geometric object modeling: Analytical representation of curves & surfaces, Various curves and surfaces (B-Spline, Bezier, NURBS), Intersection calculations, Assembly modeling techniques.

Computer graphics: Linear algebra, Screen coordinates, Window coordinates, Graphics library, Rendering pipeline architecture, Homogeneous coordinates & transformation matrices, Quaternion, Projection matrices, Types of buffers, Display interpolation techniques, Lightning, Wireframe, Shading models, Texture mapping, Ray casting, Ray tracing, Normal vectors, Evaluators & NURBS, Modeling of sculpture surface, Selection and feedback, Concepts of scenes and scene graphics, Hierarchical modeling Concepts, Kinematic simulation of an hierarchical model, Stereo visualization.

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AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute CSIR-CMERI

Course 3 : Advanced Course Mathematical & Information Sciences Total Credits 6

Title:		Course Code	Credits
	Finite Element Methods	AcSIR-12-MIS-AD-004	3

Matrix methods review; Stationary Principles, Rayleigh Ritz and Hellinger Reissner Methods. Virtual Work, Governing Equations, Weighted Residual (Galerkin) Method and Weak Forms, Formulations of one dimensional elements (axial bar, the Euler beam) using Direct and Variational Methods. Solutions to simple truss and frame problems. Interpolation, C0 and C1 elements, Convergence requirements. Isoparametric one and two dimensional elements; Linear and Quadratic Timoshenko beam elements; shear locking. Linear 2D plane stress /plane strain element; parasitic shear, Reduced integration, Elementary theory of plates and plate elements; Mindlin and Kirchhoff element formulations, Concepts of locking. Full, reduced and selective integration techniques. Axi-symmetric elements. The Bestfit paradigm of FEA.

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AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute CSIR-CMERI

Course 3 : Advanced Course Mathematical & Information Sciences Total Credits 6

Title:		Course Code	Credits
	A Comprehensive Approach to Computer Vision	AcSIR-12-MIS-AD-005	3

Fundamentals of Computer Vision: Role of vision to achieve simple goals i.e. high level capabilities of vision using cognitive processes, geometric models and low level capability for object perception, representation of images.

Computer Vision Research and Application on image formation, camera model and camera calibration, properties of projection, interaction of light and its modeling, perspective modeling, homogeneous coordinate, lens equation, types of image digitizers and image digitizing components.

Filtering and Edge Detection, Fourier transform, Feature Extraction, Wavelets and sub-band coding.

Scale Invariant Feature Transform, Optical Flow, Singular Value Decomposition, Fundamental Matrix, Stereo Vision, Epipolar Geometry and Essential Matrix

Tutorial on MATLAB platform and Project.

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AcSIR Academic Centre Code: 12

CSIR-Central Mechanical Engineering Research Institute	**CSIR-CMERI**

Course 3 : Advanced Course	**Mathematical & Information Sciences**	**Total Credits 6**

Title:	**Machine Learning**	**Course Code**	**Credits**
		AcSIR-12-MIS-AD-006	**3**

Machine Learning Basics and Statistical Modelling : Machine Learning languages, types and examples, Machine Learning vs. Statistical Modelling, Supervised vs. Unsupervised. Learning : Learn about Classification, K-Nearest Neighbor's, Regression, The differences between Supervised and Unsupervised Learning

Machine Learning Algorithms, Linear Regression, Logistic Regression, Decision Tree, Support Vector Machines, Naive Bayes Classifier.

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CSIR-Central Mechanical Engineering Research Institute	CSIR-CMERI

Course 3 : Advanced Course	Mathematical & Information Sciences	Total Credits 6

Title:	Computer Programming and Numerical Methods	Course Code	Credits
		AcSIR-12-MIS-AD-007	3

Computer programming: Introduction of 'C', Operators, Conditional statements and loops, Arrays, Functions, Structures and unions, Pointers, Files handling
C++ overview, Classes in C++, Overloading, Inheritance, Overview of Visual C++
MATLAB - Basic, Matrix operations and functions in MATLAB, MATLAB scripts and functions (m-files), Simple sequential algorithms, Reading and writing data
Numerical methods: Introduction, finite floating point arithmetic, catastrophic cancellation, chopping and rounding errors, Solution of nonlinear equations, bisection, , Newton's & Muller's method, fixed point iteration, Numerical optimization, Golden section search, Newton's method optimization; linear algebraic equations, forward Gaussian elimination, pivoting, scaling, back substitution, LU-decomposition, norms and errors, condition numbers, iterations, Newton's method for systems, computer implementation, Interpolation- Lagrange, Newton & inverse.
Numerical Integration; finite differences, Newton-Cotes, trapezoidal, Simpson's rule, extrapolation, Gaussian quadrature; Numerical solution of ODE, Euler's method, Runge-Kutta method, multi-step methods, predictor-corrector methods, rates of convergence, global errors, algebraic and shooting methods, boundary value problems, computer implementation.

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14	CSIR-CRRI	3	*Advanced Course*

Faculty of Study	Course Code	Course Title
Engineering Sciences	AcSIR-14-ES-AD-001	Advanced Geotechnical Engineering
Engineering Sciences	AcSIR-14-ES-AD-002	Advanced Highway Engineering Materials
Engineering Sciences	AcSIR-14-ES-AD-003	Design and Construction of Pavements
Engineering Sciences	AcSIR-14-ES-AD-004	Dynamics of Structures
Engineering Sciences	AcSIR-14-ES-AD-005	Finite Element Analysis
Engineering Sciences	AcSIR-14-ES-AD-006	Noise and Vibration
Engineering Sciences	AcSIR-14-ES-AD-007	Pavement Evaluation Techniques and Management System
Engineering Sciences	AcSIR-14-ES-AD-008	Soft Computing Techniques in Transportation Engineering
Engineering Sciences	AcSIR-14-ES-AD-009	Traffic Engineering & Road Safety
Engineering Sciences	AcSIR-14-ES-AD-010	Transportation Planning

AcSIR Academic Centre Code: 14

CSIR-Central Road Research Institute CSIR-CRRI

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Course Code	Credits
Advanced Geotechnical Engineering	AcSIR-14-ES-AD-001	3

Introduction to basic Geotechnical engineering: Sub soil investigation using SPT, SCPT, DCPT and Plate load tests, analysis of data, shear strength, consolidation characteristics, and settlement analysis.
Ground improvement Techniques: Soil improvement, dynamic compaction, Lime stabilization, Cement stabilization, organic and inorganic stabilizers, , Blasting, drains, Lime columns, Soil grouting, soft soils, embankments on soft soils, stage construction Vertical sand drains, Prefabricated vertical drains (PVD), Fiber drains, Instrumentation techniques, peizo-meters, settlement gauges, inclinometers, Field tests on soft soils, Stone columns, wet and dry methods, soil nailing, pull out tests, construction process, design methods, case studies.
Stability of slopes and earth retaining structures: Earthen embankments, specifications, case histories, Finite and infinite slopes, Method of slices, Bishop’s method, Factor of safety, submerged case, sudden draw-down case, steady seepage case, long term and short term stability, gravity walls, cantilever walls.
Geosynthetic materials for highway applications: Geotextiles, woven, non-woven, Geo ties, Geogrids, Properties, applications, Reinforced earth walls, Mechanism, Reinforcement-soil interaction, Analysis and design checks, Internal and external stability, Tests for soil reinforcement, Field applications, software applications.
Environmental Geo-techniques: Utilization of Waste materials, Reduction of carbon footprint, Hazardous waste containment, slurry wastes, Liners, Stability of landfills, landfill construction, Design aspects, Barriers.

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AcSIR Academic Centre Code: 14

CSIR-Central Road Research Institute	CSIR-CRRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Highway Engineering Materials	AcSIR-14-ES-AD-002	3

Soils and Aggregates : New Materials for Soil Stabilization, Geosynthetics (Applications and Economics) , Production of Quality Aggregates, Requirements of Aggregates for High Speed Road Corridors and Airfield Pavements, Factors affecting Adhesion of Bitumen with different Aggregate, Durability, Transportation and Economics. Beneficiation of Marginal Materials, New Materials for Sub base and Base Courses. Characterization of Fly Ash, Properties and Applications of Metallurgical Slag as Soil & Aggregate, Beneficiation and Use of Industrial and Mining Waste, Characterization and Use of Demolition Waste. Paving Bitumen: Composition, Structure and Rheology, Durability, Physical Constants, Performance Based (SHRP) Specifications, Additives viz. Warm Mix Additives and Anti-stripping Agent. Value Added Bitumen Products: Specification of Multigrade Bitumen, Rubber and Polymer Modified Bitumen, Bitumen Emulsion, Modified Bitumen Emulsions, Foam Bitumen, Rejuvenating Agents, Pigmentable Bitumen, Fuels Resistant Bitumen, Cut-back Bitumen, Hard Bitumen, Oxidized Bitumen, Sulphur Extended Bitumen.

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AcSIR Academic Centre Code: 14

CSIR-Central Road Research Institute	**CSIR-CRRI**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Design and Construction of Pavements	**AcSIR-14-ES-AD-003**	**3**

Introduction: Types, components and comparison of pavements, Factors affecting design/performance of pavements, Road and airport pavements;
Stresses and deflections in flexible pavements: Stresses and deflections in homogenous masses; layer theories; wheel load stresses, ESWL computation, Repeated loads and EWL factors; sustained loads. Transient traffic loads. Flexible pavement design methods;
Stresses in rigid pavements: Types of stresses and causes, general considerations in rigid pavement analysis, EWL;
Rigid pavement design: Design of CC pavements, Types of joints in cement concrete pavements and their functions, joint spacing ; design of joint details;
Equipment/Machinery in highway construction: Equipments for excavation, grading and compaction. Equipments for bituminous, cement concrete, stabilised and composite pavements. Earthwork construction, problems, quality control aspects. Design factors; Flexible pavements: Specifications of materials, choice, construction method and field control checks for various specifications of sub-base, base, binder and surface course layers and mix design methods;
Cement concrete pavement layers: Specifications and method of cement concrete pavement construction, quality control aspects;
Drainage: Design and construction of drainage systems for road pavements, drainage materials, procedures and guidelines. Maintenance of pavements, shoulders and drainage; Hill Roads: Special problems in construction and maintenance of hill roads; landslides, causes, investigations and remedial measures.

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AcSIR Academic Centre Code: 14

CSIR-Central Road Research Institute	**CSIR-CRRI**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Dynamics of Structures	**AcSIR-14-ES-AD-004**	**3**

Introduction (need of dynamics, role of dynamics in mechanics-safety-forensic eng., source & nature of dynamic loading). Single degree freedom system (SDOF). Multi-degree of freedom system. Continuous system. Random Vibration. Frequency domain and time domain analysis, spectral methods. Modeling of dynamic forces- Wind forces on structures. Earthquake loading on structures. Blast-Resistant design. Modeling sea wave forces. Soil structure interaction, nonlinearity in structures, Pushover analysis. Control of vibration. Experimental study of vibration from structures with a case study.

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AcSIR Academic Centre Code: 14

CSIR-Central Road Research Institute CSIR-CRRI

Course 3 : Advanced Course | Engineering Sciences | Total Credits 6

Title:	Course Code	Credits
Finite Element Analysis	AcSIR-14-ES-AD-005	3

Introduction to Finite Element: Mathematical aspects of analysis, Matrix operations, Elastic modeling of an object. Basic Concepts: Concepts of Finite Element Analysis, Virtual Work and Variational Principle. Finite Element Method: Displacement Approach, Stiffness Matrix and Boundary Conditions. Element Properties: Natural Coordinates, Triangular Elements, Rectangular Elements, Lagrange and Serendipity Elements, Solid Elements, Isoparametric Formulation. Stiffness Matrix of Isoparametric Elements, Beam elements. Solution of equations, Numerical Integration. Interpretation of results.
Exposure to general FEM software- NISA, SAP, STAAD etc.
Case studies: One Dimensional heat problem, truss, beam and shells.

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AcSIR Academic Centre Code: 14

CSIR-Central Road Research Institute CSIR-CRRI

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Course Code	Credits
Noise and Vibration	AcSIR-14-ES-AD-006	3

Introduction to Noise and Vibration: Concepts of Noise and Vibration, Noise Absorption, Reflection & Transmission. Air born Noise and Vibration, Ground Born Noise and Vibration, Sound Transmission Loss (TL), Noise Reduction Coefficient (NRC) & Sound Transmission Class (STC); Noise and Vibration Criteria: Noise and Vibration criteria in Train and Building; Noise and Vibration Measurement: Instrument and Sensors, Indoor Measurement and Outdoor Measurement, Compare with National and International Guidelines; Noise and Vibration Propagation: Noise Propagation for Line Source and Point Source, Vibration Propagation in different types of soil and Rock; Noise & Vibration Control Techniques: Design of Noise Isolation System, Design of Vibration Isolation System.

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AcSIR Academic Centre Code: 14

CSIR-Central Road Research Institute	**CSIR-CRRI**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Pavement Evaluation Techniques and Management System	**AcSIR-14-ES-AD-007**	**3**

Pavement Evaluation

Evaluation of functional performance and serviceability of pavements, evaluation of pavement structural capacity, distress types and causes, safety- skid resistance etc., combined measures of pavement quality, data management.

Introduction to PMS - Prediction models for pavement deterioration, rehabilitation and maintenance strategies, Framework for pavement design, characterization of physical design inputs, basic structural response models, Intervention criteria for maintenance planning, economic evaluation of alternate pavement design strategies – selection of optimal design strategy, HDM – 4 & other tools, Pavement life cycle assessment. Implementation of PMS, Asset Management.

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AcSIR Academic Centre Code: 14			
CSIR-Central Road Research Institute			CSIR-CRRI
Course 3 : Advanced Course	Engineering Sciences		Total Credits 6
Title: Soft Computing Techniques in Transportation Engineering		Course Code	Credits
		AcSIR-14-ES-AD-008	3

Introduction to Neural Networks: Artificial Neuron and its models, activation functions, Neural Network architecture, single layer and multilayer feed forward networks, various learning techniques, convergence rules.

Neural Network Models: Architecture, perception models, Single ANN model, Multi layer ANN model, back propagation learning models, effect of learning rules, back-propagation algorithm, factors effecting back-propagation algorithm, Radial basis function. Bayesian networks, Application of ANN models to traffic engineering and transportation planning.

Introduction to Fuzzy Logic: Basic concepts of fuzzy logic, fuzzy sets, fuzzy set theory and operations, Properties of fuzzy sets, Fuzzy and crisp relations.

Fuzzy logic Models: Membership functions, interference in fuzzy logic, fuzzy if then rules, fuzzy implications and fuzzy algorithm, fuzzyfications and de- fuzzyfications, fuzzy controllers. Applications of fuzzy logic in Traffic and Transportation Planning.

Genetic Algorithm: Basic concepts, Procedure of GA, Genetic representations, Initialization, genetic operators, mutation, generation, cycle. Applications related to transportation engineering.

Hybrid Modeling Techniques: Integration of Neural Networks, Fuzzy Logic and Genetic Algorithms, Genetic Algorithm Based Back propagation Networks, Fuzzy Back Propagation Networks.

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CSIR-Central Road Research Institute	CSIR-CRRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title: Traffic Engineering & Road Safety	Course Code	Credits
	AcSIR-14-ES-AD-009	3

Traffic Engineering - Definition, concepts, scope and utility;
Traffic Flow Theory – Fundamentals, Scope, relationship between the variables of traffic flow, relationship between speed and traffic elements;
Design of Streets and Highways Infrastructure - Design Control Criteria for highway alignment, geometry of highway elements;
Highway Capacity - Review, definition, factors affecting capacity and level of service, capacity of basic freeway segment and two lane bi directional rural carriageways, capacity of signalized intersection, design and operation, evaluation of weaving section;
Design of Intersection and Inter Changes - Intersection conflict, type of intersections, design of inter-section design elements, ramp gradient, acceleration and deceleration lanes; Traffic Signal Control and Regulation - Introduction, warrant for signal phasing, signal aspect and inter green period. Vehicle actuated signal facilities, effect of traffic and environmental factors, optimization of signal approach, Coordination of traffic signals, Area Traffic Control (ATC) system. Regulation of speed, Parking regulation and enforcement; Street Infrastructure - Street lighting, vehicle lighting, Lighting of carriageways, Guard rails, traffic signs, highway landscapes and drainage;
Traffic Management - Traffic management measures, Transport System Management (TSM) techniques and its application, Impact of TSM techniques;
Road Safety - Characteristics of Road accidents. Planning & Road Design for Safety. Safety Audits (RSA) including RSA Principles and Issues, RSA Procedures and RSA Checklists.

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AcSIR Academic Centre Code: 14

CSIR-Central Road Research Institute CSIR-CRRI

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title: Transportation Planning	Course Code	Credits
	AcSIR-14-ES-AD-010	3

Introduction to Transportation Planning: Introduction to transport planning practices, transportation problem and problem domain in Indian context, objectives and constrains, flow chart for transportation planning process.

Transportation Planning Process: Zoning & travel demand surveys, transportation planning process-inventory, model building, forecasting and evaluation stages.

Trip Generation Models: Regression models, Category analysis, House hold models, Trip attractions, Quick Response Techniques.

Trip Distribution Models: Trip distributions Models-Growth factor models, Gravity models, Opportunity models.

Mode Choice Models: Utility maximisation theory, functional form, elasticity of demand, modelling mode choice - probabilistic models such as probit, logit model etc.

Network Assignment Models: Elements of transport networks, shortest paths, All-or-Nothing (AON) Assignment, equilibrium, user equilibrium (UE), stochastic user equilibrium (SUE), and Frank Wolfe (FW) Algorithm and MSA algorithm.

Land Use Transportation Models: Location Models-Opportunity models, accessibility models, lower based land use transportation models in practice, Lowry models.

Urban and Regional Mass Transport Planning: Introduction to Urban and Regional mass transportation planning, planning for intermediate public transport (IPT)

Planning for non motorised transport: Issues of non motorised transport, planning for bicycles, pedestrians and other slow moving vehicles.

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Faculty of Study	Course Code	Course Title
Engineering Sciences	AcSIR-15-ES-AD-001	Biomedical-Instrumentation
Engineering Sciences	AcSIR-15-ES-AD-002	Circuit Theory
Engineering Sciences	AcSIR-15-ES-AD-003	Digital Image Processing
Engineering Sciences	AcSIR-15-ES-AD-004	Electronic Design & Simulation
Engineering Sciences	AcSIR-15-ES-AD-005	Mechanical Design & Simulation
Engineering Sciences	AcSIR-15-ES-AD-006	Signal Processing
Engineering Sciences	AcSIR-15-ES-AD-007	Statistical Analysis & Machine Learning
Physical Sciences	AcSIR-15-PS-AD-001	Advanced Materials and Nanoscience
Physical Sciences	AcSIR-15-PS-AD-002	Analytical Instrumentation
Physical Sciences	AcSIR-15-PS-AD-003	Electronic Devices
Physical Sciences	AcSIR-15-PS-AD-004	Optics and Opto-electronics
Physical Sciences	AcSIR-15-PS-AD-005	Photonics Devices and Systems
Physical Sciences	AcSIR-15-PS-AD-006	Sensors & Transducers
Physical Sciences	AcSIR-15-PS-AD-007	Smart Materials and Applications

AcSIR Academic Centre Code: 15	
CSIR-Central Scientific Instruments Organisation	CSIR-CSIO

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Biomedical-Instrumentation	AcSIR-15-ES-AD-001	3

Introduction-Cellular organization: Cell, Action potential of cell, Transport of substances across biological membrane.
Cardiovascularsystem: Heart, arterial and venous system, blood, cardiac cycle. Basics of ECG, PCG. Measurement of blood pressure by direct and indirect methods. Plethysmography. Defibrillators: DC defibrillators, AC defibrillators of capacitance discharge and delayline capacitancedischargewith basic circuitdiagrams. Types of electrodes andtheirfeatures.
Cardiac Pacemakers: AsynchronousandSynchronous(demand)Modeofoperation.External andImplantableAsynchronous pacemakers. Working Principles, modes of triggering. Respiratory system: TracheaandLungs. RespiratoryPhysiology,Spirometry, Ventilators. Nervoussystem andspecialsenses:Nervephysiology.BasicsofEEG.Electrodesusedfor measurement ofEEG.
Skeletalsystem: ClassificationofBones,JointsandMuscles-Structureandfunction,Basics of EMG.
Bi-potential Electrodes: Electrode electrolyte interface, half-cell potential polarization, electrodeskin interfaceand motion artefact. Types of electrodes. Micro electrodes.
Miscellaneous: Hearing aids, Heamodialysers- types of exchangers. Lasers in Surgery, Principles and applications of Endoscopes.
Electrical hazardsinhospitals:Patientelectricalsafety, typesof hazards,patientisolation, physicaleffects of current,let–go–current,Microshocks,different waysfor electricalaccident tooccur, safetyinstructioncircuits, electricalgrounding &effects.

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AcSIR Academic Centre Code: 15

CSIR-Central Scientific Instruments Organisation **CSIR-CSIO**

Course 3 : Advanced Course	**Engineering Sciences**		**Total Credits 6**
Title: Circuit Theory		**Course Code**	**Credits**
		AcSIR-15-ES-AD-002	**2**

Electriccircuitsandcomponents:Introduction, basicelectricalelements, resistor, capacitor, inductor, Kirchhoff'slaws, voltageandcurrentsourcesandmeters, networktheorems, AC/DC circuitanalysis, transformer, impedancematching,grounding and electrical interference. Waveforms, signals, untransient steady state responses of RLC circuits, Laplace, signal superposition & Fourier transforms along with linear algebra, Differential equations for solving circuit problems.

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CSIR-Central Scientific Instruments Organisation	CSIR-CSIO

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title: Digital Image Processing	Course Code	Credits
	AcSIR-15-ES-AD-003	3

Introduction: Elements of visual perceptions, digital Image sensing, sampling and quantization, digital image representation, basic relationship between pixels, elements of digital image processing system.
Image transforms: Discrete Fourier transform and properties, separable image transforms, image enhancement. Wavelet transforms.
Restoration and Reconstruction: Image restoration, image segmentation, image reconstruction from projections.
Statistical pattern recognition: Cluster analysis, feature selection &extraction, syntactic pattern recognition: stochastic languages, problem solving methods for pattern recognition.
Case studies: Medical image processing, colour image processing, thermal image processing.

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AcSIR Academic Centre Code: 15			
CSIR-Central Scientific Instruments Organisation			CSIR-CSIO
Course 3 : Advanced Course	Engineering Sciences		Total Credits 6

Title:	Electronic Design & Simulation	Course Code	Credits
		AcSIR-15-ES-AD-004	2

Introduction to Electronic design, automation, EDA development tools & applications, basics of schematic capture, properties & characteristics of active and passive components; PCB layout design, PCB manufacturing processes, Circuit design for analog and digital signals, mix signal simulation, ground and power supply requirements.
EMI fundamentals, thermal design and simulation.

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AcSIR Academic Centre Code: 15			
CSIR-Central Scientific Instruments Organisation			CSIR-CSIO
Course 3 : Advanced Course	Engineering Sciences		Total Credits 6
Title: Mechanical Design & Simulation	Course Code		Credits
	AcSIR-15-ES-AD-005		2

Introduction to Optics Software for Layout &Optimization (OSLO), Paraxial Optics, third order aberrations; Design & Evaluation of Optical Systems Consisting of One, two & three elements using OSLO.

Introduction to drawings 2D, 3D and Projection, Drawing view of components & assembly. Modelling Approaches: Geometric modelling, Wire-frame modelling, part modelling, assembly modelling, Sheet Metal modelling. Rendering of Visualization.

Introduction to Finite Element Analysis: Static, Frequency, Thermal & Dynamic analysis

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AcSIR Academic Centre Code: 15

CSIR-Central Scientific Instruments Organisation CSIR-CSIO

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Course Code	Credits
Signal Processing	AcSIR-15-ES-AD-006	3

Signals and Systems, Continuous time signals, sampling theorem, discrete time signals and systems, classification; Transforms, Analysis and Filters, Analysis of linear systems, correlation of discrete time signals, frequency domain analysis, DFT, FFT, z-transform, IIR/FIR digital filter design, basics of DSP processors; Signal processing in instrumentation, case studies.

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AcSIR Academic Centre Code: 15

CSIR-Central Scientific Instruments Organisation **CSIR-CSIO**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits**	**6**

Title:		Course Code	Credits
	Statistical Analysis & Machine Learning	**AcSIR-15-ES-AD-007**	**3**

Statistical Analysis: Statistics In Research, Common Terms in Statistics, Constraints in Research, Population and Sample, Choosing Appropriate Sample Size, Sampling, Errorsin Sampling, Data Collection, Biasin Statistics, Data representation, Types of Data, Data Analysis, Measures of Central Tendency, Standard deviation, Variance, Standard Error of Means, Gaussian Distribution, Normal Distribution Curve, Skewness,Tests of Significance– t/z/ANOVA, chi squaretest, correlation and regression analysis.

Applied Machine Learning: Linear algebra revisited, ML Tools, Introduction to Machine Learning - Supervised Vs. Unsupervised Learning, Linear regression, Logistic regression, Regularization, Neural networks- Representation and Learning, Machine Learning System Design, Support Vector Machines, Clustering, Dimensionality reduction, Anomaly detection, Recommender systems, Largescale machine learning, Applications- e-Nose, i-Tongue, cancer,Iris, Boston housing, sonar, wine, etc.

Hybrid systems: Uncertainty and imprecision, fuzzy systems, linguistic rules, approximate reasons, neuro-fuzzy systems, genetical gorithms and evolving neural networks, applications in control, inspection, monitoring, forecasting, recognition and diagnosis, Applications/Case Studies: Engineering design optimization, optimiser behaviour evaluation through stochastic analysis, performance analysis, optical design and engineering, mechatronic products, agro applications.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 15

CSIR-Central Scientific Instruments Organisation **CSIR-CSIO**

Course 3 : Advanced Course	**Physical Sciences**	**Total Credits 6**

Title: **Advanced Materials and Nanoscience**	**Course Code**	**Credits**
	AcSIR-15-PS-AD-001	**3**

Polymeric materials: Science and engineering, Overview about the different types of organic, inorganic and polymeric materials, Liquid crystalline polymers and conducting polymers, Hybrid materials for electronic and electrochemical applications.

Bio-inspired nanomaterials and nano bioconjugates: Chemistry of reactive groups, Homo-/hetero-/multifunctional cross linkers, Nanobioconjugates and biomolecule immobilization, Multi-responsive biomaterials, Polymeric nanostructures for biodetection and controlled release applications.

Inroduction to material science & engineering: Geometry of crystals, Space lattices and crystal structures, Crystal directions and planes, Joint imperfections, Geometry of dislocations, Other properties of dislocations, Surface imperfections, Phase rule, Single-component systems, Binary phase diagrams, Microstructural changes during cooling, Lever rule, Iron-carbon phase diagram. Structural characterization, X-ray diffraction.

Dielectric & magnetic nano materials: Polarization temperature and frequency effects, Electric breakdown, Ferroelectric Materials, Basic magnetic Phenomena, Diamagnetism, Paramagnetism, Ferromagnetism, Ferrimagnetism, Anti-ferromagnetism, Some examples of these materials and their applications, Hysteresis loop, Soft magnetic materials, Hard magnetic materials, Superconducting materials.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 15	
CSIR-Central Scientific Instruments Organisation	CSIR-CSIO

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Analytical Instrumentation	Course Code	Credits
		AcSIR-15-PS-AD-002	2

Spectroscopic techniques: Atomic emission and absorption spectroscopy (UV-visible, NIR, FTIR, Photoluminescence), Raman spectroscopy, NMR.
Separation techniques: Chromatography (gas, ion, liquid, high-pressure liquid chromatography)
Electro-chemical instrumentation: Electro-analytical techniques- Cyclic voltammetry, Potentiometry, Impedance spectroscopy, Amperometry
Microscopy: Scanning electron microscopy, Transmission electron microscopy, Tunnelling microscope, Atomic force microscope and applications in material characterization.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 15

CSIR-Central Scientific Instruments Organisation	CSIR-CSIO

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Electronic Devices	AcSIR-15-PS-AD-003	2

Semiconductor electronics: Junction diode, Zener diode, Analysis of diode circuit, Three terminaldevices-BJT,JFET,MOSFET, Photo devices photodiodes, Phototransistors, LED, LCD, Opto-isolatorandopto couplers, Amplifiers: BJT, FET amplifier, Singlestage, Multistage power amplifiers, Class A, B, C and D amplifiers, Differential amplifiers, OPAMPs, Specifications, characteristics and applications, Practical OPAMP, Interpretation of data sheets of an OPAMP, Active filters and oscillators.
Number system and code conversion, Logic gates, Boolean algebra, Combinational logic circuits, Sequential logic circuits-latch, RS, JK, T, D flip flops, Shift registers, Counters,
Digital building blocks: Decoder, Encoder, MUX, DMUX, A/D, D/A converters, memories, Programmable logic devices, Microprocessors, Microcontrollers, Display devices.
Four terminal devices: SCR, DIAC, TRIAC, Construction, Rating characteristics and applications of SCR, DIAC, TRIAC, IGBT.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 15		
CSIR-Central Scientific Instruments Organisation		CSIR-CSIO
Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Optics and Opto-electronics	AcSIR-15-PS-AD-004	2

Reflection, Refraction, Wave theory, Interference, Diffraction, Polarization, Micro optics, Tolerance theory, Principles of holography

Basics of lasers and its applications, Optical fibres and its properties, Fibre half-block, Directional couplers, Fibre polarization components, Fibre gratings, OTDR, Optical spectrum analyzer

Photo detectors and detection techniques, Fibre optic and radiation sensors, Electro-optic and acousto-optic effect and its applications, Micro-structured optical fibre.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 15

CSIR-Central Scientific Instruments Organisation	CSIR-CSIO

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Photonics Devices and Systems	**AcSIR-15-PS-AD-005**	**2**

Optical amplifiers, Distributed feedback laser, Distributed Bragg reflector laser, FBG/LPG based sensing.

FO interferometric sensor: Fiber fabry perot and Mach Zehnder interferometer, FBG interrogation techniques based on amplitude, Wavelength, Phase and time demodulation, Raman, Brillion and Rayleigh scattering based sensors surface plasmon resonance: Basics and applications.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 15

CSIR-Central Scientific Instruments Organisation	CSIR-CSIO

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Sensors & Transducers	AcSIR-15-PS-AD-006	2

Sensor technologies: Physical principles & basic mechanisms in sensor systems, Thin and thick film technologies, Processing of micro-sensors, MEMS.
Sensor Structures: Impedance type, Semiconductor based, Resonance based, Electro-chemical cell, Colorimetric and fibre optic sensors.
Sensing effects and performance: Dielectric, Sorption, Conductivity, Resistivity, optical behaviour, Selective chemical sensing, Transduction principles, Transducer characteristics, classification of transducers, Methods for characterization of transducers-performance characteristics, Static & dynamic characteristics.
Sensor applications & hands on session: Mechanical, Acoustic, Temperature, IR, Humidity, Ion-selective, Medicine and biology.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 15			
CSIR-Central Scientific Instruments Organisation			**CSIR-CSIO**
Course 3 : Advanced Course	**Physical Sciences**		**Total Credits 6**
Title: Smart Materials and Applications		**Course Code**	**Credits**
		AcSIR-15-PS-AD-007	**2**

Concept of smart materials, Classification of smart and functional materials, Organic and inorganic smart materials, Photoresponsive materials, pH stimuli materials, Temperature sensitive materials, Dual responsive, Piezoelectric materials, Shape-memory alloys, Self-healing materials chemoresponsive materials, Functional coating, Bomimetic functional materials, Multifunctional optical materials, Synthesis and characterization, Optical metamaterials, Smart optical material based light sources, Sensors and actuators, Applications of smart optical materials.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-16-BS-AD-001	Advancement in Plant Biotechnology
Biological Sciences	AcSIR-16-BS-AD-002	Advances in Agronomy and Soil Chemistry
Biological Sciences	AcSIR-16-BS-AD-003	Advances in Bioresources and Natural Products
Biological Sciences	AcSIR-16-BS-AD-004	Advances in Genetics and Plant Breeding
Biological Sciences	AcSIR-16-BS-AD-005	Advances in Microbiology and Its Application
Biological Sciences	AcSIR-16-BS-AD-006	Algal Technologies
Biological Sciences	AcSIR-16-BS-AD-007	Marine Ecology and Environment
Biological Sciences	AcSIR-16-BS-AD-008	Stress Signalling in Plants for Crop Improvement
Chemical Sciences	AcSIR-16-CS-AD-001	Advanced Catalysis
Chemical Sciences	AcSIR-16-CS-AD-002	Advanced Materials Science
Chemical Sciences	AcSIR-16-CS-AD-003	Advanced Methods in Organic Reaction
Chemical Sciences	AcSIR-16-CS-AD-004	Advanced Separation Science and Technology
Chemical Sciences	AcSIR-16-CS-AD-005	Marine Natural products
Chemical Sciences	AcSIR-16-CS-AD-006	Polymers for Membrane Applications
Chemical Sciences	AcSIR-16-CS-AD-007	Chemistry of Common Salt & Bittern Products

16	CSIR-CSMCRI	3	Advanced Course

Faculty of Study	Course Code	Course Title
Engineering Sciences	AcSIR-16-ES-AD-001	Advanced Computational Fluid Modelling
Engineering Sciences	AcSIR-16-ES-AD-002	Aspects of Biochemical Engineering
Engineering Sciences	AcSIR-16-ES-AD-003	Electronics and Optics for Device Applications
Engineering Sciences	AcSIR-16-ES-AD-004	Environmental Monitoring and Assessment
Engineering Sciences	AcSIR-16-ES-AD-005	Marine Ecology and Biodiversity
Engineering Sciences	AcSIR-16-ES-AD-006	Process Engineering and Case Studies
Engineering Sciences	AcSIR-16-ES-AD-007	Salt Technology
Engineering Sciences	AcSIR-16-ES-AD-008	Science of Renewable Energy Sources

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 16

CSIR-Central Salt and Marine Chemicals Research Institute **CSIR-CSMCRI**

Course 3 : Advanced Course	**Biological Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Advancement in Plant Biotechnology	**AcSIR-16-BS-AD-001**	**2**

Introduction of Biotechnology; Tissue Culture: Types and Methods; Somaclonal variations (concept and applications, visual, molecular and other screening methods); Different Culturing methods: Haploids (anther, ovule culture and bulbosum technique, detection of haploids, applications); Endosperm culture, triploid production and its application; Protoplast culture, somatic hybrids and cybrids, selection strategies and applications; Secondary metabolites, hairy root culture, molecular farming, scale up studies using bioreactors; Ex situ conservation, short and long term storage of germplasm; Applications of tissue culture in commercialization; In vitro methods of crop improvement using transgenic technology and their Implications: Gene amplificatuion and cloning: Cloning vectors and their characteristics, Restriction digestion, Ligation of DNA molecules, Recombinant selection and confirmation; Plant transformation: Construction of expression vector, Methods of transformation-Agrobacterium mediated and Gene gun; Transgenic analysis: PCR approach, Southern blotting, Northern blotting.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 16

CSIR-Central Salt and Marine Chemicals Research Institute	CSIR-CSMCRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Advances in Agronomy and Soil Chemistry	AcSIR-16-BS-AD-002	2

Modern concept of Agronomy and Principles of Agronomy; Plant essential nutrients and factors effecting nutrient availability to plants; Soil water; Soil microbes and biofertilizers, soil enzymes, biofertilizers; fertilizers and manures, soil-plant-water relations; dryland agriculture and abiotic stress mitigation in plants; biostimulants and their mode of action; Chemical composition of earth crust, soils, rocks and minerals; Soil colloids: Inorganic and organic colloids; Silicate structure, crystalline oxides and amorphous materials; stability and weathering of minerals; clay mineral transformation and synthesis; Origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-change soil components, surface charge characteristics of soils; Soil acidity - formation and properties of acid and acid sulphate soils; Salt-affected soils - formation and properties; Chemical speciation of nutrient; chemistry of waterlogged soils; Organic matter – extraction, fractionation and characterization; interaction of organic matter with clay minerals and metals ions.

AcSIR Academic Centre Code: 16

CSIR-Central Salt and Marine Chemicals Research Institute	CSIR-CSMCRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Advances in Bioresources and Natural Products	AcSIR-16-BS-AD-003	2

Concept of resource; classification of natural resources; Factors influencing resource availability; endemic bioresources of India, ecological principles for managing bioresources, ethical and historical aspects of bioresources; Resources and their related natural products: microbial, plant, mineral, water (including marine), land (including forest and soil) and energy resources; Concept of sustainability; Sustainable use of natural resources; Ethics of sustainable utilization: Bioresources for food security and rural livelihood: Bioresources and the global human economy, Life Cycle Assessment of production systems.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 16

CSIR-Central Salt and Marine Chemicals Research Institute	CSIR-CSMCRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Advances in Genetics and Plant Breeding	Course Code	Credits
		AcSIR-16-BS-AD-004	2

History of Genetics, Cell ultra structure, Chromosome structure and Function, Chromosomal Aberrations : Structural and Numerical, Laws of Mendel: a. Law of Segregation, b. Law of Independent Assortment, Physical Basis of Heredity (Chromosomal theory of inheritance) Gene Symbols, Dominance and Lethal Genes, Gene interaction and Epistasis, Linkage and Crossing Over, Multiple Alleles, Mutation, The Genetic Material Replication and Repair of Genetic material, Organization of Genetic material, Genome maps, Gene Action: Genes, Biochemical Reaction and Protein, Transcription and RNA Processing, Translation, Population Genetics: Hardy Weinberg Law, factors affecting Gene Frequencies. Facts about plant breeding before the discovery of Mendelism; evolutionary concepts of genetics and plant breeding, Mating systems and their exploitation in crop breeding; Types of pollination - Mechanisms promoting cross pollination: self incompatibility and sterility, Sterility: male and female sterility – Types of male sterility: genic, cytoplasmic and cytoplasmic-genic, Genetic engineering technologies to create male sterility; prospects and problems - Use of self incompatibility and sterility in plant breeding – case studies, Population formation by hybridization - Types of population - Mendelian population, gene pool, composites, synthetics etc., Genetic basis of population improvement - Selection in cross fertilizing crops - Mass and recurrent selection methods and their modifications, Selection in self fertilizing crops and ways of creation of genetic variability; selection methods - Selection methods: mass selection, pureline selection, pedigree method (selection in early generations vs advanced generations); selection methods in cross pollinated crops - Selection in clonally propagated crops – assumptions and realities. characterization of ion-exchange polymers and adsorbents, regeneration in water treatment and other industrial applications.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

Course 3 : Advanced Course **Biological Sciences** **Total Credits 6**

Title:	Advances in Microbiology and Its Application	Course Code	Credits
		AcSIR-16-BS-AD-005	2

Current development in microbial taxonomy, phynotypic microarrays, chemotaxonomy, nuclic acid and protein based methods, Metagenomics approach, Basis of adaptation to extreme environments, biotechnological applications of extremophilic microorganisms, indistrially important extremophylic enzymes, Bioprospecting salt tolerant bacteria, Mechanisms of action of plant growth promoting bacteria, General introduction to biofertilizers, Current status of use of biofertilizers, plant growth promoting bacteria for soil fertility, disease, and stress tolerance.

AcSIR Academic Centre Code: 16

CSIR-Central Salt and Marine Chemicals Research Institute	CSIR-CSMCRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Algal Technologies	AcSIR-16-BS-AD-006	2

Natural product Extraction, Characterization purification and utilization of industrially important phycocolloids from seaweeds, Cultivation methods of seaweeds, seaweed diseases and their control measures, Cultivation of seaweeds through spore culture; factors influencing commercial seaweed farming, Nutritional physiology of seaweeds, seaweed diversity, Diversity of microalgae, phytoplankton ecology, bioprospecting of microalgae, General Introduction to seaweed based biostimulant: Seaweeds generally used for making biostimulants in different countries.Constituents of biostimulants: micro- and macro- nutrients, hormones, quaternary ammonium compounds, anti-oxidants, phenolics and other constituents.Current status of use of biostimulant: India and the world, effect of biostimulants on crops-economic and ecological studies, Mechanism of action of biostimulants: agronomic, physiological and molecular basis. Application of biotechnological interventions for genetic improvement, Introduction to seaweeds, their habitat, types, molecular phylogeny, culturing of seaweeds, life histories, Microalgae for healthcare, energy and environment; upstream and downstream processing techniques for microalgal based product development.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 16

CSIR-Central Salt and Marine Chemicals Research Institute	**CSIR-CSMCRI**

Course 3 : Advanced Course	**Biological Sciences**	**Total Credits 6**

Title:	**Marine Ecology and Environment**	**Course Code**	**Credits**
		AcSIR-16-BS-AD-007	**2**

Components of environment, Physical and chemical composition of seawater; Biogeochemical cycles, Marine Zonation: Marine and coastal ecosystem; Food web; Food chain; Biotic and a-biotic stress. Marine biodiversity; Global warming and Climate Change; Marine Pollution; Water and wastewater treatment technology; Marine EIA.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 16

CSIR-Central Salt and Marine Chemicals Research Institute	CSIR-CSMCRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Stress Signalling in Plants for Crop Improvement	AcSIR-16-BS-AD-008	2

Introduction of plant stress, stress perception, signalling, molecular interaction, molecular regulation, biochemical regulation, homeostasis, epigenetic regulation, post transcriptional regulation

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 16	
CSIR-Central Salt and Marine Chemicals Research Institute	CSIR-CSMCRI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Advanced Catalysis	Course Code	Credits
		AcSIR-16-CS-AD-001	2

Fundamental aspects of catalysis. Homogeneous catalysis: Acid-base catalysis and its industrial applications, Elementary steps in catalysis, Transition metal and complex mediated reactions, Cooperative and autocatalysis,Organocatalysis, N-heterocyclic carbenes Application of homogeneous catalysis in industrial applications. Assymmetric Catalysis, Heterogeneous catalysis: Basic concepts. Theories and general mechanism. Bulk synthesis and advanced characterizations. Catalytic materials (Zeolites, Carbons, metal oxides, inorganic-organic hybrid materials). Heat and mass transfer effects, diffusion in porous catalyst, Catalysts deactivation/poisoning, various deactivation mechanisms and regeneration. Application of heterogeneous catalysis in: Energy and CO2. Biomass conversion, Hydrocarbon reforming and refining, NH3 synthesis other industrial applications, Photocatalysis. Reactors: classification chemical of reactors, laboratory reactor systems, commercial Reactors, chemical kinetics, and chemical process equipment.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 16

CSIR-Central Salt and Marine Chemicals Research Institute — CSIR-CSMCRI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Materials Science	AcSIR-16-CS-AD-002	2

Rational design and engineering of lipid-based targeted drug delivery vehicles and their therapeutic applications - Design of polymeric micelles as nano drug carriers - Design of polymer-based nanometric targeted delivery systems and their therapeutic applications - Set-backs and unmet challenges – Cancer and its Hall Marks - Principles of designing anti-cancer therapeutics – Molecular basis of lung, breast, melanoma and prostate cancers – Rationale for selecting leading pathways in cancer therapy – Nuclear hormone receptors as targets in cancer therapy – Rationale for design of cancer therapy against multiple pathways-Concept of designing hybrid molecules as a dual strategy - Use of nanotechnology in cancer therapy - Concept of cancer stem cells and design of cancer stem cell therapeutics.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 16

CSIR-Central Salt and Marine Chemicals Research Institute	CSIR-CSMCRI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title: Advanced Methods in Organic Reaction	Course Code	Credits
	AcSIR-16-CS-AD-003	2

Stereochemistry, reaction mechanism, C-C and C-X bond formations, Retrosynthetic analysis, photochemistry, pericyclic reactions, reactive intermediates, Methods of asymmetric synthesis and their application in total synthesis, oxidation-reduction reactions, organocatalysis, metathesis reactions.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 16

CSIR-Central Salt and Marine Chemicals Research Institute	CSIR-CSMCRI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title: Advanced Separation Science and Technology	Course Code	Credits
	AcSIR-16-CS-AD-004	2

Classification of membranes, Principle of osmosis, Reverse Osmosis, Forward osmosis, Nanofiltration, Ultrafiltration, Microfiltration, Mass transport through membrane, Membrane element configurations, Spiral wound membrane systems, Basics of membrane system design, Concentrate management in Reverse Osmosis systems Electro-membrane processes: Ion-exchange membranes, Synthesis of ion exchange membranes, Applications of Ion exchange membranes: Electrodialysis and related processes, Diffusion dialysis, Donnan dialysis, Polymer electrolyte membranes, Fuel cell, Membrane electrolyzer for hydrogen production, Reverse electrodialysis, Redox flow battery. Ion Exchange Polymers and Adsorbents: Introduction, Classification of ion exchange polymers and adsorbents, Synthesis and characterization of ion-exchange polymers and adsorbents, regeneration in water treatment and other industrial applications.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

CSIR-Central Salt and Marine Chemicals Research Institute	**CSIR-CSMCRI**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:		Course Code	Credits
	Marine Natural products	**AcSIR-16-CS-AD-005**	**2**

Bioactive compounds from Marine Invertebrates: Sponges, Tunicates, Corals, other invetebrates, marine microorganisms; Biosynthesis of Natural Products; Strcutural Elucidation of Natural Products; Halophytes; Seaweed polysaccharides; Gelling polysaccharides, extraction from natural sources; Polysaccharide contents of various seaweeds; Stimuli responsive materials; Preparation of polysaccharide based biodegradable materials; Applications of polysaccharide based materials.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 16		
CSIR-Central Salt and Marine Chemicals Research Institute		**CSIR-CSMCRI**
Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Polymers for Membrane Applications	**AcSIR-16-CS-AD-006**	**2**

Polymers for membrane: Glassy and rubbery polymers, Chain and controlled block copolymerization, monomer reactivity ratios, copolymer compositions, molecular architecture, blends, grafts, melts, self-assembly and phase separation, phase diagram, range of applicability of copolymerization equation; types of copolymerization; Block copolymers with controlled molecular weight, block copolymer synthesis, Living Polymerization, characterization techniques, block copolymers for biomedical and industrial applications, Amphiphilic block copolymer micelles, Block copolymer thin films. Functional polymers containing styrene and its derivatives; Functionalized poly (arylene ether)s, Nafion and other Poly(perfluorosulfonic acid) membranes, Post functionalized polymeric membranes, functional poly (imide)s; functional polyphosphazene; functionalized bio- polymers, polymer nanocomposites, characterization of polymer membranes.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 16

CSIR-Central Salt and Marine Chemicals Research Institute	**CSIR-CSMCRI**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title: **Chemistry of Common Salt & Bittern Products**	**Course Code**	**Credits**
	AcSIR-16-CS-AD-007	**2**

Composition of seawater, solubility behavior of various oceanic salts and influence of various factors, crystallization methods & fractional crystallization of salts, phase equilibrium & its applications in aqueous systems to recover various salts from brine/bittern, Chemistry of common salt manufacture, solar salt production process and related field activities & equipment, Scientific design and layout of solar salt works, Quality parameters of different grade common salts, Analytical techniques for analysis of salts and marine chemicals, Factors affecting quality and yield of common salt production & their improvement aspects, Fortification of salt with essential nutrients, Bittern and its composition, Recovery of valuable bittern products, Applications of common salt and bittern products.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 16

CSIR-Central Salt and Marine Chemicals Research Institute	CSIR-CSMCRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Computational Fluid Modelling	AcSIR-16-ES-AD-001	2

Introduction to CFD, Integral and differential forms of Mass, Momentum and Energy conservation. Reynolds Number and Geometry effects, Introduction to Boundary layer theory, Laminar and Turbulent boundary flows. Numerical Modelling and application for computational fluid dynamic case study, Equations governing fluid flow, Hyperbolic partial differential equations and shocks, finite difference technique and difference equations, Time discretization, Predictor corrector methods, Stability Analysis of Numerical scheme, Numerical Grid Generation, Explicit and implicit methods, Boundary conditions.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 16

CSIR-Central Salt and Marine Chemicals Research Institute | CSIR-CSMCRI

Course 3 : Advanced Course | Engineering Sciences | Total Credits 6

Title:	Course Code	Credits
Aspects of Biochemical Engineering	AcSIR-16-ES-AD-002	2

Steps in bioprocess development; Basic configurations of fermenter and ancillaries; Kinetics of microbial growth and production formation; Modes of bioreactor operation: batch, fed batch and continuous cultivation; Overview on downstream unit operations; Enzymes: classification and mechanism of action; Kinetics of single substrate enzymatic reactions and determination of Michaelis–Menten parameters; Enzyme immobilization techniques; Scale up of bioprocess.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 16

CSIR-Central Salt and Marine Chemicals Research Institute	CSIR-CSMCRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:		Course Code	Credits
	Electronics and Optics for Device Applications	AcSIR-16-ES-AD-003	2

Resistors, capacitors, inductors, Transformers, Circuit Analysis and Network Theorems (Thevenin, Norton, Superposition, Maximum Power Transfer), Diodes, transistors (BJT, FET, MOSFET), linear power supplies, operational amplifiers, instrumentation amplifiers, analog filters (passive and active), ADC, DAC, Microchip PIC 16F877, Arduino Uno & Mega, LED, Laser diodes, UV-VIS Photodetectors, Lens, Prisms, Mirrors, Optical Filters, Apertures, applications of all above components in transducer interface and signal conditioning, circuit design, power budgeting, building optical system, device development, calibration and validation

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 16			
CSIR-Central Salt and Marine Chemicals Research Institute			**CSIR-CSMCRI**
Course 3 : Advanced Course	**Engineering Sciences**		**Total Credits 6**
Title: Environmental Monitoring and Assessment		**Course Code**	**Credits**
		AcSIR-16-ES-AD-004	**2**

Baseline data Collection-Air, noise, water (ground & marine), soil/sediments, Physical, Chemical & Biological parameters of environmental monitoring, Socio-economic impact assessment, Resettlement and rehabilitation, Acts and Rules related to environmental protection, Environmental impact assessment (EIA)-Process and procedures, Environmental management plan (EMP), Mitigation and corrective actions.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 16

CSIR-Central Salt and Marine Chemicals Research Institute	CSIR-CSMCRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title: Marine Ecology and Biodiversity	Course Code	Credits
	AcSIR-16-ES-AD-005	2

Marine Ecosystem-Structure, function, trophic levels, components, succession. Ecological indicators-Phytoplanktons, Zooplanktons and Benthos, Intertidal Ecology-Mangroves, halophytes, sediments, Biodiversity-Types, Values, Threats, Conflicts & Conservation, Coastal Regulation Zone-Requirements, Marine microbiology, Marine environmental management plan.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 16

CSIR-Central Salt and Marine Chemicals Research Institute CSIR-CSMCRI

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Course Code	Credits
Process Engineering and Case Studies	AcSIR-16-ES-AD-006	2

Overview of Unit operations and processes in chemical engineering, Basics of process design, Economics of overall process and plant design engineering, Case study in energy optimization and management, Case study in membrane system design, Case study in green process development, Case study in Biodiesel production process, Case study in Integrated Salt and Marine Chemical process.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 16

CSIR-Central Salt and Marine Chemicals Research Institute CSIR-CSMCRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Salt Technology	AcSIR-16-ES-AD-007	2

Basic Knowledge about salt, types of salt, brine and bittern, brine management, salt production methods, introduction to planning and layout of solar salt works, Contour surveying, site selection, components of solar salt works: Reservoir, Condenser, Crystallizer, Feeding and Discharge channels, Roads; factors affecting salt production and process, general analysis of Na^+,K^+,Cl^-, , Mg^{2+}, Ca^{2+} and instrumentation techniques, Quality Improvement of solar salt, relation of salt to industry, scenario of salt from past to present, salt for specialty applications, new challenges in solar salt production, Construction equipment used in development of solar salt works, Scientific approach, Automation and Modern Technology in solar salt works, Mechanization and Modernization, health and safety for salt workers.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 16

CSIR-Central Salt and Marine Chemicals Research Institute CSIR-CSMCRI

Course 3 : Advanced Course | Engineering Sciences | Total Credits 6

Title:	Course Code	Credits
Science of Renewable Energy Sources	AcSIR-16-ES-AD-008	2

Energy in the modern world; The need for Renewable Energy; Potential of Renewable Energy Resource; Wind Energy; Hydro power; Solar Energy Resource; Marine Energy; Biomass Energy; Geothermal Energy; Heat transfer: conduction, convection and radiation; Important instruments and sensors for measurements; Environment sustainability; Basics of structural design; Energy economics

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

17	CSIR-IICB	3	*Advanced Course*

Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-17-BS-AD-001	Biology of Macromolecules
Biological Sciences	AcSIR-17-BS-AD-002	Cancer Biology
Biological Sciences	AcSIR-17-BS-AD-003	Cell Biology and Cell Signaling
Biological Sciences	AcSIR-17-BS-AD-004	Eukaryotic Gene Regulation Mechanism
Biological Sciences	AcSIR-17-BS-AD-005	Molecular and Cellular Immunology
Biological Sciences	AcSIR-17-BS-AD-006	Protein Science and Proteomics
Chemical Sciences	AcSIR-17-CS-AD-001	Advanded Analytical Chemistry
Chemical Sciences	AcSIR-17-CS-AD-002	Advanced Organic Chemistry
Chemical Sciences	AcSIR-17-CS-AD-003	Natural Products and Drug Discovery
Chemical Sciences	AcSIR-17-CS-AD-004	Total Synthesis of Molecules

AcSIR Academic Centre Code: 17

CSIR-Indian Institute of Chemical Biology	CSIR-IICB

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:		Course Code	Credits
	Biology of Macromolecules	AcSIR-17-BS-AD-001	2

1.Protein – Nucleic acid interactions,2. Synthesis and degradation of macromolecules 3. The folding process and structural background 4. Modular structures, Protein flexibility, Domain motions, Domain-swapping; and Large macromolecular complexes 5. Enzyme activity, receptor binding and regulation, binding specificity, catalysis and cooperativity in enzymes and receptors 6. Methods for the determination of macromolecules structure and interaction 7. Macromolecular function in transcription, translation, signaling and other fields of cell biology, integration and control mechanisms 8. Structure and evolution of important protein motifs and folds. [e.g. Coiled-coil proteins, helical bundles, signaling domains (sh2, sh2, pdz etc), Immunoglobulin-like proteins, kinases, TIM barrels, DNA/RNA binding motifs 9. Principles of macromolecular engineering 10. The most important metabolic pathways and regulation 11. Relation between sequence, structure and function 12. Biological structure databases 13. Computer modeling of secondary- and tertiary structure of proteins and nucleic acid based on sequence data 14. Enzyme/receptor-based drugs-rational drug design

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 17

CSIR-Indian Institute of Chemical Biology	CSIR-IICB

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Cancer Biology	Course Code	Credits
		AcSIR-17-BS-AD-002	2

Cancer Immunology: The immunological status of adaptive and innate immune cells in cancer, cellular interactions between immune and cancer cells in tumor progression or rejection, immunological mechanisms, regulation and function involved in host responses to tumors, anti-tumor immunity, cancer-induced immune tolerance, immunosuppression, dysregulation of the immune system and poorer outcome in the disease;
Cancer stem cells : Origin/Hypothesis/Concept ; Signaling pathways in cancer stem cells; Cell signaling in cancer : Description of major classes of cell signalling: cell death signalling, cell survival signalling and developmental/stem cell signalling; signal networking and chemotherapy;
Oncogenesis and epigenetics in cancer :Oncogenes and their regulation in signaling aberration; Acetylation/methylation in DNA and histones; Silencing/De-silencing of gene expression; Metabolic Engineering in cancer; Metagenomics and cancer;
Cancer biomarkers and diagnosis: Selection of clinical specimens, recent advancement for identification of biomarkers through different approaches like genomics, proteomics and glycomics in combination with molecular pathology with potential clinical value; Application of biomarkers for cancer staging and personalization of therapy at the time of diagnosis to improve patient care.

Cancer drug discovery : Identification of lead molecules, target identification in cancer cells; combined approaches (in vitro, in vivo and in silico) for validation, various steps involved towards successful drug discovery; immunotherapeutic approaches e.g. cancer vaccines, monoclonal antibodies, adoptive immune cell transfer etc. and combination strategies to treat malignancies 8. Angiogenesis and metastasis; Project writing.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 17

CSIR-Indian Institute of Chemical Biology | CSIR-IICB

Course 3 : Advanced Course | Biological Sciences | Total Credits 6

Title:	Course Code	Credits
Cell Biology and Cell Signaling	AcSIR-17-BS-AD-003	2

1. Cell growth and division, including cell cycle: Phases of cell cycle, Regulation of cell cycle, Cell cycle check point, Cell growth 2. Intracellular sorting of proteins: Nuclear import and export mechanism; Organelle targeting; Transport of protein to cell surface; Soluble protein sorting 3. Cell adhesion, cell junction and Extra Cellular Matrix: Cell adhesion molecules; Cell Junction; Extracellular matrix; Cell-cell recognition 4. Cytoskeletal structure-function and related macromolecules: Cytoskeletal proteins;
Role in vesicular movement; Cellular morphology and cytoskeletal protein; Drug modulating cytoskeletal 5. Signal transduction pathways: Extracellular signals; Intracellular signals; 2nd Messengers; Signal transduction pathways 5. Cell death and proliferation: Programmed cell death; Cell renewal system; Mitochondria and apoptosis; ER-stress 6. Cellular starvation, stress and Autophagy: Oxidative and nitrosative stress; Stress response; Autophagic vacuole turnover; Cellular homeostasis 7. Metabolic disorder and signaling aberrations: Abnormal Signaling in Cancer; Signaling for diabetic complication Angiogensis; Signaling for failure in diabetes.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 17	
CSIR-Indian Institute of Chemical Biology	CSIR-IICB

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Eukaryotic Gene Regulation Mechanism	Course Code	Credits
		AcSIR-17-BS-AD-004	2

Chromatin Structures and Epigenetics Nucleosome assembly and the modification of nucleosomes and of DNA/ The assembly of chromatin into higher order structures/ Different aspects of heritable patterning of gene expression and the biological importance of epigenomes/ Mechanisms of inheritance as well as imprinting, X inactivation and the role of RNA in establishing silent chromatin/ The impact of chromatin structure on differentiation, cell plasticity and development. Transcriptional Regulation and Gene Expression Regulatory interplay between transcription factors: Regulatory DNA sequences (promoters, enhancers, locus control regions) /General transcription machinery/Transcription factors: cell-specific and ubiquitous regulatory factors/ Mechanisticaspects of transcription activation / Chromatin, histones, DNA methylation /Generegulatory networks /Transcription factors in health and disease/ Transcription factorsas the final integrators of signaling cascades. Structure, Processing, Trafficking and Function of RNA Chemistry and structure of RNA/ major lectures of cellular RNAs (mRNAs, tRNAs, rRNAs, snRNAs, and the newly discovered small regulatory RNAs/pre-mRNA processing with emphasis on splicing and polyadenylation/ biogenesis of tRNA and rRNA/biochemistry and function of RNA interference (RNAi) and microRNAs/ RNA trafficking in the cell/ RNA quality control and RNA degradation/regulated mRNA translation during development/ RNA-protein interactions and major lectures of ribonucleoprotein particles;RNA granules and bodies /evolution of RNAs: The RNA world.

Translational Control and Post-translational Protein Modification The translational control: Codons and frame shifting, attenuation, phosphorylation, and transformation/the role of translational control in the regulation of cell growth and differentiation.

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AcSIR Academic Centre Code: 17

CSIR-Indian Institute of Chemical Biology	CSIR-IICB

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Molecular and Cellular Immunology	Course Code	Credits
		AcSIR-17-BS-AD-005	2

History of immunological ideas and cellular components of immune system Transplantation antigens: structure, function, genetics, transplantation; Phagocytosis and antigen presentation Fc receptor and scavenger receptor mediated phagocytosis, markers to follow phagocytosis, presentation of endogenous and exogenous antigens, cross-presentation; Antibody structure, antigen-antibody interactions, binding site, affinity, avidity, Fc functions, molecular biology of immunoglobulins; B cell triggering: Tcell-B cell Interactions; Humoral immune response and cytokines: Signaling through B cell receptors, plasma cell differentiation, proinflammatory / anti-inflammatory effects of cytokines, transcriptional control of cytokine synthesis; Structure of lymphoid organs, ontogeny of lymphoid cells; Complement system and disease : Classical and alternative pathways of complement activation, complement regulation and deficiencies 6. Immune response to parasitic infections : Cell mediated immunity: delayed reactions, immunodeficiency; Allergy, Arthus reaction, serum sickness, inflammation; Autoimmunity: regulation of immune response and autoimmune diseases; Tutorial.

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AcSIR Academic Centre Code: 17

CSIR-Indian Institute of Chemical Biology | CSIR-IICB

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Protein Science and Proteomics	**AcSIR-17-BS-AD-006**	**2**

Protein Science: 1. Basic building blocks of protein and their composition, chemical behavior, properties.
2. Peptide bond, geometry and parameters; Backbone geometry and parameters, side chain geometry and parameters, Ramachandran plot. 3. Primary, secondary, tertiary and quaternary structures. 4. Protein structure stabilizing forces – hydrogen bond, electrostatic bond or salt bridges; hydrophobic forces 5. Protein folding, dynamics and thermodynamics. 6. Protein: from gene to function. 7. Protein and diseases. 8. Some important proteins in cellular functions. Proteomics: 1. Protein cloning, expression and purification. 2. Protein chromatography systems and purification procedures – HPLC, FPLC etc. 3. Bioinformatics of protein sequences – sequence analysis, comparison, alignment etc. 4. Mass spectrometry – introduction to mass spectroscopy, gel mass spectroscopy, LC-MS, LC-MS-MS, MALDI-TOF 5. Protein NMR, FTIR Raman, CD 6. Protein Crystallography.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 17	
CSIR-Indian Institute of Chemical Biology	**CSIR-IICB**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Advanded Analytical Chemistry	**AcSIR-17-CS-AD-001**	**2**

Chemical Techniques: chromatography- general principles, classification of chromatographic techniques, normal and reversed phase, bonded phase, separation mechanisms, short-column chromatography, flash chromatography, vacuum liquid chromatography (VLC), medium pressure liquid chromatography, high pressure liquid chromatography (HPLC), TLC, HPTLC. X-RD analysis and its applications. Basic Principles of Mass Spectrometry: methods of ionization (EI, CI, FAB/LSIMS, ESI, MALDI,DART, DESI) and high resolution MS; application of MS in structure elucidation of organic molecules; basic principles and applications of GC-MS, LC-MS and high resolution MS.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 17

CSIR-Indian Institute of Chemical Biology CSIR-IICB

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Organic Chemistry	AcSIR-17-CS-AD-002	2

Stereoselective C-C bond formation: nucleophilic addition to C=X (X=C, O, S, N), pericyclic reaction–asymmetric induction in [3+2] and [2+2] cycloaddition, streoselective hydroformylation, streoselective carbene addition, chirality transfer in sigmatropic rearrangements. Named Reactions and Rearrangements: Strecker, Mannich, Biginelli, Passerini, and Ugi reactions. Baker-Venkataramana, Curtius, Schmidt, Wolf, Hofmann, and Brook rearrangements. Lactonization: Yamaguchi, Corey-Nicolaou, Heck, Masamune, Mitsunobu, and Yamamoto’s Macrolactonizations. Mukaiyama Esterification. Ring-closing metathesis (RCM) using Grubbs and Schrock catalyst, Buchwald-Hartwig C-N bond and C-O bond formations, BaylisHillman Reaction, Evans aldol reaction, Ugi-reaction, Click reaction, Corey-Bakshi-Shibata (CBS) reduction, Corey-Kim oxidation, Nozaki-Hiyama-Kishi Reaction, Payne rearrangement, Prins reaction, Japp-Klingmann reaction.

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AcSIR Academic Centre Code: 17

CSIR-Indian Institute of Chemical Biology	CSIR-IICB

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Natural Products and Drug Discovery	Course Code	Credits
		AcSIR-17-CS-AD-003	2

Occurance, isolation, chemistry and biosynthesis of mono-, sesqui- and di-terpenoids, flavonoids and alkaloids. Free radicals and Antioxidants: important free radicals in living systems, sources, chemistry and reactivity of important free radicals in biological systems, natural antioxidants of different classes. In vitro Methods: free radical determination by ESR methods, impact of singlet and triplet oxygen (importance of reactive oxygen species) in radical formation in biological systems. Steroids & Saponins: sources, biological significance and structure elucidation of saponins; and of steroids – ergosterol, stigmasterol, β- sitosterol and diosgenin, squalene biosynthesis.

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AcSIR Academic Centre Code: 17

CSIR-Indian Institute of Chemical Biology CSIR-IICB

Course 3 : Advanced Course Chemical Sciences Total Credits 6

Title:	Total Synthesis of Molecules	Course Code	Credits
		AcSIR-17-CS-AD-004	2

General concepts on various types of cycloaddition reactions, application of cycloaddition reactions in the synthesis of chiral compounds and industrially important molecules. Synthesis of complex organic molecules – planning and execution; concepts of retrosynthetic analysis; total synthesis of natural products: retrosynthesis, disconnection, synthons, linear and convergent synthesis.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-18-BS-AD-001	Advanced Pharmacology
Biological Sciences	AcSIR-18-BS-AD-002	Disease Mechanisms
Biological Sciences	AcSIR-18-BS-AD-003	Environmental Toxicology
Biological Sciences	AcSIR-18-BS-AD-004	Industrial/ Applied Microbiology
Biological Sciences	AcSIR-18-BS-AD-005	Nanobiology
Biological Sciences	AcSIR-18-BS-AD-006	Protein Science and Structural based Drug Design and Development
Chemical Sciences	AcSIR-18-CS-AD-001	Asymmetric Synthesis
Chemical Sciences	AcSIR-18-CS-AD-002	Medicinal Chemistry and Drug Discovery
Chemical Sciences	AcSIR-18-CS-AD-003	Process Chemistry
Chemical Sciences	AcSIR-18-CS-AD-004	Fluoro Organics & Agrochemicals
Chemical Sciences	AcSIR-18-CS-AD-005	Advanced Catalysis & Sustainability Chemistry
Chemical Sciences	AcSIR-18-CS-AD-006	Advanced Techniques for Structural Chemistry
Chemical Sciences	AcSIR-18-CS-AD-007	Advanced Polymers & Materials
Chemical Sciences	AcSIR-18-CS-AD-008	Advanced Materials for Energy Devices
Engineering Sciences	AcSIR-18-ES-AD-001	Advanced Environmental Engineering

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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18	CSIR-IICT	3	Advanced Course

Faculty of Study	Course Code	Course Title
Engineering Sciences	AcSIR-18-ES-AD-002	Advanced Process Engineering
Engineering Sciences	AcSIR-18-ES-AD-003	Advanced Separation Processes
Engineering Sciences	AcSIR-18-ES-AD-004	Data-driven modelling in Chemical Engineering
Engineering Sciences	AcSIR-18-ES-AD-005	Multi Phase Reactor Engineering
Engineering Sciences	AcSIR-18-ES-AD-006	Sustainable Science and Engineering

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 18

CSIR-Indian Institute of Chemical Technology	CSIR-IICT

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Advanced Pharmacology	Course Code	Credits
		AcSIR-18-BS-AD-001	2

An outline of basic ethics in animal experimentation. Common laboratory animals, handling and care, different routes of administration of drugs and euthanasia techniques. Breeding techniques, random and selective breeding. Dose calculations in animals. Animal models in pharmacology, general perspectives, selection of suitable species and strains for disease models. Detailed study of the animal models related to inflammation, arthritis and diabetes. In vitro cell culture techniques, cell counting and cell viability assays. Commonly used isolated tissue experiments, physiological salt solutions, and recording transducers. Basic principles of pharmacokinetics, Concepts related to absorption, distribution, metabolism and Elimination (ADME), Factors influencing absorption of drugs.

AcSIR Academic Centre Code: 18

CSIR-Indian Institute of Chemical Technology	CSIR-IICT

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Disease Mechanisms	AcSIR-18-BS-AD-002	2

Hall Marks of Cancer; Mechanisms of carcinogenesis (oncogenes, tumor supressors, tumor virology, chemical carcinogens) and disease progression. Mechanisms of chemoresistance and alternative strategies to overcome; Current knowledge on tumor metastasis; Emerging trends in cancer therapeutics – role of micro RNA's and stem cells. Introduction to factors affecting cardiovascular diseases; Pathophysiology, epidemiology and current therapeutic interventions related to atherosclerosis, hypertension and diabetes. An overview of central nervous system and neurophysiology; Neurocircuitry – circuitry level approach to understand Brain and Behavior, chemosensory circuit, reward circuit, learning and memory circuit (Cognitive disorders and mental retardation). An overview of disease mechanisms with specific emphasis on target development and plausible therapeutic interventions pertaining to Parkinson's and Alzheimers disease. Biology of neurogenesis and Repair mechanisms (Molecular Biology of AdultNeurogenesis, Neural Progenitor or stem cells).

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 18

CSIR-Indian Institute of Chemical Technology	**CSIR-IICT**

Course 3 : Advanced Course	**Biological Sciences**	**Total Credits 6**

Title:	**Environmental Toxicology**	**Course Code**	**Credits**
		AcSIR-18-BS-AD-003	**2**

Environmental Toxicology in present and future perspective (01 lecture), Environmental hazards (physical, chemical and biological aspects), Origin, sources and types of toxicants/pollutants; Dispersal/movement of toxicants in environmental compartments Ecotoxicology : Conventional and alternate models in toxicity assessment; Assessment of toxicity of pollutants; Absorption, distribution and storage of toxicants; Dose response relationships; Biotransformation and elimination of toxicants; Mechanisms of action of toxicants; Gene-environment Interactions. Pollution monitoring and Risk assessment: Tools for detection; Fate and transport. Hazardous waste management: Regulation, approaches and strategies.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title: Industrial/ Applied Microbiology	Course Code	Credits
	AcSIR-18-BS-AD-004	2

Introduction Industrial and environmental microbiology; Intermediate microbial metabolism for exploitation of microbes; Microbial enzymology and kinetics, Intermediate microbial metabolism; Microbial transformations; Immobilization and applications; Microbial processes for waste water management; Microbial processes for Air pollution management; Anaerobic digestion of organic solids Microbial solid waste management; Microbial fermentation; Microbial Energy Engineering; Microbial energy engineering and Biorefinery.

Course 3 : Advanced Course | **Biological Sciences** | **Total Credits 6**

Title:	Course Code	Credits
Nanobiology	**AcSIR-18-BS-AD-005**	**2**

Introduction to nanoscience and nanotechnology. Optical and electronic properties of nanoparticles. Morphologies [nanotubes and nanowires, fullerenes (buckyballs, graphene)] of nanoparticles. Semiconductor/quantum dots nanoparticles. Historical background of nanotechnology/nanoparticle in medicine. Several synthesis routes for nanoparticles (physical, chemical and biological) Several physico-chemical techniques (XRD, TEM, SEM, AFM, TGA, DSC, FTIR, UV-visible spectra etc.) and their basic principles for the characterization of nanoparticles. Surface functionalization of nanoparticles for development of nanoconjugates. Application of nanoparticles in various fields. Why nanotechnology is important in biology and medicine? Application of nanotechnology in therapeutics, diagnostics and drug delivery system. Different interaction of nanoparticales with biological system. In vitro and in vivo toxicity study of nanoparticles

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CSIR-Indian Institute of Chemical Technology	CSIR-IICT

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:		Course Code	Credits
	Protein Science and Structural based Drug Design and Development	AcSIR-18-BS-AD-006	2

Biochemistry and engineering of proteins, protein structure, structural motifs in functional regulation, methods of structure determination by NMR and crystallography, enzyme inhibitor complexes, structure based inhibitor design, modeling and bioinformatics. Enzymes: Mechanism of Catalysis, Kinetics & Regulation Protein Methods: Protein separation and purification Methods Practical Training to protein separation/detection using Western blotting, Protein structure: methods of crystallization, X-ray data collection, structure determination and analysis.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

CSIR-Indian Institute of Chemical Technology **CSIR-IICT**

Course 3 : Advanced Course **Chemical Sciences** **Total Credits 6**

Title:	Course Code	Credits
Asymmetric Synthesis	**AcSIR-18-CS-AD-001**	**2**

Strategies for the preparation of optically pure compounds; Asymmetric synthesis; Synthesis of complex organic molecules:-planning and execution; Total synthesis of natural products.

AcSIR Academic Centre Code: 18

CSIR-Indian Institute of Chemical Technology CSIR-IICT

Course 3 : Advanced Course Chemical Sciences Total Credits 6

Title:	Medicinal Chemistry and Drug Discovery	Course Code	Credits
		AcSIR-18-CS-AD-002	2

Difference between conventional and medicinal chemistry; Terminology/language of medicinal chemistry, Privileged and undesired functional groups, Selectivity vs. Efficacy; Different class of drugs & targets; Drug Design and Discovery: Definition, purposes and factors governing of drug design, Interpretation of SAR of small molecules; Drug Development: Objectives, Pharmacophore, Patterns and SAR of drug development from natural sources, Modification synthetic analogues; Drug Design for Pharmacokinetcs Problems: Metabolic blockers, Prodrugs, Chemistry and Rapid Parallel Syntheses: Introduction, various drug discovery processes, design and synthesis of NCEs, combinatorial syntheses on drug discovery.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 18

CSIR-Indian Institute of Chemical Technology	CSIR-IICT

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Process Chemistry	AcSIR-18-CS-AD-003	2

Introduction, Synthetic strategy Stages of scale up process: Bench, pilot and large scale process. In-process control and validation of large scale process. Application of biocatalysis in process chemistry; Case studies of some scale up process of APIs. Impurities in API, types and their sources including genotoxic impurities; Regulatory affairs, QBD.

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AcSIR Academic Centre Code: 18

CSIR-Indian Institute of Chemical Technology CSIR-IICT

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Fluoro Organics & Agrochemicals	AcSIR-18-CS-AD-004	2

Importance of fluorine chemistry, Strategies to introduce fluorine/ trifluoromethyl group into organic molecules, Preparation of fluorinated reagents, Preparation of fluorinated carbon materials and their uses, Known fluorinated drugs and their mode of action, Biochemistry in agriculture, guidelines on agricultural crops micronutrients and fertilizers, Chemistry of pesticides, synthesis, formulations, mode of action, toxicology, resistance and residual analysis, Methodologies for the synthesis of agrochemicals and other relevant organic molecules, chemistry in Integrated Pest Management, Semiochemicals, insect growth regulators, botanical pesticides and other biotechnological approaches, Analysis of agrochemicals and residues - Botanical pesticides, hormones, pheromone, kairomones and plant volatiles.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 18

CSIR-Indian Institute of Chemical Technology CSIR-IICT

Course 3 : Advanced Course	**Chemical Sciences**		**Total Credits 6**
Title: **Advanced Catalysis & Sustainability Chemistry**		**Course Code**	**Credits**
		AcSIR-18-CS-AD-005	**2**

Basic of Organometallic chemistry, Organometallic Catalysis, Olefin Isomerization, C-C Coupling reactions: Heck, Suzuki, Stille and Sonogashira reactions, Alkene and Alkyne Metathesis, C-Heteroatom coupling: Hydroamination, Olefin Oxidation, C-H activation, Oxidation reactions, hydrogenation of Alkenes, Homogeneous and heterogeneous catalytic reactions: hydrogenation, hydrogenolysis, dehydrogenation, selective oxidation, alkylation & acylation, isomerization and C-C bond forming reactions, Enzyme catalysis in organic synthesis; Reaction mechanisms, nanomaterials and metal organic frame work in catalysis, Concept of atom economy and green chemistry, Catalysis in the utilization of renewable feed stocks and concepts of sustainable chemistry, understanding catalysis in biomass refining, Case study of catalysis in chemicals, coal and petrochemicals.

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AcSIR Academic Centre Code: 18

CSIR-Indian Institute of Chemical Technology	CSIR-IICT

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Advanced Techniques for Structural Chemistry	Course Code	Credits
		AcSIR-18-CS-AD-006	2

NMR Spectroscopy: 2D NMR, 1H-1H correlations, Heteronuclear Correlation Spectroscopy, 2D Exchange (EXSY), 2D NOESY, ROESY, DOSY Structure elucidation of small molecules, NMR of macromolecules, Multidimensional NMR Spectra, NMR Spectroscopy of Solids, 2D experiments in solids, semi rigid systems: HR MAS, Magnetic Resonance Imaging: In Vivo NMR, Imaging, MRI, functional MRI, NMR imaging of materials. Mass Spectroscopy-Applications to analyze molecular, macromolecular and biological samples, Sample Preparation Protocols, Drug Metabolism and Pharmacokinetics (DMPK), Development of Quantitative analytical methods using mass spectrometry, Application to some model drugs, Metabolomics, Proteomics, GC-MS, LC-MS, MALDI-TOF, GC-TOF, TOF/TOF MS, LC-ESI-MS, Protein Database search (MASCOT), X-ray Crystallography: Crystal growth, evaluation and mounting, Symmetry and space group determination, Crystal lattices, Structure factors, Crystal symmetry, Structure solutions, Structure refinement, An introduction to maximum entropy, Least squares fitting of parameters, Practical aspects of structure refinement, Crystallographic Database, Structure solution from Powder Diffraction Data.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 18			
CSIR-Indian Institute of Chemical Technology			CSIR-IICT
Course 3 : Advanced Course	Chemical Sciences		Total Credits 6
Title: Advanced Polymers & Materials		Course Code	Credits
		AcSIR-18-CS-AD-007	2

Advanced Polymerization techniques like Controlled or Living Radical Polymerization, ATRP, RAFT, NMP, ROMP, living ROP, Macromolecular architectures using controlled living polymerizations, polymer nano-architectures, random and block copolymers, Liquid Crystalline Polymers, Conducting Polymers, Non-linear Polymers, Polymer Blends and Composites, polymer rheology, Nature of supramolecular interactions, role of various non-covalent interactions, ,dimensions of supramolecular chemistry, Janus molecules. Photoresponsive molecules and self-assembly, Molecular recognition, classification of supramolecular host-guest complexes, supramolecular self-assembly, supramolecular polymers, low molecular weight organogels. Characterization techniques of self-assemblies and supramolecular sensors. Biomaterials for biomedical implants, coatings, wound dressings, sutures, cardiovascular devices, ophthalmology, dentistry, orthopedics and cosmetic surgeries, drug delivery and tissue engineering, Some concepts for design development of common biomaterials. Application of XPS, Xray diffraction, AFM TEM, HRTEM, SEM, STEM, EDX, Raman, Thermal and Electrical measurements for advanced materials.

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AcSIR Academic Centre Code: 18		
CSIR-Indian Institute of Chemical Technology		CSIR-IICT
Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Materials for Energy Devices	AcSIR-18-CS-AD-008	2

Energy scenario, emissions and global warming, Approaches to process organic semiconductors by covalent and non-covalent modifications, band edges and band gaps, Electron transfer at interfaces, Fabrication of organic and dye solar cell Devices, Device characterization using dark current, IV curves under illumination, IPCE, Calculation of Voc, Jsc, Vpp, Ipp, FF and Pmax., Design, Strategy and Synthesis of dyes, small organic molecules for solar cells, application of nanomaterials in third generation solar cells, solar inks and paints, use of coatings and adhesives in solar cells, Organic and inorganic sensing materials, organic fluorescence and phosphorescence materials, organic semiconductors and transistors, fuel cells, materials and polymers for electrolytes, organic, inorganic and polymeric hole transport materials, materials for super capacitors and batteries, Li, Na and Mg ion batteries- development and challenges, batteries vs super capacitors, conducting polymers for energy generation and storage.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 18

CSIR-Indian Institute of Chemical Technology	**CSIR-IICT**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Advanced Environmental Engineering	**AcSIR-18-ES-AD-001**	**3**

Environmental Chemistry, Physico-chemical Processes, Biological Processes in Environmental Engineering, Solid and Hazardous Waste Management, Air and Noise Pollution and Control.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 18

CSIR-Indian Institute of Chemical Technology CSIR-IICT

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Advanced Process Engineering	Course Code	Credits
		AcSIR-18-ES-AD-002	2

Process Route Selection Process Flow sheeting Process optimization Process Equipment Design Advanced Process Engineering Concepts

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 18

CSIR-Indian Institute of Chemical Technology	CSIR-IICT

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Advanced Separation Processes	Course Code	Credits
		AcSIR-18-ES-AD-003	3

Fundamentals of Separation Processes Binary Separation Processes Multi¬component Separation Processes Rate Based Separations Hybrid Separations Reactive Separations.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 18

CSIR-Indian Institute of Chemical Technology CSIR-IICT

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Course Code	Credits
Data-driven modelling in Chemical Engineering	AcSIR-18-ES-AD-004	2

Introduction to data-driven models for prediction and dimensionality reduction (linear methods : regression models, principle component analysis, partial least squares); (nonliear methods : Nonlinear regression analaysis, Artificial neural networks); Introduction to data-driven models for classification and clustering (linear methods : nearest neighbourhood method, fisher discriminant analysis) (nonliear methods : Artificial neural networks, self organising maps, suppot vector machines); Application examples of data-driven modelling in chemical engineering.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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CSIR-Indian Institute of Chemical Technology	**CSIR-IICT**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:		Course Code	Credits
	Multi Phase Reactor Engineering	**AcSIR-18-ES-AD-005**	**3**

Overview on Multi Phase Reactor Engineering: Hydrodynamics Characteristics of different Multi Phase Reactors: Design and Scale-up of Multi Phase Reactors: Advanced reaction engineering, mass transfer, momentum transfer.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

CSIR-Indian Institute of Chemical Technology	CSIR-IICT

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Sustainable Science and Engineering	AcSIR-18-ES-AD-006	2

Introduction- Anthropocene, Sustainability, Natural Capital, Fossils Resources, Environment and Society, Un-sustainability.
Sustainability Assessment- Carbon footprints, Metabolism Studies, Material Flow Analysis, Exergy/Emergy Analysis, Life Cycle Assessment (LCA).
Achieving Sustainability- Systems Thinking, Sustainable Production/Consumption, Design of Sustainable Processes and Products, Circular Economy, Renewable Feedstock, Bioeconomy, Low Carbon Economy, Biobased Products, Industrial Ecology and Symbiosis, Urban Ecology, Nature based Solutions, Biomimicry. Project (T)

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

19 CSIR-IIP 3 *Advanced Course*

Faculty of Study	Course Code	Course Title
Chemical Sciences	AcSIR-19-CS-AD-001	Biocatalysis and Bioprocessing
Chemical Sciences	AcSIR-19-CS-AD-002	Carbon Recycling and Management
Chemical Sciences	AcSIR-19-CS-AD-003	Catalysis
Chemical Sciences	AcSIR-19-CS-AD-004	Combustion and Emissions
Chemical Sciences	AcSIR-19-CS-AD-005	Lubricants and Tribology
Chemical Sciences	AcSIR-19-CS-AD-006	Organic Chemistry
Chemical Sciences	AcSIR-19-CS-AD-007	Refinery processes
Chemical Sciences	AcSIR-19-CS-AD-008	Separation Science and Process
Engineering Sciences	AcSIR-19-ES-AD-001	Process Control
Engineering Sciences	AcSIR-19-ES-AD-002	Thermodynamics, Kinetics and System Design of Chemical Reactions

AcSIR Academic Centre Code: 19

CSIR-Indian Institute of Petroleum | CSIR-IIP

Course 3 : Advanced Course | Chemical Sciences | Total Credits 6

Title:	Course Code	Credits
Biocatalysis and Bioprocessing	AcSIR-19-CS-AD-001	2

Microbiology and Biochemistry: Biology of the prokaryotes, Microbial biochemistry : central metabolic pathway, metabolomics,Microbial genetics, Microbial bioinformatics and genome evolution. Bioprocess and Biocatalvsis: Enzymology : correlating biocatalysts with chemical catalysts, Engineering novel proteins, Fermentation microbiology, Media for industrial fermentation. Design of a fermenter : Instrumentation and control of a fermcenter, Aeration and agitation, Downstream processing.Case Studies: Cellulase for biomass saccharification, Alcohol fermentation, Large scale production of enzymes and antibiotics.

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Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 19			
CSIR-Indian Institute of Petroleum			**CSIR-IIP**
Course 3 : Advanced Course	**Chemical Sciences**		**Total Credits 6**

Title:	Carbon Recycling and Management	Course Code	Credits
		AcSIR-19-CS-AD-002	2

Introduction:Sources of carbon, renewable carbon, Importance of carbon recycling &Energy supply, Carbon Capture:C02 Capture from the environment and Industrial off gases,Carbon Recycling for Renewables, domestic and industrial wastes Plastics, Municipal solid waste, biogas, methane, biomass, and bio char.

Utilization Strategies and Management: Methanol production, Syngas production,Formic acid production, Inorganic & organic carbonates, specialty chemicals from gas fermentation, Sustainability Aspects and Indian scenario.

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AcSIR Academic Centre Code: 19

CSIR-Indian Institute of Petroleum	CSIR-IIP

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title: Catalysis	Course Code	Credits
	AcSIR-19-CS-AD-003	2

Introduction and Basic concept of catalysis. Selection and design and Preparation of catalysts. Catalytic Materials - Metal Oxides (Supported Catalysts). Fundamentals of Catalyst Preparation. The importance solid acids in industrial catalysis. Factors governing the activity of solid acids. Acid strength requirement for various reactions. The parameters of acid site density and strength of acid sites. In built vs functionlized active sites;
chlorinated and sulphonated solid acids: activity vs limitations. Textural Properties of solid catalysts. Characterization of catalysts. Zeolite catalysts. preparation. characterization and applications. Recent trends in solid acid applications for industrial catalysis and environmentally benign catalytic, processes. Shaping of catalysts and role of inert binders. Attrition resistance and crushing strength parameters of extrudates for industrial applications, Optimal distribution of catalyst in a pellet.
Nano catalysis: Concepts and Advantages of nanocatalystsDifferent approach to prepare nanocatalysts, Detailed Characterization of nanocatalysts, Application of nanocatalysts in various reactions.
Photocatalysis: Thermodynamics of photocatalysis, quantum yield. Kinetics for photocatalysis, Photocatalysis at metals, oxides and semiconductors: concepts, discoveries and
applications. Sensitization of photocatalysis and photosplitting of water. Advances in design, preparation and characterization of photocatalysts: oxides. chalcogenides, semiconductors, layered materials, porous materials, artificial photosynthesis. Environmental Photocatalysis: water purification, organic degradation by photocataly sts. self cleaning photocatalysts. airborne pollutant degradation, reactors for photocatalysis. Photoelectrochemistry: storage and synthetic cells, energy generation, cell design, photoprocesscs at electrodes.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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Title:	Course Code	Credits
Combustion and Emissions	AcSIR-19-CS-AD-004	2

Fundamentals of Combustion; Stoichiometry, Adiabatic Flame Temperature; Non-premixed and Premixed, Combustion; Ignition Energy, Applications of Combustion,Thermodynamic Cycles. Engine Performance Parameters Diesel Combustion; Gasoline/SI Combustion Advanced Combustion Concepts, Emission formation; Emission standards; Emission reduction technologies Emission measurement methods, Implications of fuel chemistry on engine performance, Fuels for SI engines; Fuels for CI engines; Biofuels Combustion diagnostics. Mie Scattering: Shadowgraph, PLIF, LII.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 19

CSIR-Indian Institute of Petroleum | CSIR-IIP

Course 3 : Advanced Course | Chemical Sciences | Total Credits 6

Title:		Course Code	Credits
	Lubricants and Tribology	AcSIR-19-CS-AD-005	2

Basic Principles of Lubrication: Stribeck Curves, Hydrodynamic lubrication. Hydrostatic lubrication, elastohydrodynamic lubrication, Boundary and extreme pressure lubrication Lubricants: Classification of Lubricants, Lubrication chemistry: Types of Lubricants and their Compositions. Lubricants in the tribological system, Lubricant formulation, Additives Chemistry, Technology, and Commercial Importance. Lube Base Oils: Classification, Mineral lubes, biolubricants and synthetic lubes; Lubricant Additives:Antioxidants, Dispersants. Detergents, VI Improvers, Pour Point Depressants, Rust and Corrosion Inhibitors, Friction-modifiers, Anti-Wear

Agents and Extreme Pressure Additives, Multi-functional additives; Lubricant Additives: Synergistic Environmental Implications and Sustainability

Concepts of Lubricants; Lubricant Properties and Test Methods, Mechanical-dynamic test methods for lubricants, Test confidence and correlation with

service, Molecular Modeling, Material studio Surface Chemistry/Engineering: Thin films,Tribo-chemical nature of antiwear films, Surface

chemistry of tribo-activated processes. Molecular architecture at solid-liquid interfaces, adhesion on the nano-scale, Langmuir monolayer, supramolecular organic layer, wetting and capillary phenomena at nanometer scale, Normal forces at the atomic scale. Understanding of lateral forces.

Dissipation mechanisms: Nano-rheology and nanoconfinement. Greases: Fundamental, types, composition, micro structure and applications

Industrial Tribology: Tribology of elastomers. Tribology of miniature systems, Tribology of Hard.

Disk Drives — Magnetic Data Storage Technology, Tribology of thin layers, Tribology of plastic materials, Rolling bearing types and applications,

Lubricant films in rolling element-racew contacts. Friction in rolling bearings, Lubricant in rolling bearings.

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AcSIR Academic Centre Code: 19

CSIR-Indian Institute of Petroleum	CSIR-IIP

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Organic Chemistry	AcSIR-19-CS-AD-006	2

Chemistry of Carbohydrates Classification of carbohydrates, reducing and non-reducing sugars, General Properties of Glucose and Fructose, their open chain structure, Epimers, mutarotation and anomers, Determination of configuration of Glucose (Fischer proof). Cyclic structure of glucose. Haworth projections. Cyclic structure of fructose. Linkage between monosaccharides, structure of disaccharides (sucrose, maltose, lactose) and polysaccharides
(starch and cellulose) excluding their structure elucidation Chemistry of Peptides: Classification of Ammo Acids. Zwitter ion structure and Isoelectric point. Overview of Primary, Secondary structure, Determination of Primary structure of Peptides, determination of N-terminal amino acid (by DNFB and Edman method) and C-terminal amino acid (by thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by Nprotection (tbutyloxycarbonyl and phthaloyl) & Cactivating groups and Merrifield solid phase synthesis. Recombinant method of peptide synthesis. Carbon dioxide: capture, storage and its utilization: Chemistry of carbon dioxide. Chemicals denved from C02. conversion of CO to fuels.reaction mechanism. Applications. Green chemistry and its role in sustainability: Definition, Principles, E-factor Atom efficiency, Examples of green chemistry, Dimethyl carbonate as a green reagent, Applications of green chemistry in organic transformations. Corrosion chemistry and inhibition Fundamentals of corrosion, forms of corrosion, corrosion rate and monitoring techniques, effect of environmental variables, corrosion inhibitors classification, and orrosion inhibition mechanism, Organometallic complexes and Catalysis. Overview Bonding in organometallic compounds. Reactions in organometallic compounds, Reaction mechanism. Applications of organometallic compounds in organic synthesis. Carbonyl complexes. Applications of organometallic complexes, Industnal processes and available technologies Macromolecules Types of polymers, regular and irregular polymers, synthesis of polymers by chain and step reactions, physical properties of solid polymers (crystallinity, plasticity and elasticity), vulcanization of rubbers. molecular mass determination by osmometry, viscometer, light scattering and ultracentrifuge methods, number and mass average molecular masses, polymer solutions. factors affecting the solubility of polymers, conducting polymers, doping of polymers, mechanism of conduction, Hydrocarbon Chemistry: C1-Chemistry, Petrochemicals from n-paraffins, Petrochemicals from olefins and aromatics.

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AcSIR Academic Centre Code: 19

CSIR-Indian Institute of Petroleum	CSIR-IIP

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Refinery processes	AcSIR-19-CS-AD-007	2

Refinery processes for gasoline production Gasoline properties: Octane number, combustion and emission properties, Lead phase down, octane requirement. Octane enhancing refinery processes. Catalytic reforming, light paraffin isomerization, alkylation. Properties of FCC naphtha and selective processes for S and olefin reduction sustain octane. Unconventional processes. Hydroprocessing Basics: Hydroprocessing Reactions. Kinetics, Catalysts for hydroprocessing reactions. hydroprocessing Applications and its Practical Aspects Hydroprocessing Unit, Operation Examples and Exercises. Troubleshooting Real-Life Case Studies and problems, atalyst Selection: Economic Evaluation of Catalyst Selection Catalyst pilot plant testing for catalyst selection Heavy oil processing Chemistry of Crude oil. Thermal cracking. Visbreacking. Coking. Hydro cracking. Refinery Petrochemical Integration.

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AcSIR Academic Centre Code: 19

CSIR-Indian Institute of Petroleum	CSIR-IIP

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Separation Science and Process	AcSIR-19-CS-AD-008	2

Distillation: Basics and theory of distillation, dew point, bubble point, reboiler and non-reboiler distillation, type of distillation operations, batch and continuous distillation, steam distillation, binary and multicomponent distillation, azeotropic distillation, extractive distillation, choice of distillation, Solvent Extraction: Salient features, extraction verses distillation, different Kind of solvents-organic solvents, Ionic liquid solvents, criteria of solvent selection, thermodynamic fundamentals in extraction, liquid-liquid equilibria, vapor-liquid equilibrium, activity coefficient, ternary diagram, continuous phase, dispersed phase, criteria for disperse phase selection, separation factor, selectivity, distribution coefficient, performance factor, industrial usability index. Batch and continuous extraction theory and operation and challenges, Solvent extraction applications in refinery and petrochemicals aromatics production, aromatic removal, sulfur removal, solvent extraction as complimentary process. Adsorption and membrane: Special Topics in Adsorption: Adsorbents; Equilibrium Isotherms; PSA / TSA Applications in Industry; Concepts of Simulated Moving Bed in Industrial Applications; New Developments in Adsorbents; Adsorber simulations; Experiments in Adsorption: Breakthrough curve measurement with gas mixtures: Adsorption equilibria in liquid systems: evaluation of equilibrium and kinetics data: Characterization of adsorbents. Overview of Membrane Separation Processes Gas separation membranes and Industrial applications. Absorption: Principles of absorption; Equilibrium relation between phases; Single and multiple equilibrium contact stages; Mass transfer between phases; Absorption in plate and packed tower; Estimation of mass transfer coefficient. Absorption with chemical reaction.

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AcSIR Academic Centre Code: 19

CSIR-Indian Institute of Petroleum | CSIR-IIP

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Process Control	AcSIR-19-ES-AD-001	2

PART I: THE CONTROL OF A CHEMICAL PROCESS: ITS CHARACTERISTICS AND THE ASSOCIATED PROBLEMS
CHEMICAL PROCESS CONTROL BENIFITS: Mitigating the Influence of External Disturbances, Ensuring the Stability of a Process, Optimizing the Performance of a Chemical Process
DESIGN ASPECTS OF A PROCESS CONTROL SYSTEM: Classification of the Variables in a Chemical Process, Elements of the Design of a Control System, The Control Aspects of a Complete Chemical Plant

PART II: MODELING THE DYNAMIC AND STATIC BEHAVIOR OF CHEMICAL PROCESSES
THE DEVELOPMENT OF A MATHEMATICAL MODEL: The Need for Mathematical Modelling in Process Control? State Variables and State Equations for a Chemical Process, Additional Elements of the Mathematical Models, Dead-Time, Additional Examples of Mathematical Modelling, Modelling Difficulties
MODELING CONSIDERATIONS FOR CONTROL PURPOSES: The Input-Output Model, Degrees of Freedom, Degrees of Freedom and Process Controllers, Formulating the Scope of Modelling for Process Control

PART III: ANALYSIS OF THE DYNAMIC BEHAVIOR OF CHEMICAL PROCESSES
COMPUTER SIMULATION AND THE LINEARIZATION OF NONLINEAR
SYSTEMS: Computer Simulation of Process Dynamics, Linearization of Systems With One Variable , Deviation Variables , Linearization of Systems With Many Variables
TRANSFER FUNCTIONS AND THE INPUT-OUTPUT MODELS: The Transfer Function of a Process with a Single Output, The Transfer Function Matrix of a Process with Multiple Outputs, The Poles and the Zeros of a Transfer Function, Qualitative Analysis of the Response of a System
THE DYNAMIC BEHAVIOR OF FIRST-ORDER SYSTEMS: What is a First-Order System?, Processes Modelled as First-Order Systems, The Dynamic Response of a Pure Capacitive Process, The Dynamic Response of a First-Order Lag System , First-Order Systems with Variable Time Constant and Gain .

PART IV: ANALYSIS AND DESIGN OF FEEDBACK CONTROL SYSTEMS
INTRODUCTION TO FEEDBACK CONTROL: The Concept of Feedback Control, Types of Feedback Controllers , Measuring Devices (Sensors), Transmission Lines , Final Control Elements
THE DYNAMIC BEHAVIOR OF FEEDBACK CONTROLLED PROCESSES: Block Diagram and the Closed-Loop Response, The Effect of Proportional Control on the Response of a Controlled Process, The Effect of Integral Control Action, The Effect of Derivative Control Action, The Effect of Composite Control Actions
STABILITY ANALYSIS OF FEEDBACK SYSTEMS The Notion of Stability, The Characteristic Equation, The Routh-Hurwitz Criterion for Stability; The Root-Locus Analysis

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AcSIR Academic Centre Code: 19

CSIR-Indian Institute of Petroleum	**CSIR-IIP**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:		Course Code	Credits
	Thermodynamics, Kinetics and System Design of Chemical Reactions	**AcSIR-19-ES-AD-002**	**2**

Kinetics of Homogeneous Reactions; Concentration-Dependent Term of a Rate Equation, Temperature-Dependent Term of a Rate Equation, Searching for a Mechanism, Predictability of Reaction Rate from Theory

Introduction to Reactor design: Interpretation of Batch Reactor Data, Ideal Reactors for a Single Reaction, Ideal Batch Reactors, Performance equations for Steady-State Mixed Flow Reactors and Plug Flow Reactors, Design for Single and multi-reaction systems

Temperature and Pressure Effects - Single Reactions and Multiple Reactions, Choosing the Right Kind of Reactor

Basic concepts of chemical Thermodynamics: Application of thermodynamic Laws to real processes, Entropy, Enthalpy and basic thermodynamic relations, Gibbs and Helmholtz free Energy, Gibbs Energy as a generating Function

Sensible Heat Effects, Latent Heats of Pure Substances, Standard Heat of reaction, Standard Heat of Formation, Standard Heat of Combustion, Temperature Dependence of ΔHo, Heat Effects of Industrial Reactions .

Chemical reaction equilibrium; reaction co-ordinate; equilibrium criteria for chemical reactions; equilibrium constant and the effect of temperature; temperature and pressure effects on conversion; Duhem’s theorem for reacting systems; simple examples of multi-reaction equilibrium.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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20	CSIR-IMTech	3	Advanced Course

Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-20-BS-AD-001	Advanced Biochemical Engineering
Biological Sciences	AcSIR-20-BS-AD-002	Advanced Bioinformatics
Biological Sciences	AcSIR-20-BS-AD-003	Biology of Tuberculosis
Biological Sciences	AcSIR-20-BS-AD-004	Bio-methodology of Laboratory Animals
Biological Sciences	AcSIR-20-BS-AD-005	Frontiers of Biology: Synthetic Biology
Biological Sciences	AcSIR-20-BS-AD-006	Metagenomics

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 20		
CSIR-Institute of Microbial Technology		CSIR-IMTech
Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title: Advanced Biochemical Engineering	Course Code	Credits
	AcSIR-20-BS-AD-001	2

Bioreactions – Cell growth and product formation kinetics, growth associated, non-growth associated and mixed-growth associated product formation, cell growth and product formation models – quantitative review of biochemistry, metabolism and metabolic engineering, engineering aspects of microbial process and bioconversions – Bioreactors – Design of bioreactors – kinetic analysis, packed bed bioreactor, Fluidized bed batch, fed-batch and continuous culture – Bioprocess development – Exploitation of genetic engineering and bioprocess development, Plant cell culture, Mammalian cell culture, Enzyme technology – Downstream processing – Purification and separation technology, integrated bio separation schemes – Case studies – Production of protein pharmaceuticals as a paradigm of the application of biochemical engineering to advanced process development within the frame work of current business and regulatory requirements – Chemicals from biomass

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AcSIR Academic Centre Code: 20

CSIR-Institute of Microbial Technology CSIR-IMTech

Course 3 : Advanced Course | Biological Sciences | Total Credits 6

Title:	Course Code	Credits
Advanced Bioinformatics	AcSIR-20-BS-AD-002	2

Computer Software - Concept of LAMP (Linux, Apache MySQL and PERL) learning. Introduction to Linux. Installation of Linux; Basic and advance Linux commands. Editors (vi, emacs). Software installation and configuration; Introduction to Apache. Configuration of Apache. Launching of web site using Apache; Introduction of HTML. Development of web sites; Concept of common gateway interface (CGI). Concept of FORMS in HTML. Introduction to MySQL. Development of Databases using MySQL. Introduction to PERL. Example PERL programs. Handing FASTA files. Program for calculating amino or nucleotide composition of sequences – Algorithms - Algorithms and techniques used for developing programs for biological problems. Quantitative matrices. Introduction to Machine Learning Techniques. Artificial Neural Network. Support Vector Machine. Hidden Markov Model. Example-based leanings. Major Software for implementing algorithms (SVM_light; SNNS; HMMER; Weka). Introduction to R: Introduction to R. Installation of R. Description of R environment. Using R
interactively. Getting help with functions. Assigning variables. Arrays and vectors. Functions on vectors. Using R commands from terminal. Reading data from files. Programming in R. - Bioinformatics Software for Annotation of Proteins - Important of annotation of proteins. Classification of protein annotation methods. Protein Sub-cellular Localization (amino acid, dipeptide, split-amino acid ncomposition). Prediction of Antigenic regions in proteins (motif, matrix and ANN based methods). Secondary structure prediction (probability, segment, evolutionary approaches). DNA/RNA interacting residues in proteins (binary,

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AcSIR Academic Centre Code: 20

CSIR-Institute of Microbial Technology CSIR-IMTech

Course 3 : Advanced Course Biological Sciences Total Credits 6

Title: Biology of Tuberculosis	Course Code	Credits
	AcSIR-20-BS-AD-003	2

Introduction to TB & A historical prospective of TB - Diagnosis of TB- development of Tuberculosis Vaccines - Treatment of tuberculosis-Drugs under development - Experimental animal models of tuberculosis - Molecular evolution of Mycobacterium - Ultra-structure and Biochemistry of mycobacterial cell- Lipids of mycobacterium- Structure, biosynthesis and biological activity - Redox homeostasis in Mycobacterium - Latency of mycobacterium- An overview of latency and mechanisms involved in persistence - Hypoxia and NO-A window to persistence of mycobacterium - Mechanism of signal transduction in mycobacterium. Serine-threonine kinases and two component proteins of mycobacterium - Transcription machinery of mycobacterium-Sigma factors and their role in the virulence of mycobacterium - Experimental Genetics of Mycobacterium - Interaction of Mtb with macrophages - Immunopathology of TB.

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AcSIR Academic Centre Code: 20

CSIR-Institute of Microbial Technology CSIR-IMTech

Course 3 : Advanced Course Biological Sciences Total Credits 6

Title:	Bio-methodology of Laboratory Animals	Course Code	Credits
		AcSIR-20-BS-AD-004	2

Basics of biology and husbandry practices of small laboratory animals (mouse, rat, hamster, guinea pig, rabbit etc) Regulatory guidelines of CPCSEA/IAEC, record keeping, animal welfare, planning animal experiments, breeding of laboratory animals, environmental enrichment, animal feed and nutritional requirement, experimental techniques viz. handling, sexing, injections/immunization, blood collection, anaesthesia, humane end points in animal experiments and euthanasia, surgical techniques, pre and post-operative care, biosafety and occupational hazards diseases of laboratory animals, genetic and health monitoring of animals, biostatistics in animal research.

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AcSIR Academic Centre Code: 20

CSIR-Institute of Microbial Technology	**CSIR-IMTech**

Course 3 : Advanced Course	**Biological Sciences**	**Total Credits 6**

Title:	**Course Code**	**Credits**
Frontiers of Biology: Synthetic Biology	**AcSIR-20-BS-AD-005**	**2**

Introduction to synthetic biology – Biobricks/parts, devices, systems – Peptide and protein building blocks for synthetic biology – reconstruction of genetic circuits, logic gates – application of synthetic biology – in medicine, energy, environment etc – Future perspectives – Major ongoing and international initiatives – Methods for large scale reconstruction of parts/ metabolic pathways.

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AcSIR Academic Centre Code: 20

CSIR-Institute of Microbial Technology	CSIR-IMTech

Course 3 : Advanced Course	Biological Sciences	Total Credits	6

Title:	Course Code	Credits
Metagenomics	AcSIR-20-BS-AD-006	2

Introduction to metagenomics, challenges, functional applications - A typical metagenomic study - eg. human distal gut microbiome Metagenomic library preparation and sequencing - Metagenomicassembly basics - Metagenomic gene identification, metabolic reconstruction - Genome variations, Detecting genome variations in metagenomic data, Quasi species detection Community and comparative metagenomics - Amplicon sequencing and Gene Targeted (GT) metagenomics - Strategies for enrichment, functional screens – Bioprospecting metagenomes for novel enzymes - Metatranscriptomics and metaproteomics.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-22-BS-AD-001	Environmental Toxicology
Biological Sciences	AcSIR-22-BS-AD-002	Gene Environment Interactions
Biological Sciences	AcSIR-22-BS-AD-003	Target and Non- Target Organ Toxicity
Chemical Sciences	AcSIR-22-CS-AD-001	Advanced analytical Instrumentations
Chemical Sciences	AcSIR-22-CS-AD-002	Principles and Applications of Organic Spectroscopy
Chemical Sciences	AcSIR-22-CS-AD-003	Green Chemistry and its Applications

CSIR-Indian Institute of Toxicology Research	CSIR-IITR

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Environmental Toxicology	AcSIR-22-BS-AD-001	3

Environmental Toxicology in present and future perspective; Environmental hazards (physical, chemical and biological aspects); Origin, sources and types of toxicants/pollutants; Dispersal/movement of toxicants in environmental compartments; Conventional and alternate models in toxicity assessment; Assessment of toxicity of pollutants; Absorption, distribution and storage of toxicants; Dose response relationships; Biotransformation and elimination of toxicants; Mechanisms of action of toxicants; Gene-environment Interactions Pollution monitoring and Risk assessment; Tools for detection; Fate and transport Hazardous waste management; Regulation, approaches and strategies; Mitigation of environmental pollutants; Physico-chemical and biological processes In vitro: Basics and principles of cell and tissue culture; primary cell cultures, cell lines, stem cells. In vivo: Bacteria, Yeast, Paramecium, Tetrahymena, Caenorhabditiselegans, Drosophila, Daphnia, Tubifex, Snail, Zebrafish, mammalian models. In silico: Basics of QSAR and modelling of macromolecules Practicals: Xenobiotics exposure/effect assessment using alternate animal models; Case histories/studies and new concepts or topics will be interactively discussed; Case studies: real-life contaminated sites/ecological settings/industry in and around Lucknow.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

Course 3 : Advanced Course **Biological Sciences** **Total Credits 6**

Title:	Course Code	Credits
Gene Environment Interactions	**AcSIR-22-BS-AD-002**	**3**

An introduction to abiotic stress, effect of temperature and pollutants on the gene expression, recent advances in organismal responses to abiotic stresses; Current tools to measure environmental exposures/pollutants; Effect of environment and methods to detect genetic variation; Genes, environment and neurodegenerative diseases; Genes, environment and cancer; Genes, environment and asthma and allergy; Genes, environment and reproductive diseases.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 22

CSIR-Indian Institute of Toxicology Research CSIR-IITR

Course 3 : Advanced Course | Biological Sciences | Total Credits 6

Title:	Course Code	Credits
Target and Non- Target Organ Toxicity	AcSIR-22-BS-AD-003	3

Introduction to the discipline of toxicology and basic concepts essential for understanding the action of exogenous agents on biological systems; Principles underlying the absorption, distribution, metabolism, and elimination of chemicals. Toxicokinetics, specific classes of toxic responses, and experimental methods used to assess toxicity; ethics in toxicological studies, Regulatory toxicology. Target Organ Toxicity : Overview: Types of injury that may be produced in specific mammalian organs and organ systems by exposure to chemical toxicants; Neurotoxicity and its mechanisms: Concepts in neuropharmacology and neurophysiology; Neurogenesis; Neuro-behavioral toxicology; Chemical induced neurodegeneration and neuroprotection/neuroregeneration; Hepatotoxicity: Overview; Effect of xenobiotics on liver; Regulatory mechanism involved in hepatotoxicity; Nephrotoxicity: Renal structure and function; Chemical induced renal injury; Pulmonary toxicity: Structure and function of the respiratory system with emphasis on lungs; Systemic lung injuries; Immunotoxicity: Basics of the immune system; Mechanisms of immunotoxicity; Immunosensitization and allergy; Endocrine and reproductive toxicity: Teratogenicity; Reproductive organs and chemicals affecting reproduction; Endocrine system and chemical induced endocrine disruption Non-target organ toxicity: Epigenetics, genotoxicity and developmental toxicity Chemical Carcinogenesis: Past, Present and Future, Genetic and Epigenetic Mechanism of Carcinogenesis, Models, Mechanism and Etiology of Cancer, Role of Oncogenes in Cancer Development, Cell Transformation and Apoptosis,Mutation and Cancer, Targeted Drug Delivery in Cancer Chemotherapy

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 22			
CSIR-Indian Institute of Toxicology Research			CSIR-IITR
Course 3 : Advanced Course	Chemical Sciences		Total Credits 6
Title: Advanced analytical Instrumentations		Course Code	Credits
		AcSIR-22-CS-AD-001	3

Thermal methods (TG, DTG, DTA, TMA, DSC), X-ray methods (XRD, XRF, SAXS), NMR (1H, 13C) and other Spectroscopic methods (EPR, IR, UV, Fluorescence), Chromatographic methods (TLC, GC, LC), Mass spectroscopy, Electro Analytical instrumentation, signal and noise, Overview of optical methods of analysis: Components of optical instruments, atomic and molecular spectrometry based on absorption, emission and scattering, Analytical techniques (basic electrochemistry, voltammetry, potentiometry), Analytical separations and introduction to chromatographic methods, GC, LC, Mass spectrometry, electromigration techniques, hyphenated techniques, detectors, Analytical tools for petroleum refining. Iron Microscopy (SEM, TEM), Electron Probe Micro Analysis (EDS, WDS), Quantitative Analysis (AAS, ICP, CHN).

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 22

CSIR-Indian Institute of Toxicology Research	**CSIR-IITR**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	**Principles and Applications of Organic Spectroscopy**	**Course Code**	**Credits**
		AcSIR-22-CS-AD-002	**3**

Mass spectroscopy, IR spectroscopy, Proton magnetic resonance spectroscopy, Structural assignment by employing NMR techniques, Carbon-13 NMR spectroscopy, Introduction COSY, HSQC, HMBC, NOESY,ROESY, Structural elucidation using 2D-NMR methods, Applications to analyze macromolecules in biological samples, Sample Preparation Protocols, Application of Spectroscopy in xenobiotic metabolism and toxicokinetics. Development of Quantitative analytical methods using mass spectrometry, Application to some model drugs, Metabolomics , Proteomics, GC-MS/MS, LC-MS/MS , MALDITOF, Protein Database search (MASCOT), Clinical Mass Spectrometry.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 22

CSIR-Indian Institute of Toxicology Research	**CSIR-IITR**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	**Green Chemistry and its Applications**	**Course Code**	**Credits**
		AcSIR-22-CS-AD-003	**3**

Green chemistry concepts: Basic understanding, scope and interdisciplinary nature of green chemistry; Environmental factors; Carbon credit, Energy efficiency and atom economy, Catalysis and green chemistry, Alternate reaction media and reaction systems, ionic liquids, supercritical fluids, solvent less chemistry. Introduction to ionic liquids, ionic liquids vs. molecular solvents/ionic salts (solids), ionic liquids vs. Eutectic mixtures, solvent polarities using different spectral techniques (parameters), physicochemical properties of ionic liquids, effect of functional groups on the properties of ionic liquids, surface active ionic liquids, aggregation behaviour of ionic liquids, interaction of ionic liquids with different molecular solvents, interaction of ionic liquids with biopolymers, thermodynamics of the binary mixtures of ionic liquids, structure property relationship in ionic liquids, Introduction to task specific ionic liquids, self-assembly of ionic liquids in aqueous/non aqueous media and synthesis of nanomaterials therein, ionic liquids in catalysis, extraction of metal ions, ionic liquids and biopolymers: dissolution, regeneration and ionic-gel formation, processing of lignocellulosic biomass using ionic liquids, clean separation of various fractions of biomass and recovery of valuable chemicals using ionic liquids, application of ionic liquids in electrochemistry, separation of azeotropic mixtures using ionic liquids, organic reactions in ionic liquids.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

Faculty of Study	Course Code	Course Title
Engineering Sciences	AcSIR-24-ES-AD-001	Advances in Computational Intelligence and Application
Engineering Sciences	AcSIR-24-ES-AD-002	Corrosion Engineering
Engineering Sciences	AcSIR-24-ES-AD-003	Stability of Structures
Engineering Sciences	AcSIR-24-ES-AD-004	Surface Modification Technologies

CSIR-National Aerospace Laboratories	CSIR-NAL

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Advances in Computational Intelligence and Application	Course Code	Credits
		AcSIR-24-ES-AD-001	3

Soft Computing: Artificial Neural Network: Neurons, Single layer and multilayer architecture, back propagation learning algorithm. Radial basis function (RBF) neural network, learning algorithm. Fuzzy Logic: Types, membership functions, fuzzification and defuzzification, rule-based fuzzy inference engine, Type-1 and Type-2 fuzzy logic, typical applications. Genetic Algorithm: Basic concept, Parameters, Reproduction, Crossover, Mutation, Types: Real coded GA, Binary GA, Mixed integer GA, Parallel GA,

Hybrid GA. Swarm Intelligence: Basic Concept, parameters of PSO, Real and binary PSO, Boolean PSO, Pareto Front Multi-Objective PSO. Bacterial Foraging Optimization: Basic Concept, chemotaxis, swarming, reproduction and elimination-dispersion, algorithm of BFO. Applications of Soft Computing: Applications to Electromagnetics Communications, Controls, Aerospace, Signal Processing.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

CSIR-National Aerospace Laboratories	CSIR-NAL

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Corrosion Engineering	AcSIR-24-ES-AD-002	3

Electrochemical and thermodynamic principles, Nernst equation and electrode potentials of metals, EMF and galvanic series, merits and demerits; origin of Pourbaix diagram and its importance to iron, aluminium and magnesium metals. Exchange current density, polarization - concentration, activation and resistance, Tafel equation; passivity, electrochemical behaviour of active/passive metals, Flade potential, theories of passivity. Atmospheric, pitting, dealloying, stress corrosion cracking, intergranular corrosion, corrosion fatigue, fretting corrosion and high temperature oxidation; causes and remedial measures. Susceptibility tests for IGC, stress corrosion cracking and pitting, sequential procedure for laboratory and on-site corrosion investigations, corrosion auditing and corrosion map of India, Salt Spray Test and standards. Corrosion prevention by design improvements, anodic and cathodic protection, metallic, non-metallic and inorganic coatings, mechanical and chemical methods and various corrosion inhibitors.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 24

CSIR-National Aerospace Laboratories CSIR-NAL

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Course Code	Credits
Stability of Structures	AcSIR-24-ES-AD-003	3

Concepts of stability, bifurcation and limit point instability, stability of discrete systems, linear and nonlinear behavior, stability of beams and columns, energy methods, static and dynamic formulations, axial-flexural buckling, lateral-torsion buckling, buckling of beams on elastic foundations, imperfection sensitivity analysis, stability of plates, axial-flexural buckling, shear-flexural buckling, buckling under combined loads, introduction to inelastic buckling and dynamic stability, parametric instabilities and stability under non-conservative forces, introduction to aeroelasticity, divergence and flutter.

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Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 24

CSIR-National Aerospace Laboratories CSIR-NAL

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Surface Modification Technologies	AcSIR-24-ES-AD-004	3

Introduction to Surface Modification – Importance and Methods. Surface degradation-tribology, wear and corrosion- types of wear, adhesive, abrasive, oxidative, corrosive, erosive and fretting wear, role of friction and lubrication; overview of different forms of corrosion, Tribocorrosion. Chemical and electrochemical polishing, chemical conversion coatings- phosphating, chromating, chemical colouring, anodization; Electro/elctroless deposition - deposition of copper, zinc, nickel and chromium, alloy and composite plating by electro/electroless methods, sol-gel coatings, their properties and applications. Thermochemical and plasma chemical processes- nitriding, carburising, ion implantation etc. Vacuum deposition techniques - physical vapour deposition (PVD), evaporation, sputtering, ion plating, plasma nitriding, chemical vapour deposition (CVD), plasma assisted CVD. Thermal spraying, techniques, advanced spraying techniques plasma surfacing, detonation gun and high velocity oxy-fuel processes, laser surface alloying, laser cladding, specific industrial applications.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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25	CSIR-NBRI	3	Advanced Course

Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-25-BS-AD-001	Agro-Horticulture Technology
Biological Sciences	AcSIR-25-BS-AD-002	Cell signaling
Biological Sciences	AcSIR-25-BS-AD-003	Developmental Biology – Plants
Biological Sciences	AcSIR-25-BS-AD-004	Environmental Biochemistry and Biotechnology
Biological Sciences	AcSIR-25-BS-AD-005	Genomics & Epigenomics
Biological Sciences	AcSIR-25-BS-AD-006	Phytochemistry and their utilization
Biological Sciences	AcSIR-25-BS-AD-007	Plant Biodiversity and Systematics
Biological Sciences	AcSIR-25-BS-AD-008	Plant Microbe Interactions

AcSIR Academic Centre Code: 25

CSIR-National Botanical Research Institute	CSIR-NBRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Agro-Horticulture Technology	AcSIR-25-BS-AD-001	3

Agriculture development in India Pre green revolution Post green revolution Recent concepts (Organic farming, Natural farming, Contractual farming, Zero budget framing, Precision farming) Genetic improvement and mutation breeding Basics of crop production Soil Water Plant SPAC (Soil, Plant, Atmosphere Continuum) Agronomic crop management practices Cropping System/Cropping pattern, Crop rotation, Intercropping Mixed cropping, Sole cropping, Monoculture, planting geometry) Factors influencing Crop Growth Soils &Problems with Soils (Erosion, Salinity, Soil Sodicity, Soil Acidity and Alkalinity) Ameliorating problem soils Plant Nutrition (Nutrient Deficiencies and sources, Organic Fertilisers, Biofertilizers, Integrated Nutrient Management,) Water management Weed management Insect/Pest/Disease Management Post harvest management and storage Crop Diversification Floriculture, Medicinal and Aromatic Plants, Spices, Olericulture)

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 25	
CSIR-National Botanical Research Institute	CSIR-NBRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Cell signaling	AcSIR-25-BS-AD-002	3

Introduction to cell signaling General plant growth, role of various hormones during the entire plant growth, use of mutants to deduce pathways Auxin Role in plant development (including root development, apical dominance etc) mutant defects Regulation of biosynthesis, metabolism, signaling pathway Regulation of genes and pathway components Ethylene Role in plant development (including triple response, ripening, abscission , senescence) mutant defects Regulation of biosynthesis, metabolism, signaling pathway Regulation of genes and pathway components Cytokinins Role in plant development (branching, tissue culture, root gorwth etc), mutant defects Regulation of biosynthesis, metabolism, signaling pathway Regulation of genes and pathway components Abscisic acid Role in plant development (dormancy, germination, abiotic stress responses, stomatal closure,), mutant defects Regulation of biosynthesis, metabolism, signaling pathway Regulation of genes and pathway components Gibberellic acid Role in plant development (cell elongation, green revolution, role of DELLA proteins, flowering) mutant defects Regulation of biosynthesis, metabolism, signaling pathway Regulation of genes and pathway components Jasmonic acid Role in plant development, herbivory, resistance to insects and necrotrophic organisms, mutant defects Regulation of biosynthesis, metabolism, signaling pathway Regulation of genes and pathway components Salicylic acid Role in plant development, pathogenesis (antagonism with JA) mutant defects Regulation of biosynthesis, metabolism, signaling pathway Regulation of genes and pathway components Brassinosteroids Role in plant development , mutant defects Regulation of biosynthesis, metabolism, signaling pathway Regulation of genes and pathway components Striogolactones Role in plant development, branching, mutant defects.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 25	
CSIR-National Botanical Research Institute	CSIR-NBRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Developmental Biology – Plants	AcSIR-25-BS-AD-003	3

Root - Architecture and types, cell types, molecular basis of root development, lateral root formation, adventitious roots, root hairs, storage roots, gravitropism, hormonal control, root symbiosis, root apex Reproduction - Male and female gametophyte development, pollination, fertilization, zygote, embryogenesis, molecular basis, male sterility, self incompatibility, somatic embryogenesis Fruit - Development, size control, ripening, parthenocarpy, molecular basis, hormonal control, climacteric fruits, abscission, sex determination Seed - Genetic control of seed development, seed structure, types of storage reserves, molecular basis, oil seeds, dormancy and germination, hormonal control, recalcitrance, photomorphogenesis, endosperm, secondary growth, cambium, trichomes, fibre, totipotency, Somatic embryogenesis and organogenesis and their molecular basis. Shoot - Shoot apical meristem, cell division, differentiation, xylogenesis, phloem, branching, secondary wood, molecular basis of development, hormonal control, cell growth, programmed cell death Leaf - Types, phyllotaxis, size and shape control, cell types, venation, plastid biogenesis, stomatal development, senescence Flower - Types, determinacy, ABC model, architecture, pigmentation, control of flowering time, photoperiod control, senescence, hormonal basis, scent, development of reproductive organs, pollination, and apomixes Light Signaling in Plants - Photomorphogenesis, Skotomorphogenesis, Signal transduction of UV perception, and Hormonal regulation of light signaling.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 25

CSIR-National Botanical Research Institute	CSIR-NBRI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title: Environmental Biochemistry and Biotechnology	Course Code	Credits
	AcSIR-25-BS-AD-004	3

Recent Advances in Environmental Biotechnology Physiology of Metalloid Transport and Accumulation by Plants Molecules and Pathways Associated with Metal Detoxification and Tolerance in Plants Transgenic crops for safer and low accumulation of toxic metals Gene Mining for Heavy Metal(loid) Transport and Accumulation Physiology of toxic metal transport and accumulation by plants – heavy metals and its availability in nature Biochemical basis of metal hyperaccumulation in plants and phytoremediation Metalloid stress in plants and strategies for transgenic plants GM crops and their impact on the environment Transgenic microbes for pollution management.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 25			
CSIR-National Botanical Research Institute			CSIR-NBRI
Course 3 : Advanced Course	Biological Sciences		Total Credits 6
Title: Genomics & Epigenomics		Course Code	Credits
		AcSIR-25-BS-AD-005	3

Introduction: From Sequence to function in the Age of genomics, Genomedatabases of various plants. Genome Organization: Nuclear, Mitochondrial and Chloroplast Genome Genome analysis: Cloning systems used in genomics, Sequencing and analysing genome, Principles of Gene Annotation and prediction, tools and resources Genomes and transcriptomes of model organisms Transcriptional Gene Regulation: Operon Concept, Transcription Factors and Classification, promoters, cis-regulatory elements and enhancers, Pre-initiation complex and RNA Polymerase, transcription elongation and termination Functional genomics: Strategies to find important genes in the genome and theirfunctional analysis Differential gene expression profiling methods (differential display, subtractiveanalysis, Microarrays, comparative transcriptomics) Comparative genomics and synteny (Multiple Sequence Alignments & Phylogenetic analysis) Theory Epigenetics: DNA methylation and concept of epigenetics, Histonemodifying enzymes and their role, Chromatin modifying machinery,Chromatinarchitecture, Histone modifications, Histone methylation, demethylation etc Gene Silencing: Transcriptional gene silencing, Post transcriptional gene silencing: Small RNA world and mechanism of regulation Post-transcriptional gene regulation: RNA processing, Intron splicing etc., Post-translationalmodifications of protein and their regulation.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 25

CSIR-National Botanical Research Institute CSIR-NBRI

Course 3 : Advanced Course Biological Sciences Total Credits 6

Title:	Course Code	Credits
Phytochemistry and their utilization	AcSIR-25-BS-AD-006	3

Phytomolecules Extraction of phyto metabolites using Hot extraction (Soxhlet apparatus) and Cold extraction (Polytron Homogenizer) techniques. Isolation and fractionation of metabolites through liquid and solid phase extraction techniques. Analyses performed on GC-MS/ LC-MS/NMR spectroscopy to characterize the metabolites. Principles of pharmacognosy, chromatographic parameters, factors affecting and applications of: Thin Layer chromatography, column chromatography, gas chromatography, affinity chromatography, ion exchange chromatography, size exclusion chromatography, high performance liquid chromatography, high performance thin layer chromatography. Electron microscopy: Principle, instrumentation and applications of scanning electron microscopy (SEM), transmission electron, microscopy (TEM).Nutrition in health and disease Introduction, significance, classification, formulation evaluation of micro and macro nutrients, malnutrition deficiencies.Dose and variability in biological activity Dissolution and drug release testing, compendial methods of dissolution, alternative methods of dissolution testing, problems of variable control in dissolution testing.Target validation and assay development In vitro – in vivo correlation (IVIVC), study designs, evaluation of the data, clinical significance of bioequivalence studies. Traditional knowledge and product development Scope of pre-formulation studies, pre-formulation testing criteria, design of pre-formulation studies, selection of drug candidate based on AYUSH system of drug development and prakarti (vata, pita and kappa) treatment in product development.

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AcSIR Academic Centre Code: 25

CSIR-National Botanical Research Institute CSIR-NBRI

Course 3 : Advanced Course Biological Sciences Total Credits 6

Title:	Plant Biodiversity and Systematics	Course Code	Credits
		AcSIR-25-BS-AD-007	3

Aims and Objectives of the study of biodiversity Bio-Geographic Regions of Plant diversity in India Different terminology with biodiversity: Megadiverse countries, Hotspots, keystone species, Endemism Diversity Within Algae Diversity Within Lichens Diversity Within Bryophytes Diversity WithinPteridophytes Diversity Within Gymnosperms Diversity Within Angiosperms Different Types of Biodiversity Role of Taxonomy in Biodiversity Assessment Assessment of Biodiversity Through Classical Taxonomic Methods: Flora & Revision Causes of Biodiversity Loss Biodiversity Conservation: ex-situ and in-situ conservation IUCN Categories of Conservation Assessment Significance of Biodiversity and its Sustainable Uses Biodiversity and Traditional Knowledge Legal and policy instruments on Biodiversity Methods of Plant Collections Herbarium Techniques Herbaria of India and World Species concepts Naming of plant Plant identification: methods and Importance National and International Bodies of Biodiversity Practical work: 1. Visit to herbarium and different labs

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AcSIR Academic Centre Code: 25

CSIR-National Botanical Research Institute **CSIR-NBRI**

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Plant Microbe Interactions	**AcSIR-25-BS-AD-008**	**3**

Soil: the medium of plant and microbe interaction Soil Microbiology Plant microbe interaction and soil ecology Physiological changes in plants in response to PGPRs and pathogens/ The plant immune system

Molecular changes in plants in response to PGPRs and pathogens Strategies for physiological studies in plant microbe interactions Strategies for molecular studies in plant microbe interactions Role and strategies of microscopy in study of plant microbe interactions Effectors in plant microbe interactions Application of proteomics in plant microbe interaction Signalling in plant microbe interaction Viral Infection in Plants Response of microbes to plant microbe interaction Importance of mutation studies in understanding plant microbe interaction Application of Plant microbe interaction. Biofertilizers/biopesticides/bioremediation

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-26-BS-AD-001	Advanced Biomaterials
Biological Sciences	AcSIR-26-BS-AD-002	Advanced Techniques in Biology
Biological Sciences	AcSIR-26-BS-AD-003	Advances in Chemical Biology
Biological Sciences	AcSIR-26-BS-AD-004	Advances in Nanoscience and Nanotechnology
Biological Sciences	AcSIR-26-BS-AD-005	Applications in Plant Biotechnology
Biological Sciences	AcSIR-26-BS-AD-006	Beyond Genomes: Concepts in comparative and functional genomic
Biological Sciences	AcSIR-26-BS-AD-007	Cell Signalling
Biological Sciences	AcSIR-26-BS-AD-008	Cell Structure and Membrane Protein Dynamics
Biological Sciences	AcSIR-26-BS-AD-009	Chemistry and Biology of Heterocycles
Biological Sciences	AcSIR-26-BS-AD-010	Concepts in Microbiology
Biological Sciences	AcSIR-26-BS-AD-011	Concepts in Plant Biotechnology
Biological Sciences	AcSIR-26-BS-AD-012	Introduction to Infectious Diseases
Biological Sciences	AcSIR-26-BS-AD-013	Introduction to Protein Misfolding Diseases
Biological Sciences	AcSIR-26-BS-AD-014	Mathematics and Statistics for Biologists
Biological Sciences	AcSIR-26-BS-AD-015	Molecular Aspects of Infectious Diseases

Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-26-BS-AD-016	Molecular Recognition and Molecular Interactions in Structural Biology
Biological Sciences	AcSIR-26-BS-AD-017	Structure Determination and Analysis of Biomolecules
Chemical Sciences	AcSIR-26-CS-AD-001	Polymer Synthesis
Chemical Sciences	AcSIR-26-CS-AD-002	Physical Organic Chemistry
Chemical Sciences	AcSIR-26-CS-AD-003	Total Synthesis
Chemical Sciences	AcSIR-26-CS-AD-004	Catalysis in Petroleum Refining
Chemical Sciences	AcSIR-26-CS-AD-005	Thermochemical Conversion of Biomass
Chemical Sciences	AcSIR-26-CS-AD-006	Modern Polymerization Methods for Functional Macromolecules
Chemical Sciences	AcSIR-26-CS-AD-007	Molecular Self Assembly
Chemical Sciences	AcSIR-26-CS-AD-008	Organic Biomolecular Chemistry
Chemical Sciences	AcSIR-26-CS-AD-009	Polymer Characterization
Chemical Sciences	AcSIR-26-CS-AD-010	Molecular modeling and simulation
Chemical Sciences	AcSIR-26-CS-AD-011	Advanced Physical Chemistry
Chemical Sciences	AcSIR-26-CS-AD-012	Advanced Inorganic Chemistry
Chemical Sciences	AcSIR-26-CS-AD-013	Advanced Organic Chemistry

Faculty of Study	Course Code	Course Title
Chemical Sciences	AcSIR-26-CS-AD-014	Advanced Materials Science
Engineering Sciences	AcSIR-26-ES-AD-001	Advanced Algorithms
Engineering Sciences	AcSIR-26-ES-AD-002	Advanced Reaction Engineering
Engineering Sciences	AcSIR-26-ES-AD-003	Advanced Separation Processes
Engineering Sciences	AcSIR-26-ES-AD-004	Biochemistry and Structural Biology Computational Techniques
Engineering Sciences	AcSIR-26-ES-AD-005	Biochemistry and Structural Biology Biomolecular Dynamics
Engineering Sciences	AcSIR-26-ES-AD-006	Computational Functional Genomics
Engineering Sciences	AcSIR-26-ES-AD-007	Environmental Pollution Control
Engineering Sciences	AcSIR-26-ES-AD-008	Fundamentals of Biology
Engineering Sciences	AcSIR-26-ES-AD-009	Green Process Technology
Engineering Sciences	AcSIR-26-ES-AD-010	Industrial Flow Modeling
Engineering Sciences	AcSIR-26-ES-AD-011	Mathematical Fundamentals
Engineering Sciences	AcSIR-26-ES-AD-012	Multiscale Simulations in Materials
Engineering Sciences	AcSIR-26-ES-AD-013	Numerical Methods and Programming
Engineering Sciences	AcSIR-26-ES-AD-014	Process Design Principles

Faculty of Study	Course Code	Course Title
Engineering Sciences	AcSIR-26-ES-AD-015	Reaction and Reactor Engineering
Engineering Sciences	AcSIR-26-ES-AD-016	Separation Processes: Chromatography and Crystallization
Engineering Sciences	AcSIR-26-ES-AD-017	Statistical Analysis
Engineering Sciences	AcSIR-26-ES-AD-018	Systems Biology
Engineering Sciences	AcSIR-26-ES-AD-019	Systems Pharmacology
Engineering Sciences	AcSIR-26-ES-AD-020	Thermodynamics and Statistical Mechanics
Engineering Sciences	AcSIR-26-ES-AD-021	Transport Phenomena
Physical Sciences	AcSIR-26-PS-AD-001	Equilibrium and Non-Equilibrium Statistical Mechanics for Soft Matter
Physical Sciences	AcSIR-26-PS-AD-002	Operando Surface Techniques
Physical Sciences	AcSIR-26-PS-AD-003	Polymer Physics
Physical Sciences	AcSIR-26-PS-AD-004	Polymer Processing and Rheology
Physical Sciences	AcSIR-26-PS-AD-005	Special Topics in Polymers 1
Physical Sciences	AcSIR-26-PS-AD-006	Special Topics in Polymers 2

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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CSIR-National Chemical Laboratory	CSIR-NCL

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Biomaterials	AcSIR-26-BS-AD-001	3

Definition of biomaterials, Surface property requirements of biomaterials, Types of materials used in medicine, Synthesis and surface characterization, Biology of wound healing, foreign body response and tissue remodeling, Molecular and cellular interactions of materials with biological environment, Degradation and long term fate of materials used in medicine, Requirements of biomaterials for biomedical implants, surface coatings, wound dressings, sutures, cardiovascular devices, ophthalmology, dentistry, orthopedics and cosmetic surgeries, Applications in drug delivery and tissue engineering, Standard protocols for testing the efficacy and efficiency of biomaterials, The regulatory environment for biomaterials, Some concepts for design development of common biomaterials.

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AcSIR Academic Centre Code: 26			
CSIR-National Chemical Laboratory			CSIR-NCL
Course 3 : Advanced Course	Biological Sciences		Total Credits 6
Title: Advanced Techniques in Biology		Course Code	Credits
		AcSIR-26-BS-AD-002	2

Sequencing of nucleic acids and proteins Functional characterization of biomolecules Advanced microscopy (TEM, SEM, Confocal, AFM, etc.) Biophysical techniques (UV, Fluorescence, CD) Spectrometry (GC-MS, LCMS) High performance chromatography (HPLC, FPLC) Tracer techniques, NMR for biomolecules Proteomics (2D, MALDI-TOF, ESI, Database search, de novo sequencing) Microarray analysis Techniques in molecular biology (PCR, RT-PCR, Sequencing, Southern, Northern, etc.) Gene cloning and over-expression: identification of genes, designing primers, selecting vectors and cloning, expression in cells, solubilization of inclusion body, protein purification, site-directed mutagenesis Immunological techniques- Antigen-Antibody reaction, ELISA, RIA, In situ hybridization, immunoblotting, Western blotting, etc. Techniques in structural biology: crystallization and X-ray structure determination Bioinformatics tools and databases.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory CSIR-NCL

Course 3 : Advanced Course Biological Sciences Total Credits 6

Title: Advances in Chemical Biology	Course Code	Credits
	AcSIR-26-BS-AD-003	3

Amino Acids, Peptides & Proteins: Structure and functions of peptides and proteins, Design of poly peptides, Peptide hormones and their pharmaceutical significance, Peptide mimetics as therapeutics The Chemistry of Carbohydrates: Glycosylation methods, Oligosaccharide Synthesis and biosynthesis, Sugar derivatives and reactions, Glycoconjugates and glycomimetics Nucleic acids: Structural aspects of nucleic acids, Building blocks of nucleic acids Structure & function of DNA and RNA, Nucleic acid mimetics & their therapeutic applications. The Chemistry of Enzymes: Enzymes: Classification & Nomenclature, The Mechanism of Enzyme action, Enzymes as Catalysts Lipids, Fats & Steroids: Chemical synthesis & biosynthesis, Drug discovery , Basic principles of medicinal chemistry, The process of drug discovery and combinatorial chemistry, Case studies in drug discovery, Drugs from Nature: Introduction to natural products chemistry, Natural products based drug discovery, Naturally occurring antimalarials, anticancer and antimicrobial agents.

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory | CSIR-NCL

Course 3 : Advanced Course | Biological Sciences | Total Credits 6

Title:	Course Code	Credits
Advances in Nanoscience and Nanotechnology	AcSIR-26-BS-AD-004	2

Low-dimensional structures: Quantum wells, Quantum wires, and Quantum dots, Nano clusters & Nano crystals, fullerenes, carbon nano tubes and graphene, Nano Composites, synthesis and characterization techniques, Properties at Nano Scales and comparison with bulk materials, fabrication techniques, general applications, nanomaterials in biology.

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory	**CSIR-NCL**

Course 3 : Advanced Course	**Biological Sciences**	**Total Credits 6**

Title:	**Applications in Plant Biotechnology**	**Course Code**	**Credits**
		AcSIR-26-BS-AD-005	**3**

Plant –pathogen/microbe/insect interactions, plant defense, defense proteins, such as AI, PI, lectins, defensins, etc. Abiotic stress tolerance in plants Plant genetic engineering for crop improvement with case studies, safety practices in handling GMOs Applications of molecular markers in linkage mapping, gene tagging, gene introgression, synteny mapping, Hybrid testing, germplasm analysis, DNA fingerprinting, MAS, map based cloning Identifying and mapping of QTLs including strategies of QTL mapping (SMA, SIM, CIM, MTIM), QTL x QTL and QTL x environment interactions, expression QTLs, Softwares used, Association mapping Biodiversity including genetic diversity, molecular diversity and taxonomy, DNA barcoding, population genetics, conservation of diversity and endangered species Metabolomics including plant secondary metabolites, functional molecules, metabolic engineering, analytical methods Molecular farming and Biotransformation Proteomics including recognition, sequencing, applications of proteomics in plant biotechnology, identification, differential analysis, intensity fading etc. Application of nano-biotechnology in plant sciences.

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory	CSIR-NCL

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Beyond Genomes: Concepts in comparative and functional genomic	Course Code	Credits
		AcSIR-26-BS-AD-006	3

Overview of genome sequencing, assembly and annotation. Will discuss recent advances in genome sequencing technology and assembling short reads, gene finding and annotation. Accessing genome sequences and genomic-scale datasets: Genome browsers and databases Genome wide experiments 1. Gene expression and genetic variation analysis by microarray and sequencing. 2. Gene silencing / knock down techniques (micro RNA / siRNA) 3. Epigenetics / Histone modifications 4. Chemical genomics Comparative genomics 1. Synteny mapping 2. Overview of phylogenetics, orthology (orthologs / paralogs), gene duplication and functional specialization. Case study – the human kinome 3. Lateral gene transfer and functional specialization. Case study – the apicoplast organelle genome and function of apicomplexan parasite Metagenomics Population genetics Genome wide association studies (GWAS) and systems biology – integrating diverse datasets to understand biological functions and disease mechanisms Genomics and Drug discovery. The druggable genome concept. The EnCODE and 1000 genome projects Case study on current status of select genomes (humans / mouse / Arabidopsis / Plasmodium species / Mycobacterium species)

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory **CSIR-NCL**

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Cell Signalling	**AcSIR-26-BS-AD-007**	**2**

Introduction to Cellular Signalling Principles of Cell Signalling Modes of Cell Signalling Endocrine Paracrine Juxtacrine Cell-cell Signalling Synaptic Amplification and Coordination of Signals; Signalling at the Membrane Membrane Receptors G protein Coupled Receptors (GPCRs) Receptor Tyrosine Kinases (RTKs) Guanyl Cyclase Receptors Cytokine Receptors TNF (Tumor Necrosis Factor) Receptor Family Regulation of Receptors; Cellular Signalling and Post translational modifications Reversible Phosphorylation; Kinase and Phosphatase Serine and Threonine Phosphorylation and de-Phosphorylation Tyrosine and Histidine Phosphorylation and de-Phosphorylation Ubiquitination Other covalent modifications CAAX modification Modifications due to reactive oxygen and reactive nitrogen species; Key signalling elements Cyclic Nucleotides Cyclases G Proteins; Secondary Messengers. Role of Calcium as a secondary messenger Nitric Oxide Lipid based secondary messengers; Most studied signalling pathways Ras, Raf, and the MAP Kinase Pathway Wnt Pathways Pinephrine and Norepinephrine Pathways Apoptotic Pathways Insulin Signalling System; Over view of Signaling at the Neuromuscular Junction; Biochemical and Biophysical tools to study Signaling pathways 9. Introduction to mathematical modeling of pathways Systems Biology Simulation and data based modelling Dynamic modelling

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AcSIR Academic Centre Code: 26	
CSIR-National Chemical Laboratory	CSIR-NCL

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Cell Structure and Membrane Protein Dynamics	Course Code	Credits
		AcSIR-26-BS-AD-008	2

Membrane protein dynamics: Membrane Proteins: Membrane lipids and chemical composition and differences among eukaryotes, bacteria, and archaea. Mechanisms of membrane protein synthesis, SRP, membrane targeting and molecular machinery for translocation, trafficking, and topogenesis. T he secretory pathway: Prokaryotic and Eukaryotic pathways, molecular mechanisms of endo- and exocytosis, notch signaling, membrane fusion and SNARE proteins Membrane Receptors: ligand-gated ion channels, GPCR, and catalytic receptors. Signalling cascades. Transport of Ions across Biological Membranes: Ion channels, ion pumps, transporters, cotransporters, exchangers, and the underlying physicochemical principles. Cytoskeleton: Microfilaments, intermediate filaments: Actin Structure and the dynamics of Actin assembly. Intermediate filaments and their regulation. Microtubules: Microtubules organization (microtubule assembly, dis-assembly of tubulin) and dynamics. Intracellular transport and the role of kinesin and dynein. Microtubule dynamics and Motor Proteins in Mitosis.

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory CSIR-NCL

Course 3 : Advanced Course Biological Sciences Total Credits 6

Title:	Course Code	Credits
Chemistry and Biology of Heterocycles	AcSIR-26-BS-AD-009	2

Privileged heterocycles, Electronic properties, reactivity (electrophilicity and nucleophilicity), Synthetic methodologies, Biological properties of Natural products and drug candidates, Biosynthesis, Dimeric compounds and related stereochemistry.

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CSIR-National Chemical Laboratory	CSIR-NCL

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Concepts in Microbiology	AcSIR-26-BS-AD-010	2

Architecture of Bacterial cell Architecture of Fungal cell Taxonomy of bacteria Taxonomy of fungi Bacterial genetics Fungal genetics Microbial diversity Fungi from different environments Strain improvement Whole cell & enzyme immobilization Secondary metabolites Morphological and physiological characterization of microorganisms.

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory	CSIR-NCL

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Concepts in Plant Biotechnology	AcSIR-26-BS-AD-011	2

Structural genomics including genome architecture, gene structure, large insert libraries and classical genome sequencing, next generation sequencing, physical mapping Functional genomics including differential expression (microarray technology, real time and digital PCR), over expression, gene silencing (miRNA and siRNA), mutation, transposable elements, Genome-wide technologies (Transcriptomics, TILLING, SAGE, etc.) Molecular markers including concept, properties, classes, advantages and applications, population development Plant cell, tissue and organ culture Plant transformation methods including tissue culture and non tissue culture based, Agro bacterium mediated co-cultivation, particle bombardment, plant vectors, promoters and analysis Endophytes and their applications Phytoremediation.

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CSIR-National Chemical Laboratory	CSIR-NCL

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Introduction to Infectious Diseases	AcSIR-26-BS-AD-012	2

Human microbiome and normal flora Pathogens responsible for human infectious diseases
i. Virus: classification, biology and diseases caused / Specific case studies will be discussed
ii. Bacteria: classification, biology and diseases caused / Specific case studies will be discussed
iii. Protozoans: classification, biology and diseases caused / Specific case studies will be discussed
iv. Fungal: classification, biology and diseases caused / Specific case studies will be discussed
v. Worm: classification, biology and diseases caused / Specific case studies will be discussed

Virulence mechanisms Host pathogen interaction and overview of host immune response against specific Pathogens Overview on veterinary pathogens Epidemiology / Transmission / preventive strategies Diagnostic methods and techniques against infectious diseases Drugs / Drug resistance / Drug discovery Vaccines Infectious disease studies in the ‘post genomic era’. Overview of genome sequencing efforts, and highlight the importance of genome information in helping to under the biology and disease caused by specific pathogens. Discuss the role of genomics in epidemiology, diagnosis and drug discovery Special focus on neglected tropical diseases.

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CSIR-National Chemical Laboratory	CSIR-NCL

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Introduction to Protein Misfolding Diseases	AcSIR-26-BS-AD-013	2

Molecular Features of Neurodegenerative disease: Alzheimer's Disease, Parkinson Disease, Huntington Disease, Amyotrophic Lateral Sclerosis and Prion Diseases; Role of Protein Misfolding and Aggregation in Disease: Protein folding problem, mis-folding and aggregation machinery. Structural role and stabilization of molecular chaperones in protein misfolding diseases; Structural and mechanistic Basis of Protein Misfolding and Aggregation: Conformation of various stages of molecules (unfolded nature, proto-fibrils, Oligomer and polymer (Paired helical filaments)). Dis-aggregation mechanism in protein misfolding diseases; Cell Culture and Animal models of Neurodegenerative Diseases Misfolded protein conformation in Drosophila, mouse, C. elegans, and hibernating animal model. Primary neuronal cell culture model for protein misfolding diseases. Target for Therapy: Stabilization of the native protein conformation; Inhibition and reversion of protein conformational changes; and Increase the clearance of the misfolded protein.

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AcSIR Academic Centre Code: 26			
CSIR-National Chemical Laboratory			CSIR-NCL
Course 3 : Advanced Course	Biological Sciences		Total Credits 6

Title:		Course Code	Credits
	Mathematics and Statistics for Biologists	AcSIR-26-BS-AD-014	2

Introduction to algebra and geometry Trigonometry: Ratios of single and compound angles, their relations, inverse function. Complex numbers: algebra and geometrical interpretation Matrices and determinants: algebra, inverse of matrix, elementary transformations and solving equations Vectors: algebra, coordinate system, unit vectors, direction cosines, vector operations, products. Eigen value and eigen vectors Coordinate transformations and rotation about a general direction Calculus: continuity and limit of functions, derivatives, integrals, differential equations, Fourier transform, applications. Biostatistics: introduction Probability distributions (normal, binomial and Poisson), Sampling techniques, Correlation and Regression, Null hypothesis, Confidence intervals, Significance levels Experimental Design and Methods of sampling, Basic and Two-Way ANOVA.

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory	**CSIR-NCL**

Course 3 : Advanced Course	**Biological Sciences**	**Total Credits 6**

Title:		Course Code	Credits
	Molecular Aspects of Infectious Diseases	**AcSIR-26-BS-AD-015**	**2**

This course will focus on the basics of infectious disease caused by viruses, bacteria and eukaryotic pathogens. In depth discussion will be on the biology and pathogenesis caused by the parasites belonging to the eukaryotic phylum Apicomplexa. Specific examples of pathogenesis (e.g., TB, malaria, leishmaniasis and toxoplasmosis) and host parasite interaction will be introduced and discussed. Recent finding regarding the interplay between the human micro biome and infectious disease will be addressed in he course. Further focus will be given to the following topics - pathogen transmission, diagnostics and treatment strategies; drug discovery and drug resistance; pathogen genomics and genomic epidemiology (with respect to malaria only).

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory CSIR-NCL

Course 3 : Advanced Course Biological Sciences Total Credits 6

Title:	Molecular Recognition and Molecular Interactions in Structural Biology	Course Code	Credits
		AcSIR-26-BS-AD-016	3

Databases and tools used in structural biology Enzyme kinetics, active site and inhibition Metabolism of DNA and RNA: Replication, recombination, transcription Ribosome structure and mechanism of protein synthesis. Protein folding, degradation and prediction of protein conformation Protein-DNA interaction: case study of transcription factors and student assignment. Protein-carbohydrate interactions: case study of lectins and student assignment. Structural studies of genetic diseases and student assignment. Proteins as enzymes: case study of proteases and student assignment. Proteins as enzymes: carbohydrate digesting enzymes and assignment. Protein superfamily: Ntn hydrolases and assignment. Molecular recognition: case study of antigen-antibody interactions and student assignment. Virus structures. Membrane proteins and student assignment Protein evolution: globins and cytochromes and student assignment Cell signaling and cell-cell interactions and student assignment Cell motility and transport and student assignment Structure based drug design: case study. Structural genomics, proteomics and metabolomics

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory | CSIR-NCL

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Structure Determination and Analysis of Biomolecules	AcSIR-26-BS-AD-017	2

Introduction to the structure of biomolecules: DNA, RNA, sugar, lipid, protein Conformation of biopolymers, energetics of folding Crystallization of Proteins: Principles and techniques, preparation of heavy atom derivatives, Freezing protein crystals for storage and data collection Single crystals: Three-dimensional structure determination using protein crystallography, Arrangement of molecules in crystals, Lattice, symmetry, unit cell, point groups, space groups. Diffraction: X-ray diffraction, Laue an Bragg equations, reciprocal lattice, structure factor equation, Fourier transform, phase problem, diffraction data collection, indexing, systematic absences Structure determination: Solution to phase problem using direct methods, molecular replacement, Patterson method, isomorphous replacement and anomalous scattering, phasing of protein reflections, accuracy of phasing and refinement of phases, electron density and model fitting, Refinement: methods for structure refinement, structure validation, structure deposition, database. Fiber diffraction and small angle scattering Biophysical and spectroscopic techniques: NMR, Fluorescence, Circular Dichroism

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AcSIR Academic Centre Code: 26	
CSIR-National Chemical Laboratory	CSIR-NCL

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Polymer Synthesis	AcSIR-26-CS-AD-001	2

Radical chain polymerization, Rate of Radical Chain Polymerization, Initiation, propagation, Termination, Chain Transfer, Types of initiators, Autoacceleration, Molecular Weight Distribution, methods of polymerization, e.g. bulk, solution, suspension, emulsion, gas phase etc. Controlled or Living Radical Polymerization (CRP/LRP). Ziegler Natta polymerization, Coordination or insertion polymerization, Functional Olefin polymerization, Organometallic mediated polymerization; ROMP, ADMET, TEMPO-mediated polymerization and atom transfer radical Polymerization (ATRP). Step-growth Polymerization, kinetics, molecular weight control in linear polymerization. Examples - polyesters, polyethers, polyamides, polyurethanes, polyurea, polycarbonate and other condensation polymers.
Cationic Polymerization and Anionic Polymerization, Applications of ionic polymerizations for synthesis of block copolymers, Ring Opening Polymerization, Polymer nanoarchitectures - star, graft, and cyclic polymers, dendritic polymers, alternating, random and block copolymers.

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AcSIR Academic Centre Code: 26	
CSIR-National Chemical Laboratory	CSIR-NCL

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Physical Organic Chemistry	AcSIR-26-CS-AD-002	2

Hammett concepts: Quantitative structure activity relationships, Linear free energy relationships, Molecular mechanics, Semi-empirical and ab initio molecular theory, Pericyclic reactions, Substituent effects, Frontier molecular orbitals, HOMO-LUMO Interactions, Aromaticity, Odd and Even alternant Hydrocarbons, Pericyclic reactions, Woodward-Hoffman rules.

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Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Total Synthesis	AcSIR-26-CS-AD-003	2

Synthesis of complex organic molecules : Planning and execution, Concepts of retrosynthetic analysis and Total synthesis of natural products, Retrosynthesis, Disconnection, Synthons, Linear and Convergent synthesis, Photochemistry in total synthesis, MCRs in total synthesis, Breakthrough synthesis - past and present.

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CSIR-National Chemical Laboratory	**CSIR-NCL**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:		Course Code	Credits
	Catalysis in Petroleum Refining	**AcSIR-26-CS-AD-004**	**2**

Deactivation in Catalysts and its consequences, Regeneration and rejuvenation in Catalysis, Industrial Catalytic Processes; Hydro cracking; Hydro treating; Reforming; Isomerization and Alkylation; Fluid Catalytic Cracking and Deep Catalytic Cracking, Catalysis for Clean Fuels; Gas to Liquid Technology; Catalysis for Hydrogen Production, Catalysis beyond Petroleum; Electro catalysis; Photo catalysis, Laboratory Training in Catalysis.

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AcSIR Academic Centre Code: 26	

CSIR-National Chemical Laboratory	CSIR-NCL

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Thermochemical Conversion of Biomass	Course Code	Credits
		AcSIR-26-CS-AD-005	2

Thermochemical conversion technologies for biomass pyrolysis, gasification, combustion, thermal and catalytic conversion of biomass; upgradation of pyrolysis products; bio-refining products and applications.

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CSIR-National Chemical Laboratory	CSIR-NCL

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:		Course Code	Credits
	Modern Polymerization Methods for Functional Macromolecules	AcSIR-26-CS-AD-006	2

Combination of mechanistically distinct polymerization techniques, Incorporation of functionalities into polymers using Click Chemistry, Use of click reactions in combination with above polymerization techniques.

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory	**CSIR-NCL**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	**Molecular Self Assembly**	**Course Code**	**Credits**
		AcSIR-26-CS-AD-007	**2**

Basic physical chemistry of self-assembly, Thermodynamics and kinetic factors affecting self-assembly, Selfassembly of small molecules, Non-covalent interactions, Supramolecular chemistry, Crystal engineering, Metal-mediated self-assembly.

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CSIR-National Chemical Laboratory	CSIR-NCL

Course 3 : Advanced Course	Chemical Sciences	Total Credits	6

Title:	Course Code	Credits
Organic Biomolecular Chemistry	AcSIR-26-CS-AD-008	2

Peptidomimetics, Molecular Recognition & Self-assembly, The Bio-organic Chemistry of Carbohydrates, Nucleic acids, chemistry of lipids, Organic Medicinal Chemistry and Drug Discovery.

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AcSIR Academic Centre Code: 26			
CSIR-National Chemical Laboratory			**CSIR-NCL**
Course 3 : Advanced Course	**Chemical Sciences**		**Total Credits 6**
Title: Polymer Characterization		**Course Code**	**Credits**
		AcSIR-26-CS-AD-009	**2**

Techniques of polymerization, polymer characterization techniques, Stereochemistry of Polymers, polymer nano-architectures, random and block copolymers, Liquid Crystalline Polymers, Conducting Polymers, Nonlinear Polymers, Polymer Blends and Composites, polymer rheology, inorganic, bio and supramolecular polymers.

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory CSIR-NCL

Course 3 : Advanced Course Chemical Sciences Total Credits 6

Title:	Course Code	Credits
Molecular modeling and simulation	AcSIR-26-CS-AD-010	2

Molecular Mechanics: Features of molecular mechanics - Force Fields: Bonds structure and bending angles, Electrostatic Vander Waals and non-bonded interactions, Hydrogen bonding - Derivatives of molecular mechanics energy function - Calculating thermodynamic properties - Force Field for inorganic systems - Energy minimization, Molecular Dynamics Simulation: Molecular Dynamics using simple models, Molecular Dynamics with continuous potentials, Solvent effects, Conformational changes Thermostats, Barostas, Lincs and shake algorithms, Monte Carlo simulation Methods, sorption, Applications of Molecular Modeling.

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory	CSIR-NCL

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Physical Chemistry	AcSIR-26-CS-AD-011	3

Thermodynamics and chemical kinetics, Quantum Mechanics, Atomic structure and spectroscopy, Chemical bonding in diatomics, Chemical applications of group theory, Colloids and Surface science, surfactants, Interface and Interfacial properties, Electrochemistry.

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory | CSIR-NCL

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Inorganic Chemistry	**AcSIR-26-CS-AD-012**	**3**

Structure & Bonding in Inorganic Compounds, Chemistry of Coordination Compounds, Symmetry in Chemistry & Group Theory, Main group chemistry, Organometallic chemistry, Electronic Spectra of Transition Metal Compounds, Magneto Chemistry, Metal Cluster Compounds, Inorganic Reaction Mechanism, Electron Transfer Reactions in Metal Complexes, Bioinorganic Chemistry (Metalloenzymes, Metal complexes as oxygen carriers, Photosynthesis), Metal Complexes in Medicinal Chemistry, Catalysis by Inorganic Complexes.

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory	**CSIR-NCL**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	**Advanced Organic Chemistry**	**Course Code**	**Credits**
		AcSIR-26-CS-AD-013	**3**

Stereochemistry, reaction mechanism, C-C and C-X bond formations, Retrosynthetic analysis, photochemistry, pericyclic reactions, reactive intermediates, Methods of asymmetric synthesis and their application in total synthesis, oxidation-reduction reactions, organocatalysis, metathesis reactions.

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory CSIR-NCL

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Materials Science	AcSIR-26-CS-AD-014	3

Crystal systems and space groups, Close packing and various simple structure types like AB, AB2, AB3 and complex structural types ABX3, AB2X4, etc. Factors affecting crystal structures, Common preparative methods; X-ray diffraction and Electron microscopy, Defect structures, colour centers, reciprocal lattices, Properties of solids – Band theory, metals, insulators, semiconductors, dielectric and ferroelectric properties, magnetic properties, optical properties, ionic conduction; structure-processing-property correlations.

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory CSIR-NCL

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Advanced Algorithms	Course Code	Credits
		AcSIR-26-ES-AD-001	

The aim is to introduce students to the theory behind computing. This should help them in two ways: (1) design better code and (2) identify which computational problems in theirresearch provably can or cannot be solved efficiently.
Modules: Asymptotic notation, recurrences, Sorting, divide and conquer, Elementary data structures, Dynamics programming and greedy algorithms, NP completeness.

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory CSIR-NCL

Course 3 : Advanced Course | Engineering Sciences | Total Credits 6

Title:		Course Code	Credits
	Advanced Reaction Engineering	AcSIR-26-ES-AD-002	2

A very detailed study of material not covered in textbooks and well beyond that taught at the M.Tech. level. The course can focus on design concepts of industry problems handling complicated reactor designs for wider range of reactions.

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory — CSIR-NCL

Course 3 : Advanced Course — Engineering Sciences — Total Credits 6

Title:	Course Code	Credits
Advanced Separation Processes	AcSIR-26-ES-AD-003	2

Provide understanding of the principles underlying various separation processes.Modules: Mass transfer and thermodynamics applications to separations, Unit operations in separation: adsorption, distillation etc, Fundamentals of separation equipment design

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory CSIR-NCL

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Biochemistry and Structural Biology Computational Techniques	Course Code	Credits
		AcSIR-26-ES-AD-004	

To introduce students to the computational aspects of modern molecular biology. The course aims to explain the molecular basis of cellular processes, thus acting as a bridge to fill the gap between systemic and reductionist approaches employed in tackling biological complexities.

Modules

Macromolecular structure and computer representation, Biological macromolecules (proteins, carbohydrates, lipids, DNA, RNA), Molecular conformations and topology of biomolecules, Computational representation of structures, Molecular interactions: protein-protein, protein-DNA, protein-membrane, protein-carbohydrate, protein-RNA and protein-small molecule interactions, RNA and protein structure prediction and modelling, Principles of structure prediction, Mathematical tools for sequence comparison, structure minimization, Homology modeling and threading, RNA secondary structure prediction, Structure validation, Structural transitions, Review of experimental tools used in structural biology.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

CSIR-National Chemical Laboratory **CSIR-NCL**

Course 3 : Advanced Course **Engineering Sciences** **Total Credits 6**

Title:	Course Code	Credits
Biochemistry and Structural Biology Biomolecular Dynamics	**AcSIR-26-ES-AD-005**	**2**

Introducing the concepts of biomolecular dynamics and computational approaches to elucidate structural transitions and dynamics.

Modules:
Understanding intramolecular dynamics in biomolecules, Basics of molecular dynamics: time scales, equations of motion, introduction to, force-fields, application of numerical solutions in simulation, Multi-scale modeling and parameterization, Computational tools for MD simulations, Analysis of MD Simulations, Understanding macromolecular dynamics (Diffusion), Introduction to Random walk and Monte Carlo approaches, Statistical mechanics of protein folding, Introduction to statistical mechanics: ensembles, partition function, Application of statistical mechanics to many-body problem, Introduction to protein folding problem, Different folding models and their limitations

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory	**CSIR-NCL**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:		**Course Code**	**Credits**
	Computational Functional Genomics	**AcSIR-26-ES-AD-006**	**2**

To introduce students to current problems in functional genomics and present them with computational tools and methods to solve them.

Modules; Genome sequencing: assembly and annotation, Algorithms for sequence alignment, Probabilistic.

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AcSIR Academic Centre Code: 26			
CSIR-National Chemical Laboratory			**CSIR-NCL**
Course 3 : Advanced Course	**Engineering Sciences**		**Total Credits 6**
Title: Environmental Pollution Control		**Course Code**	**Credits**
		AcSIR-26-ES-AD-007	

Air pollution, plume behavior, dispersion of air pollutants, Desulfurization; Industrial air pollution control, methods and equipment. Design concepts for pollution abatement systems for particulates and gases. These include gravity chambers, cyclone separators, filters, electrostatic precipitators, condensation, adsorption and absorption, thermal oxidation and biological processes.

Industrial Wastewater treatment processes: Design concepts for primary treatment, secondary treatment, tertiary treatment, advanced physic-chemical methods and application to wastewater treatment-coagulation, adsorption, ion exchange, membrane separations, emulsion liquid membranes, cavitation processes; advanced oxidation processes; process integration and hybrid processes for wastewater treatment; methods for COD, ammoniacal nitrogen removal, Industrial wastewater treatment applications.

Biological methods for wastewater treatment; aerobic and anaerobic treatment methods; activated sludge process, mechanism and design considerations, industrial applications

Water recycle and reuse

Solid waste and Hazardous waste management; management strategies. Treatment methods – component separation, chemical and biological treatment, incineration, and disposal methods.

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory	CSIR-NCL

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Fundamentals of Biology	AcSIR-26-ES-AD-008	

To review biology fundamentals, provide an introduction to students with a non-biology background. Course will focus on core concepts and a quantitative view of biology.
Modules: Biomolecules/biochemistry: DNA and RNA composition, struct

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Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Green Process Technology	AcSIR-26-ES-AD-009	

This is aimed at developing catalysts and catalytic processes for i) replacing traditional reagent based processes by catalytic processes ii) biomass valorization to value added products iii) CO_2 activation iv) replacing organic solvents by water or alternate media v) integrating catalyst development and process intensification

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory CSIR-NCL

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title: Industrial Flow Modeling	Course Code	Credits
	AcSIR-26-ES-AD-010	

To teach students the basic equations of fluid dynamics and computational methods to solve these equations as applied to flows in industrial processes. At the conclusion of the course students will be able to analyze complex flow situations, develop a simple model for complex flow and solve it numerically, and simulate the actual complex flow using available CFD software.

Modules: Introduction to CFD, Solution techniques for solving CFD equations, Introduction to CFD Software, Turbulence modeling, Multiphase flows

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CSIR-National Chemical Laboratory	**CSIR-NCL**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:		Course Code	Credits
	Mathematical Fundamentals	**AcSIR-26-ES-AD-011**	**3**

To review mathematical fundamentals, teach common mathematics prerequisites of other courses, and to impart perspective on modeling and simulation.

Modules: Analysis basics, Linear Algebra, Ordinary and partial differential equations, Optimisation.

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AcSIR Academic Centre Code: 26			
CSIR-National Chemical Laboratory			**CSIR-NCL**
Course 3 : Advanced Course	**Engineering Sciences**		**Total Credits 6**
Title: Multiscale Simulations in Materials		**Course Code**	**Credits**
		AcSIR-26-ES-AD-012	**3**

Course Objective

To be familiar with simulations at the molecular and sub-molecular scale, including quantum chemistry based and classical mechanics based methods.

Modules

Introduction to molecular modeling

Quantum-chemistry driven modeling

Classical mechanics based modeling

Example problems at multiple scales

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CSIR-National Chemical Laboratory	CSIR-NCL

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Numerical Methods and Programming	Course Code	Credits
		AcSIR-26-ES-AD-013	

Introduction to Numerical Methods / Programming, Programming in MATLAB and Problem solving, Solutions to Non-Linear equations, System of Linear Algebraic (non-homogeneous) equations, Eigen Values problems, Introduction to Optimization Techniques, Polynomial Approximation and Interpolation, Numerical Integration, Differentiation and Difference formulas, Ordinary Differential Equations (ODEs), Partial Differential Equations (PDEs)

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory	CSIR-NCL

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Process Design Principles	Course Code	Credits
		AcSIR-26-ES-AD-014	

Introduction to Process Design, Steps involved in Process design, Process Synthesis, Heuristics in Process synthesis, Role of computers in process design, Detail Approach for Process Synthesis, Reactor network Synthesis, Synthesis of separation Trains, Reactor and separation network with recycle, Heat integration, Second Law analysis, Design of batch processes, Detail design of configured process, Process flowsheet Optimization, Equipment sizing, Cost analysis, Plant wide Controllability Assessment, Control system configuration, Flowsheet controllability analysis, Documentation of process design project, Content of report, Equipment specification sheets

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory	CSIR-NCL

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Reaction and Reactor Engineering	Course Code	Credits
		AcSIR-26-ES-AD-015	

1. Chemical Kinetics: Complex reactions, Multiple reactions/reaction networks, Reactions of higher/general order, Formulation of reaction mechanisms, simulation techniques and numerical methods, sensitivity analysis, analysis of rate data

2. Homogeneous reactor analysis & design: Revision of the basic concepts, Isothermal systems: Ideal batch reactors, Single CSTR and cascade of CSTRs in series, plug flow reactors, Non-isothermal reactions & reactors: (CSTR and PFR), Energy balance and its applications to reactor design, Energy balance for reactors in series, Energy balance for reactor-separator system and relevant dynamics

3. Non-ideal reactor design: Interpretation of Residence time distribution, Macro and micro mixing, Segregation models, RTD in complex systems (with recycle, outlet response in systems with dead zones, systems with delay, etc.), Industrial relevance of the RTD, Spatial and temporal nonlinearities in the homogeneous reactors

4. Heterogeneous reactor analysis & design: Gas-liquid reactions: Mass transfer with reactions, Reactor design for mechanically agitated and bubble column reactors, Gas-solid reactions: Catalytic/non-catalytic. kinetics and reactor design, with/without diffusion limitations, design of fixed and fluidized bed reactors, Langmuir-Hinshelwood, Hougen-Watson surface kinetics, microkinetic analysis of surface reactions, External diffusion controller reactions, Unsteady states in non-isothermal fixed bed catalytic reactors

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory	CSIR-NCL

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Separation Processes: Chromatography and Crystallization	AcSIR-26-ES-AD-016	

Introduction, Adsorption: Equilibrium and Kinetics, Diffusion and Dispersion: Theory and models, Chromatography: Introduction and Theory, Chromatography column dynamics, Chromatography process design: Batch and Continuous processes, Introduction to chromatography simulation platforms: ASPEN chromatography, ChromX and CADET etc., Structural characterization and designing of the adsorbent particles, Functional characterization of the adsorbents, Introduction to crystallization, Crystallization: Equilibrium and Phase Diagrams, Crystal shape and size distribution: Mass, Energy and Population balance, Real time monitoring of the crystal size distribution, Crystallization process design: Batch and Continuous processes

Lab: Introduction to analytical and preparative scale chromatography instrumentation, Demonstration I: Chromatography parameter estimation for size exclusion chromatography (Aggregate separation from the native molecule), Demonstration II: Inverse size exclusion chromatography for pore size estimation of adsorbents, Demonstration III: Radial flow chromatography for capture stage purification of API, Demonstration IV: Focused beam reflectance measurement for real time estimation of crystal chord lengths

Simulation exercise: A specific task to simulate the analytical/preparative scale chromatogram using an existing example.

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory CSIR-NCL

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Statistical Analysis	Course Code	Credits
		AcSIR-26-ES-AD-017	

Methods for describing sets of data, random variables, sampling distributions, tests of hypotheses, nonparametric statistics, analysis of variance, and an introduction to concepts of supervised and nonsupervised learning

AcSIR Academic Centre Code: 26			
CSIR-National Chemical Laboratory			CSIR-NCL
Course 3 : Advanced Course	Engineering Sciences		Total Credits 6
Title: Systems Biology		Course Code	Credits
		AcSIR-26-ES-AD-018	

This course provides an introduction to the fundamental concepts of cellular systems biology. The purpose of the course is to provide insight into quantitative modelling of biological systems at the molecular and cellular level, as well as how they are used, analysed and developed. The course structure involves lectures, tutorials, assignments, presentations and miniprojects.

Introduction to Complex Systems and Systems Biology, Cell Mathematics (Numbers in Biology), Network Motifs and Gene Circuits, Analysis of Biochemical Networks, Gene, Signaling and Metabolic Network Analysis and Modeling, Kinetic Models of Biochemical Networks, Modeling of Biological systems, Concept of Modularity, Optimality and Evolution of Biological circuits, Experiments in Systems Biology, Integrated Analysis in Systems Biology, Variability in Biological Systems and Robustness

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory CSIR-NCL

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Systems Pharmacology	Course Code	Credits
		AcSIR-26-ES-AD-019	

Mathematical modeling of drug delivery, distribution and action Modules, Drug delivery modes and models, Basic pharmacokinetics – compartment models, Physiology based pharmacokinetics, Systems pharmacology

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory **CSIR-NCL**

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Thermodynamics and Statistical Mechanics	**AcSIR-26-ES-AD-020**	

Classical Thermodynamics, Basic Concepts
Equation of state, Heat Capacity, Zeroth Law and First Law of Thermodynamics, Entropy and Second Law of Thermodynamics, Spontaneous Process and Irreversibility, Maxwell Relations, Thermodynamic Cycles, Phase Equilibria of single Component System, Phase Diagram, Multicomponent Phase Equlibria, Colligative Properties, Raoult's Law, Henry's Law, Introduction to Molecular Thermodynamics, Intermolecular Forces, Potential Functions, Fugacities in Gas Mixture, Fugacities in Liquid Mixture, Solubilities of Gases/Solids in Liquids, High Pressure Phase Equilibria

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory CSIR-NCL

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Course Code	Credits
Transport Phenomena	AcSIR-26-ES-AD-021	

Types of transport processes, constitutive laws for diffusive mode of transport, convective mode of transport due to bulk fluid flow.
Continuum description, equation of continuity and motion for isothermal fluid flow, Navier-Stokes equation, dimensional analysis, creeping flow and inviscid flow equations, vectors and tensors (definition, properties, algebraic & differential operations), steady and time dependent diffusive transport in isothermal flow of Newtonian and non-Newtonian fluids, problems in rectangular, cylindrical and spherical coordinate systems with unidirectional and two directional transport.
Non-isothermal and binary (two component) systems, dimensional analysis of equations of change, diffusive transport in single component non isothermal systems, diffusive transport in isothermal, two-component systems, steady state forced convection in a unidirectional fully developed laminar fluid flow.

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory	CSIR-NCL

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title: Equilibrium and Non-Equilibrium Statistical Mechanics for Soft Matter	Course Code	Credits
	AcSIR-26-PS-AD-001	

Introduction1. The Laws of Thermodynamics and Thermodynamic Processes in Ideal Gases2. Principle of Maximum Work and Cycle Analyses3. Maxwell Relations: Derivations and Applications4. Gibbs-Duhem relationships5. Real GasesEquilibrium Statistical Mechanics1. Classical Mechanics2. Equilibrium Distributions3. Ergodic Hypothesis4. Ensembles in Statistical Mechanics5. Boltzmann Statistics6. Imperfect Gases: The Virial equations Coefficients7. Relationship of Thermodynamic Functions to Probability Distribution Functions8. Static structure factor and direct correlation function. Non-Equilibrium Statistical Mechanics1. Linear response theory.2. Onsagers regression hypothesis3. Fluctuation dissipation theorem4. Green-Kubo relation5. Brownian Motioni. The Langevin Equationii. Connection to Fluctuation-Dissipation Theorem6. TimeCorrelation Function Formalismi. Mean square displacementii. Velocity Autocorrelation functioniii. Diffusion, friction and Einstein Relationship.

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AcSIR Academic Centre Code: 26	
CSIR-National Chemical Laboratory	**CSIR-NCL**

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Operando Surface Techniques	Course Code	Credits
		AcSIR-26-PS-AD-002	

Basic aspects of XPS, EELS, XAS, Surface spectroscopy and microscopy tools for catalysis-applications of XPS, XAS, FT-IR, STM etc in exploring catalysis at nanoscale, Surface science techniques at operando conditions –bridging the pressure gap, Electronic structure of surfaces – techniques for probing electronic structure with examples.

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AcSIR Academic Centre Code: 26	
CSIR-National Chemical Laboratory	CSIR-NCL

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Polymer Physics	AcSIR-26-PS-AD-003	

What is a polymer? What is unique to polymers? Polymer characterization, including MW, MWD, Rg, Rh, intrinsic viscosity.Models for flexible polymers. Random walk, self-avoiding random walk. Persistence length. Excluded volume interactions. Polymer solutions in the dilute limit/semi-dilute limit. Entropy of mixing, theta temperature, rubber elasticity: elasticity of a freely jointed chain, Chains in good, bad and theta solvents; Flory theory for polymer solutions.Overview of polymer dynamics. Maxwell (phenomenological model). Bead-spring models. Reptation (scaling arguments). Polyelectrolytes: Poisson Boltzmann/Debye-Huckel theory, Bjerrum length.Polymer crystallization. Polymer chains at surfaces.

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AcSIR Academic Centre Code: 26		
CSIR-National Chemical Laboratory		**CSIR-NCL**
Course 3 : Advanced Course	**Physical Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Polymer Processing and Rheology	**AcSIR-26-PS-AD-004**	

1. Theory of Rheology: Definitions of stress, strain, Ideal fluids and solids, Linear viscoelasticity (LVE), Introduction to non-linear viscoelasticity, Linking LVE to Molecular Weight Distribution (MWD), Introduction to mol. constitutive equations.
2. Rheometry: Controlled stress and controlled strain rheometers, Cone & plate and parallel plate geometries, Capillary rheometry, Extensional rheometry: uniaxial, biaxial, exponential shear, hyperbolic die, equibiaxial, Instabilities (slip, fracture, inertia).
3. Linking rheology to macromolecular architecture: Effect of MWD on rheology or determining MWD from rheology, Transformations of LVE data, Creep to G', G" and inverse, Stress relaxation to G', G" and inverse, Effect of long-chain branching (LCB) on rheology,
4. Lab sessions on rheometry, data interpretation and problem solving
5. Basics of various processing techniques: a) Extruders: single screw and twin-screw extruders, Film blowing, Fiber spinning, Pipe extrusion, Extrusion of profiles, Extrusion of cable material, Extrusion of sheet, Calendaring, and Thermoforming. b) One-dimensional process like Coating and Adhesives. c) Molding: injection molding, Compression molding, Transfer molding, Blow molding, Rotational molding, Gas and water assisted injection molding, Reaction injection molding, other three dimensional molding.
6. Compounding: Principles of polymer formulation and modification; Classification and type of Additive for Plastics; Classification and type of Fillers and Reinforcements for Plastics; Type of Impact Modifiers and their applications; Compounding processes and equipment; Use of experimental design in compound formulation; Masterbatch compounding.
7. Reactive Extrusion: Extruder as a reactor; Fit the reactor to Chemistry; Process analysis from reaction fundamentals; Type of Reactions; Process Considerations; Design of Reactive Extruder; and Devolatization.
8. Industry visit: Polymer Processing and other ancillary industries.

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AcSIR Academic Centre Code: 26			
CSIR-National Chemical Laboratory			CSIR-NCL
Course 3 : Advanced Course	Physical Sciences		Total Credits 6
Title: Special Topics in Polymers 1		Course Code	Credits
		AcSIR-26-PS-AD-005	

1. Polymers in Healthcare:

a) Design and methods of synthesis of biocompatible and biodegradable polymers, Synthesis and characterization of drug conjugated polymers, Synthesis and characterization of polymer micelle and vesicles, Drug nanoparticles and drug containing nanofibers for biomedical applications, Pharmacokinetic study, In-vitro and in-vivo study.

b) Synthetic and Natural Polymers, blends, composites in medical devices, Physical and Chemical Properties of biomedical polymers and their characterization, Processing techniques to prepare scaffolds, implants, micro/nanoparticles, Cell and biomaterial interactions and applications and examples.

2. Water soluble polymers and Gels: Introduction to water-soluble polymers and applications, Synthetic methodologies, Structure-property relationship, Associating polymers (APs)/Hydrophobically Modified Polymers (HMPs), clarification behaviour - by solution rheology, preparations, properties and applications of hydrogels.

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AcSIR Academic Centre Code: 26

CSIR-National Chemical Laboratory	CSIR-NCL

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Special Topics in Polymers 2	AcSIR-26-PS-AD-006	

1. Membranes: Basic introduction to membranes and membrane based processes, Mechanism of separation in various types of membrane processes, Application of different polymers as membrane materials.

2. Polymers in energy: Design and methods of synthesis of polymers for energy applications, Tools and methods to characterize conjugated polymers, Fabrication and characterization of devices for energy conversion

3. Composite Materials: Scope and general characteristics of composites; a broad perspective on various applications, Characteristics of fibers, matrices, interface bonding, adhesives; microstructure of composites; types of composites, Physico-mechanical properties of conventional fiber and particulate polymer composites, Traditional and novel approaches; process fundamentals, Basic concepts, stiffness, strength, thermal and moisture expansion, Failure criteria, Laminate Strength, Stress Concentrations, How do actual composites for aerospace, automotive, sporting goods, high temperature applications behave? Problem areas, long-term performance, Synthesis, characterization and application of polymer nanocomposites. Recent advancements, Design concepts; small group design problem using composites (design, build, and test)

4. Microencapsulation: Basics of Control Release Technology, Control Release forms: microcapsules, microspheres, Characterization, Applications

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27	CSIR-NEERI	3	Advanced Course

Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-27-BS-AD-001	Bioremediation - Principles and Applications
Biological Sciences	AcSIR-27-BS-AD-002	Environmental and Applied Microbiology
Biological Sciences	AcSIR-27-BS-AD-003	Environmental Biotechnology
Biological Sciences	AcSIR-27-BS-AD-004	Environmental Genomics
Biological Sciences	AcSIR-27-BS-AD-005	Industrial Ecology
Biological Sciences	AcSIR-27-BS-AD-006	Water Resource Management
Chemical Sciences	AcSIR-27-CS-AD-001	Advanced Analytical Chemistry- Methods & Instrumentation
Chemical Sciences	AcSIR-27-CS-AD-002	Green Chemistry
Chemical Sciences	AcSIR-27-CS-AD-003	Ground Water and Geochemical Studies
Chemical Sciences	AcSIR-27-CS-AD-004	Advances in Nanoscience and Nanotechnology
Chemical Sciences	AcSIR-27-CS-AD-005	Advanced Catalysis
Chemical Sciences	AcSIR-27-CS-AD-006	Thermochemical Conversion of Biomass
Chemical Sciences	AcSIR-27-CS-AD-007	Advanced Separation Science and Technology
Engineering Sciences	AcSIR-27-ES-AD-001	Design of Water and Wastewater Systems
Engineering Sciences	AcSIR-27-ES-AD-002	Environmental Systems Modelling

Faculty of Study	Course Code	Course Title
Engineering Sciences	AcSIR-27-ES-AD-003	GIS for Environmental Planning and Management
Engineering Sciences	AcSIR-27-ES-AD-004	Industrial Pollution Prevention and Clean Technologies
Engineering Sciences	AcSIR-27-ES-AD-005	Industrial Wastewater Management and Reuse
Engineering Sciences	AcSIR-27-ES-AD-006	Socio-Economic Dimensions of Environmental Management
Physical Sciences	AcSIR-27-PS-AD-001	Materials & Environmental Applications
Physical Sciences	AcSIR-27-PS-AD-002	Air Pollution Control Technologies
Physical Sciences	AcSIR-27-PS-AD-003	Groundwater Flow and Contaminant Transport
Physical Sciences	AcSIR-27-PS-AD-004	Advanced Pollution Control Technologies
Physical Sciences	AcSIR-27-PS-AD-005	Degraded Soil Restoration Technologies
Physical Sciences	AcSIR-27-PS-AD-006	Environmental Policy, Law & Economics
Physical Sciences	AcSIR-27-PS-AD-007	Atmospheric Processes, Climate, and Climate Change
Physical Sciences	AcSIR-27-PS-AD-008	Geoinformatics

AcSIR Academic Centre Code: 27			
CSIR-National Environmental Engineering Research Institute			CSIR-NEERI
Course 3 : Advanced Course	Biological Sciences		Total Credits 6

Title: Bioremediation - Principles and Applications	Course Code	Credits
	AcSIR-27-BS-AD-001	2

Concept and dynamics of ecosystem, biogeochemical cycles; Types of ecosystems, Community structure and organisation; Environmental pollution and importance of microbes, Bioremediation: Microcosms, Mesocosms, Bioaugmentation, Biostimulation of Naturally occurring microbial activities, Bioaugmentation, in situ, ex situ, intrinsic & engineered bioremediation, Solid phase bioremediation - land farming, prepared beds, soil piles, Phytoremediation. Composting, Bioventing & Biosparging; Liquid phase bioremediation - suspended bioreactors, fixed biofilm reactors. Biodiversity, Climate change research, Microbe-Plant interactions, Eco-restoration and Remediation technologies, Environmental Management, Waste management through Eco-friendly approaches, Constructed wetlands for treatment of Wastewaters, Biomolecules in remediation, Microbial diversity in different Ecosystem, Bioremediation/Phytoremediation, Carbon sequestration and Clean Development Mechanisms, Resource recovery from waste, Bio-energy, Bioproduct, Environmental Biotechnology, Green chemistry. Xenobiotic compounds, recalcitrance. hazardous wastes - biodegradation of Xenobiotics . Biological detoxification - market for hazardous biotechnology application to hazardous waste management - examples of biotechnological applications to hazardous waste management – cyanide detoxification - detoxification of oxalate, urea etc. - toxic organics - phenols.

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AcSIR Academic Centre Code: 27

CSIR-National Environmental Engineering Research Institute **CSIR-NEERI**

Course 3 : Advanced Course	**Biological Sciences**	**Total Credits 6**

Title:	**Course Code**	**Credits**
Environmental and Applied Microbiology	**AcSIR-27-BS-AD-002**	**3**

Microbes as tools for understanding the biological processes: Physiology, biochemistry, genetics, molecular biology, genomics, proteomics. Microbes and environment: Pollution abatement, bioindicators, restoration of degraded ecosystems, biodegradation, bioremediation, biogenic gases, microbes in biological warfare. Application of microbes in fermentation processes: Types, design and maintenance of bioreactors, application of fermentation technology in industry. Medical microbiology: Microbes as causal agents of human and animal diseases; immunology: basic concepts, vaccines, immunotherapy. Role of microbes in relation to agriculture: Nitrogen economy, plant health, biological control. Symbiotic associations: Concepts, types and applications. Microbes in food and dairy industry: Mushrooms, fermented foods, microbial spoilage of food and dairy products, toxins. Extremophiles and their biotechnological applications. Microbial technology: Biosensors, biomolecules, enzymes.

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AcSIR Academic Centre Code: 27

CSIR-National Environmental Engineering Research Institute CSIR-NEERI

Course 3 : Advanced Course | Biological Sciences | Total Credits 6

Title:	Course Code	Credits
Environmental Biotechnology	**AcSIR-27-BS-AD-003**	**2**

Biological Treatment Processes: Biochemistry and Microbiology of Aerobic and Anaerobic Treatment Processes; Suspended and Attached Growth Type Aerobic Processes- Activated Sludge, Oxidation Ditch, Aerated Lagoons, Oxidation Ponds and Their Variations; Trickling Filters, Rotating Biological Contactors, Other Aerobic Processes. Suspended and Attached Growth Type Anaerobic Processes- Anaerobic Digesters, Fixed and Fluidized Types of Anaerobic Bioreactors, UASB Bioreactors Treatment of Typical Industrial Effluents- Diary, Distillery, Sugar, and Antibiotic Industries. Degradation of Xenobiotic Compounds in Environment: Decay Behaviour and Degradative Plasmids; Hydrocarbons; Substituted Hydrocarbons; Oil Pollution; Surfactants; Bioremediation of Contaminated Soils. Biopesticides and biofertilizers; their role in pest and nutrient Management; Wormiculture. Solid Wastes: Sources and Management; Composition; Methane Production; Food, Feed and Fuel from Biomass Global Environmental Problems: Ozone Depletion; UV-B and Green House gases and Biotechnological Approaches of their Management.

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CSIR-National Environmental Engineering Research Institute	CSIR-NEERI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Environmental Genomics	AcSIR-27-BS-AD-004	3

Concept of Genomics, Microbial Genomics as tool for understanding environment related issues in different area (soil, air water, wastewater) History of genetic engineering, restriction, modifying and polymerase enzymes used in genetic engineering, vectors used in genetic engineering of microbes, Bacterial hosts used in cloning and expression. Molecular Techniques: Isolation of nucleic acids (DNA, RNA, e-DNA, Metagenome), PCR, optimization of PCR, gene specific and degenerate primer design, automated DNA sequencing, pyrosequencing, Principles and techniques of nucleic acid hybridization and Cot curves; Southern blotting techniques; Polymerase chain reaction; RAPD, Real Time PCR, RT-PCR Construction of cDNA library, PCR based cDNA library, subtractive cDNA library, normalized cDNA library, genomic DNA library, BAC library, Cloning methods using restriction enzymes, cloning in expression vector, cloning of PCR products. Phylogenetics, cladistics and ontology; Phylogenetic representations – graphs, trees and cladograms; Steps in phylogenetic analysis; Methods of phylogenetic analysis – similarity and distance tables, distance matrix method; Method of calculation of distance matrix (UPGMA, WPGMA); The Neighbor Joining Method: - maximum parsimony, maximum likelihood; Phylogenetic softwares –PHYLIP. Genome maps and types; current sequencing technologies; partial sequencing; gene identification; gene prediction rules and software's; Genome databases; Annotation of genome. Genome diversity: taxonomy and significance of genomes. Methods of sequence alignment: Sequence similarity searches and alignment tools – dynamic programming algorithms; Needlman-Wunch and Smith Waterman, Optimal global alignment and optimal local alignment; Concept; Programmes (Dot matrix, Dot plot, Dynamic programming); Similarity Searches; Sequence repeats and inversion; Database searching (BLAST and FASTA. Multiple Sequence alignment (MSA) – significance; softwares (Clustal, ClustalW, Meme).

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 27	
CSIR-National Environmental Engineering Research Institute	CSIR-NEERI

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Industrial Ecology	AcSIR-27-BS-AD-005	2

Industrial ecology and sustainable industrial development Techniques for eco-leveling, inventory analysis and input/output models. Material flow analysis and dematerialization Scope of Environmental Management System in industries Recycling of waste materials in industries Scope of green belt development in and around industrial zones.

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AcSIR Academic Centre Code: 27

CSIR-National Environmental Engineering Research Institute CSIR-NEERI

Course 3 : Advanced Course Biological Sciences Total Credits 6

Title:	Course Code	Credits
Water Resource Management	AcSIR-27-BS-AD-006	2

Global distribution of water resources, water need and consumption; Threats to surface water resources; Principles and approaches to surface water management. Watershed management: Catchment infiltration models, rain water harvesting and storage, recharging of ground water; Role of dams. Properties of sewage and industrial effluents; Effluent standards; Treatment of industrial effluents, sewage treatment (primary, secondary and tertiary treatment), advanced treatments (nitrate and phosphate removal); Sludge treatment and disposal; Waste water use. Drinking water quality and water treatment (desalination, ion-exchange, reverse osmosis and disinfection of water). Management of degraded water resources. People's participation and mass awareness programmes for water resource management.management – cyanide detoxification - detoxification of oxalate, urea etc. - toxic organics - phenols.

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AcSIR Academic Centre Code: 27

CSIR-National Environmental Engineering Research Institute **CSIR-NEERI**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits**	**6**

Title:		Course Code	Credits
	Advanced Analytical Chemistry- Methods & Instrumentation	**AcSIR-27-CS-AD-001**	**3**

Techniques for Structural Characterization and Materials Characterization
Techniques for Structural Characterization: Basic theory, instrumentation and analytical applications of the following physical methods: Spectroscopic techniques [NMR, ESR, MS (EI, FAB, MALDI-TOF), IR, UVVis, Fluorescence and Phosphorescence, Atomic Absorption], X-ray diffraction (single crystal XRD)

Techniques for Materials Characterization: Basic theory, instrumentation and analytical applications of the following physical methods: X-ray diffraction methods (powder method), Thermoanalytical methods (TGA, DSC, DTA), Microscopic methods (Polarized optical microscope, SEM, TEM, AFM), Surface Properties (XPS, BET), Mechanical Properties (DMA), Rheological properties (Viscometer, Rheometer), Electrical properties (Conductivity, Cyclic Voltammetry).

Advanced Separation Techniques: Chromatographic techniques: Introduction, classification of chromatographic methods, terms and relationships in chromatography, sample characterization.
Principle, instrumentation and applications of : High performance thin layer chromatography(HPTLC), Gas chromatography (GC) ,High performance liquid chromatography (HPLC), Ion exchange chromatography(IEC),Gel permeation chromatography(GPC/SEC), Affinity chromatography(AC), Supercritical fluid chromatography and extraction (SFC& SFCE),Hyphenated Techniques: Principles and Applications of: LC-MS, GC-MS, GCFTIR, Electrophoretic Separation Techniques: Principle, Instrumentation and Applications of: Polyacrylamide Gel Electrophoresis (PAGE), Capillary electrophoresis (CE), High Performance Capillary Electrophoresis (HPCE),Pulsed Field Gel Electrophoresis (PFGE),Membrane Separation Techniques: Principle, Instrumentation and Application of : Reverse Osmosis (RO) and Nanofiltration (NF), Ultra Filtration (UF), Micro Filtration (MF), Dialysis and Electro dialysis (ED), Pervaporation.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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CSIR-National Environmental Engineering Research Institute **CSIR-NEERI**

Course 3 : Advanced Course **Chemical Sciences** **Total Credits 6**

Title:	Course Code	Credits
Green Chemistry	**AcSIR-27-CS-AD-002**	**3**

Emerging greener methodologies: Sonochemistry and green aspects; Microwave in chemical synthesis: Basic principles, advantages and examples; Electrochemical synthesis: concepts and examples.
Organic solvents: Environmentally benign solvents, Solvent-free synthesis; Water as a reaction solvent; Ionic liquids
Phase transfer catalysis: Definition, Mechanism, Types of phase transfer catalysts, Synthesis and synthetic applications
Transition metal catalyzed organic reactions Organocatalysis.

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AcSIR Academic Centre Code: 27

CSIR-National Environmental Engineering Research Institute	CSIR-NEERI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Ground Water and Geochemical Studies	AcSIR-27-CS-AD-003	2

Water movement in the subsurface; Groundwater and the hydrologic cycle; The groundwater environment; Types of aquifers; Sources of contamination; Saturated flow: continuity equation; Darcy's Law; Equation of flow; Analytical solutions and numerical modeling; Unsaturated flow; Ground water sampling methods and analyses.

Transport of contaminants; Transport equation; Dispersion and diffusion in porous media; Reaction terms; Analytical solutions; Soil chemistry; Groundwater quality; Common soil minerals and components; Forces at soil-water interfaces;

Adsorption and surface complexation models; Interaction of non-polar compounds with soils; Soil chemical kinetics; Modelling Groundwater Pollution; Coupling of contaminant-soil interactions with transport; Reaction and transport of trace metals, ligands and nonpolar organic solutes.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 27

CSIR-National Environmental Engineering Research Institute CSIR-NEERI

Course 3 : Advanced Course Chemical Sciences Total Credits 6

Title:	Advances in Nanoscience and Nanotechnology	Course Code	Credits
		AcSIR-27-CS-AD-004	3

Synthesis and Properties: Method of Synthesis: RF Plasma Chemical Methods, Thermolysis, Pulsed Laser Methods, Biological Methods: Synthesis using micro-organisms, Synthesis using Plant Extract, Metal Nanoclusters, Magic Numbers, Modelling of Nanoparticles, Bulk to Nano Transitions.
Carbon Nanostructures: Nature of Carbon Clusters, Discovery of C60, Structure of C60 and its Crystal, Superconductivity in C60, Carbon Nanotubes: Synthesis, Structure, Electrical and Mechanical Properties. Graphene: Discovery, Synthesis and Structural Characterization through TEM, Elementary Concept of its applications.
Quantum Wells, Wires and Dots: Preparation of Quantum Nanostructures, Size Effects, Conduction Electrons and Dimensionality, Properties Dependent on Density of States.
Analysis Techniques for Nano Structures/ Particles: Scanning Probe Microscopes (SPM), Diffraction Techniques, Spectroscopic Techniques, Magnetic Measurements
Bulk Nanostructure Materials: Methods of Synthesis, Solid Disorders Nanostructures, Mechanical Properties, Nanostructure Multilayers, Metal Nanocluster, Composite Glasses, Porous Silicon.

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AcSIR Academic Centre Code: 27

CSIR-National Environmental Engineering Research Institute **CSIR-NEERI**

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Catalysis	**AcSIR-27-CS-AD-005**	**2**

Surface Chemistry and Catalysis: Bimolecular surface reactions - reaction between a gas molecule and an adsorbed molecule, reaction between two adsorbed molecules, inhibition and activation energy of such reactions. Catalytic activity at surfaces (volcano curve), transition state theory of surface reactions: rates of chemisorption and desorption, unimolecular and bimolecular surface reaction, comparison of homogeneous and heterogeneous reaction rates, surface heterogeneity, lateral interaction.

Transition metal compounds in catalysis: Hydrogenation, hydroformylation and polymerization; Waker Process.

Determination of reaction order, stochiometric number, and transfer coefficient. Electrocatalysis- comparison of electrocatalytic activity. Importance of oxygen reduction and hydrogen evolution reactions and their mechanisms.

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AcSIR Academic Centre Code: 27

CSIR-National Environmental Engineering Research Institute CSIR-NEERI

Course 3 : Advanced Course | Chemical Sciences | Total Credits 6

Title:	Course Code	Credits
Thermochemical Conversion of Biomass	AcSIR-27-CS-AD-006	3

Bio-energy: Biomass as energy source, biomass production; energy farming; biomass types and their characteristics; biomass conversion processes – Thermo-chemical and bio-chemical; thermo-chemical – combustion, gasification, liquefaction and pyrolysis of biomass; fermentation of biomass; anaerobic digestion of biomass and digester types; biodiesel; environmental consequences of biomass resource harnessing.
Energy storage and distribution: Importance; biological, chemical, electricity and heat storage; mechanical storage, distribution of energy.
Energy conservation: National energy policy, energy efficiency improvement, audit and energy saving.

High-rate algal ponds for the treatment of wastewaters and for the production of useful biomass and energy; immobilized and inactivated algal biomass for metal and nutrient removal.

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CSIR-National Environmental Engineering Research Institute	CSIR-NEERI

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Separation Science and Technology	AcSIR-27-CS-AD-007	2

Chromatographic techniques: Introduction, classification of chromatographic methods, terms and relationships in chromatography, sample characterization.
Principle, instrumentation and applications of: High performance thin layer chromatography (HPTLC), Gas chromatography (GC), High performance liquid chromatography (HPLC), Ion exchange chromatography (IEC), Gel permeation chromatography (GPC/SEC), Affinity chromatography (AC), Supercritical fluid chromatography and extraction (SFC& SFCE), Hyphenated Techniques: Principles and Applications of: LC-MS, GC-MS, GCFTIR. Electrophoretic Separation Techniques: Principle, Instrumentation and Applications of: Polyacrylamide Gel Electrophoresis (PAGE), Capillary electrophoresis (CE), High Performance Capillary Electrophoresis (HPCE)
Pulsed Field Gel Electrophoresis (PFGE) Membrane Separation Techniques: Principle, Instrumentation and Application of: Reverse Osmosis (RO) and Nanofiltration (NF)
Ultra Filtration (UF), Micro Filtration (MF), Dialysis and Electro dialysis (ED), Pervaporation.

AcSIR Academic Centre Code: 27

CSIR-National Environmental Engineering Research Institute CSIR-NEERI

Course 3 : Advanced Course | Engineering Sciences | Total Credits 6

Title:	Design of Water and Wastewater Systems	Course Code	Credits
		AcSIR-27-ES-AD-001	2

General considerations for source of drinking water; Economic sizing of pumping mains; Considerations for layout of treatment plant; Water treatment plant design, Design of water distribution network and wastewater collection system using EPANET AND LOOP program.
Design of Screens; Grit chamber; Aerated grit chamber; Communitor; Sizing of flow equalisation tank; Design of primary sedimentation tank. Activated sludge process and its modifications; Trickling filter design along with hydraulic considerations; Rotating biological contactor; Aerated lagoons; Waste stabilisation ponds.
Anaerobic treatment Process; Design of upflow anaerobic sludge blanket reactor; Design of anaerobic sludge digester; Design of sludge drying beds.

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AcSIR Academic Centre Code: 27

CSIR-National Environmental Engineering Research Institute — CSIR-NEERI

Course 3 : Advanced Course — Engineering Sciences — Total Credits 6

Title:	Course Code	Credits
Environmental Systems Modelling	AcSIR-27-ES-AD-002	3

Definition; Classification; Examples of models for environmental systems. Introduction to air quality models; Meteorology; Atmospheric stability and turbulence; Gaussian plume model and modifications; Numerical models, Urban diffusion models, Calibration and sensitivity analysis; Applications of public domain models and software, Global radiation balance and climatic changes.

Transport and fate of pollutant in aquatic systems; Introduction to river, estuarine and lake hydrodynamics; Stratification and eutrophication of lakes; Dissolved oxygen model for streams; Temperature models. Transport and fate of pollutants in soils and ground water; Utility of environmental models for forecasting. Computational methods in environmental modelling.

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AcSIR Academic Centre Code: 27

CSIR-National Environmental Engineering Research Institute	**CSIR-NEERI**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:	**GIS for Environmental Planning and Management**	**Course Code**	**Credits**
		AcSIR-27-ES-AD-003	**3**

Introduction to GIS, Data input, verification, storage and output, Data structures in GIS, Data analysis and spatial modeling, DEMS, DTMS, Surfaces, TINS and Networks in GIS.
Introduction to remote sensing particularly for getting Input data from remote sensing.
Introduction to GIS software and hardware. Laboratory sessions with hands on practice on GIS software say ArcGIS.
Case studies on various applications of GIS for environmental planning and management

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AcSIR Academic Centre Code: 27

CSIR-National Environmental Engineering Research Institute	CSIR-NEERI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Industrial Pollution Prevention and Clean Technologies	Course Code	Credits
		AcSIR-27-ES-AD-004	3

Principles and techniques for industrial pollution prevention and waste minimization; Nature and characteristics of industrial wastes; Prevention versus control of industrial pollution; Source reduction tools and techniques: raw material substitution, toxic use reduction and elimination, process modification and procedural changes; Recycling and reuse; Opportunities and barriers to cleaner technologies; Pollution prevention economics. Waste audits, emission inventories and waste management hierarchy for process industries; Material balance approach; Material and process mapping approach; Emission sources; Estimation of fugitive emissions; Environmental impact of VOCs; Energy and resource (material and water) audits for efficient usage and conservation. Unit operations in separation technology.

Pollution prevention for unit operations: Boilers and Heat Exchangers; Storage tanks; Distillation columns; Application of separation technologies for pollution prevention; Process optimization for cleaner industrial processes: Flowsheet analysis—qualitative and quantitative approaches using mass exchange networks; Thermodynamic constraints to waste minimization; Holistic and critical technology assessment; Environmental performance indicators; Concept of industrial ecology and symbiosis of eco-parks.

Case studies on industrial applications of cleaner technologies in chemical, metallurgical, pulp and paper, textile, electroplating, leather, dairy, cement and other industries.

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AcSIR Academic Centre Code: 27	
CSIR-National Environmental Engineering Research Institute	CSIR-NEERI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title: Industrial Wastewater Management and Reuse	Course Code	Credits
	AcSIR-27-ES-AD-005	3

Industrial wastewater treatment: Treatment of industrial effluents released from textile, dairy, leather, thermal power and chemical industries.

Disinfection of treated water: Ozonization of secondary treated wastewater; chemical and other methods for disinfection.

Water management strategies: Rain water harvesting, use of rain water, recharging of ground water; use of domestic waste water; recycling of waste water; recycling of industrial effluents after treatment.

Water pollution monitoring and management bodies: Important organizations involved in water pollution monitoring in India and role of NGOs in water pollution management.

References:

1. Stanley E. Manhan, 2007, Environmental Science and Technology, Lewis Publishers, New York.
2. Stanley E. Manhan, 2001, Fundamentals of Environmental Chemistry, Lewis Publishers, New York.
3. Stanley E. Manhan, 2005, Environmental Chemistry, Lewis Publishers, New York.
4. APHA, 1998, Standard methods for examination of water and waste water, American Public Health Assocation, 18th Edition, Washington, D.C.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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Title:	Course Code	Credits
Socio-Economic Dimensions of Environmental Management	AcSIR-27-ES-AD-006	2

Population explosion and social factors affecting development - poverty, affluence, education, employment, child marriage and child labour.
Environment and human health, human rights, value education, women and child welfare, Impact of development on environment - changing patterns of land use, land reclamation, deforestation, resource depletion, pollution and environmental degradation.
Basic concepts of sustainable development and social environmental issues, Community participation and capacity building programmes for sustainable socio-economic and ecological development.
Role of NGOs in environmental awareness and management, Role of media in environmental awareness and management

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AcSIR Academic Centre Code: 27

CSIR-National Environmental Engineering Research Institute CSIR-NEERI

Course 3 : Advanced Course | Physical Sciences | Total Credits 6

Title:	Course Code	Credits
Materials & Environmental Applications	AcSIR-27-PS-AD-001	3

Metals: Process analysis, Instrumentation and control, Iron and steel making, Deformation behavior and microstructure evolution during creep and superplasticity, Mineral processing and extractive metallurgy, Metal forming, Mechanical behavior, Welding, Physical metallurgy, Phase transformation, Structure property relationship, Thermomechanical processing and texture analysis.

Ceramics: Electronic ceramics, Bioceramics, Glasses and glass ceramics, Electrical and optical properties, Magnetic materials, Dielectric and piezoelectric ceramics and devices, Ceramic foams, Industrial ceramics, High temperature ceramics, Near net shape forming, Gel casting, Rheology of suspensions.

Semiconductors and magnetic materials: Devices of thin film elemental semiconductors and alloy systems, Surface treatment and surface engineering, Chemical vapor deposition, Structure property correlation in nanocrystalline magnetic materials, Magneto-resistor materials, Materials for sensors and batteries, Superconductors, Thermoelectric materials, Organic semiconductors, Solar cells, Nanophotonic, Synthesis and processing of ion conductors, Materials for energy generation and storage materials for quantum computing and ultrahigh vacuum systems for thin film systems.

Polymers and composites: Polymer blends, Polymer carbon nanotube composites, Polymer thin films, Polymer nanocomposites, Thermodynamic, metamorphological, Mechanical properties of polymers, Responsive, functional and conjugated polymers, Metal matrix composites, Structure property relations.

Wear and corrosion: Fracture and failure, Nondestructive evaluation, Aqueous corrosion, Metallurgy of corrosion, Oil and gas corrosion, and protective coatings (paints, high temperature coatings etc.).

Modeling and simulations: Modeling of metallurgical processes, Heat and mass transport, Modeling of metal forming, Optimization, Monte Carlo simulations, Dislocation dynamics simulations, Molecular dynamics & simulations, Phase field modelling, First principle calculations, Crystal plasticity.

References:

W.D. Callister, 1997, Materials Science an Engineering-, 5th Ed, John Wiley & Sons.

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AcSIR Academic Centre Code: 27

CSIR-National Environmental Engineering Research Institute CSIR-NEERI

Course 3 : Advanced Course | Physical Sciences | Total Credits 6

Title:	Course Code	Credits
Air Pollution Control Technologies	AcSIR-27-PS-AD-002	3

Atmospheric composition and climate: Gaseous and particulate pollutants, Emission trends and scenarios: Climate change, Drivers of climate change, Greenhouse gas emission scenarios: Indoor air pollution.
Sulphur derivatives: Sources and cycling of sulphur, Effects on plants, Human health and ecosystems, Mechanisms of toxicity, Resistance and buffering, Sulphur metabolism, Threshold and injury.
Nitrogen derivatives: Formation and sources, Deposition, uptake, metabolism, critical load, Effects on plants, human health and ecosystems.
Fluoride derivatives: Sources and cycling, Bioaccumulation, threshold and injury, Eeffects on plants, Human health and ecosystems.
Oxidants: Formation and sources, Photochemical smog, Effects on plants and human health, Mechanisms of toxicity, Resistance, Critical load.
Stratospheric ozone depletion: Phenomenon, causes, irradiation scenarios, Effects of enhanced UV-B on plants, Microbes and human health, Biological action spectra.
Greenhouse effects: Process, consequences, global warming, Sea level rise, Albedo, Oceanic influences, Agriculture, Natural vegetation, Effects of increased CO2 on plants, Human implications.
Acid rain: Formation, dispersion and deposition, Trends, Consequences on soil fertility, rivers and lakes, Effects on plants, leaf injury, buffering, reproduction, Forest decline, Effects on fisheries.
Biomonitoring of air pollution: Concept, active and passive monitoring, Bioindicator parameters, Air pollution tolerance indices, Control of air pollution by plants, Green belt design.

References:

1. A.B. Pittock, 2009, Climate change, the Science, Impacts and Solution. (2nd edition). CSIRO publication.
2. Hirt Heribert, Kazuoshinozaki (Eds.), 2004, Plant Responses to Abiotic Stress. Springer-Verlag Berlin.
3. J.N.B. Bell and M. Treshow (Eds.), 2004. Air Pollution and Plant Life. John Wiley and Sons, England.
4. Jelte Rozema, Viannis Manetas, L. Bjorn (Eds.), 2001. Response of Plants to UVB radiation; Kluwer Academic Publishers, the Netherland.
5. W.W Heck, O.C. Taylor and D.T Tingey (Eds.), 1988. Assessment of Crop Loss from Air Pollutants. Elsevier Applied Science, New York.

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AcSIR Academic Centre Code: 27

CSIR-National Environmental Engineering Research Institute CSIR-NEERI

Course 3 : Advanced Course Physical Sciences Total Credits 6

Title:	Course Code	Credits
Groundwater Flow and Contaminant Transport	**AcSIR-27-PS-AD-003**	**3**

Water movement in the subsurface, Groundwater and the hydrologic cycle, Groundwater environment, Types of aquifers, Sources of contamination. Saturated flow: Continuity equation, Darcy's Law, Equation of flow, Analytical solutions and numerical modeling, Unsaturated flow, Ground water sampling methods and analyses.

Transport of contaminants: Transport equation, Dispersion and diffusion in porous media, Reaction terms, Analytical solutions, Soil chemistry, Groundwater quality, Common soil minerals and components, Forces at soil-water interfaces.

Adsorption and surface complexation models, Interaction of non-polar compounds with soils, Soil chemical kinetics, Modelling Groundwater Pollution, Coupling of contaminant-soil interactions with transport, Reaction and transport of trace metals, Ligands and nonpolar organic solutes.

References:

1. Todd, D.K., Groundwater Geology, 2nd Ed., John Wiley, NY, 2001
2. Domenico, P.A., and Schwartz, F.W., Physical and Chemical Hydrogeology, John Wiley and Sons, New York, 1990.
3. Grathwohl, P., Diffusion in Natural Porous Media : Cntaminant Transport, Sorptiondesorption and Dissolution Kinetics, Kluwer Academic, Boston, 1998
4. Appelo, C.A.J., and Postma, D., Geochemistry, Groundwater and Pollution, A.A. Balkema Publishers, Rotterdam, 1993.
5. Freeze, R.A., and Cherry, J.A., Groundwater, Prentice Hall, Englewood Cliffs, New Jersey, 1979.

AcSIR Academic Centre Code: 27			
CSIR-National Environmental Engineering Research Institute			CSIR-NEERI
Course 3 : Advanced Course	Physical Sciences		Total Credits 6
Title: Advanced Pollution Control Technologies		Course Code	Credits
		AcSIR-27-PS-AD-004	3

Principles and operating methodologies of wastewater treatment technologies: ASP, Upflow aerobic sludge blanket (UASB), Biological filtration & oxygenated reactor (BIOFOR), Fluidized aerated bed (FAB), Oxidation ponds and lagoon technologies etc. Principles and operating methodologies of air pollution control technologies: ESP, Stack pollution controller, Bag filter, Ventury scrubber, Clone precipitator & Wet scrubber etc. Monitoring and control of noise pollution at source, transmission path and receiver.Principles and applications of disinfection techniques: Chlorination, Ozonation, UV treatment, Bio-filtration etc.

References:

1. Stanley E. Manhan, 2007, Environmental Science & Technology, Lewis Publishers, New York.
2. Howard S. Peavy, Donald R Rowe, George Tchobanoglous, 1985, Environmental Engineering, McGraw Hill Book Company.

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AcSIR Academic Centre Code: 27

CSIR-National Environmental Engineering Research Institute | CSIR-NEERI

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Degraded Soil Restoration Technologies	AcSIR-27-PS-AD-005	3

Definition of soil and soil properties, Nature and arrangement of soil solids, Measurement of physical properties of solid phase.
Liquid phase characteristics and measurements: Potential, Capillarity, Hysteresis; Prediction of soil moisture characteristics, Composition and properties of the air phase.
Fundamentals of unsaturated fluid flow, Hydraulic conductivity measurement and prediction, Infiltration of water, Movement of non-aqueous fluids in soils, Two-phase transport properties, Richard's equation, Immiscible displacement.
Chemical composition of soils: Soil minerals, Structure and surface functional groups, Mineral solubility and weathering, Surface chemistry and electric double layer, Composition and chemistry of soil organic matter, Inorganic and organic contaminant sorption processes.

References:

1. Jury, W.A., W.R. Gardner and W.H. Gardner, Soil Physics, 5th Ed. John Wiley, New York, 1991.
2. Hillel, D., Introduction to Environmental Soil Physics, Elsevier Academic Press, Amsterdam, 2004
3. Essington, M.E., Soil and Water Chemistry—An Integrative Approach, CRC Press, Boca Raton, 2004.
4. Sposito, G., The Chemistry of Soils, Oxford University Press, New York, 1989.

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AcSIR Academic Centre Code: 27

CSIR-National Environmental Engineering Research Institute	CSIR-NEERI

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title: Environmental Policy, Law & Economics	Course Code	Credits
	AcSIR-27-PS-AD-006	3

Management of natural resources on a sustainable basis, Reduction of threats to environmental degradation, Environmental regulations and their compliance.
Broad aspects of environmental economics, Society and environment, Sustainable development, Regional and global strategies of management of environment, Environmental movements.
Environmental legislation: Role of U.N. and its associate bodies, Role of world bank, Administering global environmental funds, Environmental programmes and policies in developed and developing countries, Environmental programmes and policies of India, Structural changes for environmental managements, Sectoral policies on land, water, forestry, energy, industrial pollution, Human resources development.
Environmental impact assessment (EIA): Rationale and historical development of EIA, Methodologies and socio-economic aspects of EIA, Status of EIAs in India, Case studies stressing socio-economic aspects of EIA. Planning Levels, Physical planning and development, Cost-Benefit analysis,
Methods of economic evaluation of intangible environmental resources: Contingent method, Travel cost, Opportunity cost, Concept of consumer behaviour, Environmental consumerism.

References:

1. Stavins, R.N, Economics of the Environment – Selected Readings. 5th ed. W.W. Nations and Co., New Delhi. 2005
2. Mukherjee, B. Environmental Management. Vikas Pub. House Pvt. Ltd., New Delhi. 1997
3. Kolstad, C.D. Environmental Economics. Oxford University Press. 2000
4. Hussen, A. Principles of Environmental Economics. 2nd ed. Routledge, U.K. 2004.
5. Tietenberg, T. 2004. Environmental and Natural Resource Economics. 6th ed. Pearson Education.
6. Ravindranath, N.H., Rao, U.K. Natarajan, B. and Monga, P. Renewable Energy and Environment – A Policy Analysis of India. Tata McGraw Hill, New Delhi. 2002.

AcSIR Academic Centre Code: 27

CSIR-National Environmental Engineering Research Institute **CSIR-NEERI**

Course 3 : Advanced Course **Physical Sciences** **Total Credits 6**

Title:	Course Code	Credits
Atmospheric Processes, Climate, and Climate Change	**AcSIR-27-PS-AD-007**	**3**

Principle laws of radiation, Geographical and seasonal distribution of solar radiation, Direct beam insolation at the earth's surface, Radiative heating and cooling, Radiative equilibrium and stratosphere, Mean heat balance of the earth atmospheric system, Poleward transport of energy, Fundamental link with general circulation.

Atmospheric aerosols and condensation nuclei, Nucleation, Physics of initial stages of condensation, Curvature and solution effect, Growth and evaporation of cloud droplets by diffusion, Physics of precipitation in warm clouds, Collision-coalescence theory, Collection efficiency, Terminal velocity, Bergeron and Findeisen's theory, Artificial cloud seeding.

Electrical field of the earth in fair and disturbed weather, Atmospheric ionization, Air earth electric current and its maintenance, Supply current, Theories of charge generation and separation in thunderstorm, Lightning discharges.

Orbital motion of satellites, Types of meteorological satellites, Visible and infrared data and their interpretation, Identification of typical weather systems from cloud picture, Estimation of winds, Vertical temperature and humidity profile and rainfall from satellite observations, Tropical cyclone grading using Dvorak's technique.

Laws of thermodynamics, Internal energy, Adiabatic process, Specific heat capacity, Enthalpy, Entropy. Thermodynamics of water vapour and moist air. Isotherms on an e diagram, Equation of state of moist air, Clausius Clapeyron equation, Adiabatic processes of saturated air and moisture variables. Hydrostatic equation, Geo-potential height computations for upper-air sounding, Hydrostatic of homogeneous atmosphere, Isothermal atmosphere, constant lapse rate atmosphere and dry adiabatic atmosphere. Properties of standard atmosphere.

Hydrostatic Stability and Instability: General consideration, Slice method, entrainment. Fundamental forces, gravitation and gravity, Geo-potential.

Equation of motion in different coordinate systems, tangential, local, rectangular coordinates, Spherical polar coordinates, Natural coordinates, Scale analysis of the equations of motion, Approximate equations, Rossby number. Continuity equation in cartesian, isobaric and spherical coordinate, Kinematics of vertical motion, Adiabatic and omega equation.

Balanced Motion: Inertial wind, Geostrophic wind, Gradient wind, Cyclostrophic wind and Thermal wind

References:

1. Compendium of Meteorology, Vol. I., 1981, Dynamic Meteorology, W.M.O. No. 364, Geneva.
2. G.J. Haltiner, and R.T. Willians, 1980, Numerical Prediction and Dynamic Meteorology, John Wiley & Sons., New York.
3. J. R. Holton, 1979, An Introduction to Dynamic Meteorology, Academic Press., New York.
4. S.L. Hess, 1979, Introduction to Theoretical Meteorology, Krieger Pub Co., New York.
5. D. S. Wilks, 2005, Statistical Methods in the Atmospheric Sciences, Academic Press., New York.
6. H. von Storch and F. W. Zwiers, 2010, Statistical Analysis in Climate Research, Cambridge University Press., London.
7. M. Iqbal, 1983, An Introduction to Solar Radiation, Academic Press., New York.
8. S. Q. Kidder and T. H. Vonder Haar, 1995, Satellite Meteorology: An Introduction, Academic Press, New York.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 27

CSIR-National Environmental Engineering Research Institute CSIR-NEERI

Course 3 : Advanced Course | Physical Sciences | Total Credits 6

Title:	Course Code	Credits
Geoinformatics	AcSIR-27-PS-AD-008	3

Geographic information systems, Map projections & surveying, Understanding geographic data, Global positioning systems, Photogrammetry methods, Remote sensing of environment, Digital image processing, Digital cartography, Applications of GIS and remote sensing in environmental monitoring and management.

References:
1. Reddy, M. A. (2004): Geoinformatics for Environmental Management. B. S. Publishers Hyderabad.
2. Bonham, Carter, G.F. (1995): Information Systems for Geoscientists – Modelling with GIS Pergamon, Oxford.
3. Burrough, P.A. and McDonnell, R. (1998): Principles of Geographic Information Systems. Oxford University Press, Oxford.
4. Chang, K.T. (2003): Introduction to Geographic Information Systems. Tata McGraw Hill Publications Company, New Delhi.
5. Chauniyal, D. D. (2004): Remote Sensing and Geographic Information Systems. (in Hindi). Sharda Pustak Bhawan, Allahabad.
6. Demers, M. N. (2000): Fundamentals of Geographic Information Systems. John Wiley and Sons,Singapore.
7. ESRI (1993): Understanding GIS. Redlands, USA
8. Fraser Taylor, D.R. (1991): Geographic Information Systems. Pergamon Press, Oxford.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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Faculty of Study	Course Code	Course Title
Physical Sciences	AcSIR-28-PS-AD-001	Advanced Geochemistry and Geochronology
Physical Sciences	AcSIR-28-PS-AD-002	Advanced Seismic Methods and Other Geophysical Techniques
Physical Sciences	AcSIR-28-PS-AD-003	Geohazards and Geological Risk analyses
Physical Sciences	AcSIR-28-PS-AD-004	Geomagnetism, Paleo magnetism, Archaeomagnetism
Physical Sciences	AcSIR-28-PS-AD-005	Geophysical Signal Processing , Inverse theory and Computational Methods
Physical Sciences	AcSIR-28-PS-AD-006	Geothermics and Geodynamics
Physical Sciences	AcSIR-28-PS-AD-007	Groundwater exploration, quality and Modelling
Physical Sciences	AcSIR-28-PS-AD-008	Nonlinear dynamics and fractal in earth sciences
Physical Sciences	AcSIR-28-PS-AD-009	Palaeoceanography and Paleoclimatology
Physical Sciences	AcSIR-28-PS-AD-010	Planetary Geology
Physical Sciences	AcSIR-28-PS-AD-011	Potential Field theory, Gravity and Magnetics
Physical Sciences	AcSIR-28-PS-AD-012	Remote sensing, GIS and Spatial Analysis methods

AcSIR Academic Centre Code: 28

CSIR-National Geophysical Research Institute | CSIR-NGRI

Course 3 : Advanced Course | Physical Sciences | Total Credits 6

Title:	Course Code	Credits
Advanced Geochemistry and Geochronology	AcSIR-28-PS-AD-001	3

Petrology: Isotopic dating Definitions,Basics of Petrography,Classification of rocks into Igneous, Sedimentary and Metamorphic rocks, Igneous Petrology:
Magma and magma genesis, Partial melting and Magmatic differentiation, Contamination and Mixing of magmas, Role of Volatile components, Binary and Ternary systems, Textures and structures of Igneous rocks, Classification of Igneous rocks - historic perspective and the IUAG systematic, Petrogenetic Provinces: Continental areas, Layered gabbroic intrusions, Plutonic, Oceanic areas and Oceanic Rift valleys , Descriptive petrology: Volcanic and Plutonic Igneous rocks, Continental and oceanic mantle lithosphere
Magmatism and plate tectonics, MidOceanic-Ridge-Basalt (MORB), Island arc basalts, Case histories with Indian Examples
Metamorphic Petrology: Concepts of metamorphism, metamorphic agents and their controlling factors, Grades of Metamorphism, Common minerals of metamorphic rocks, textures and structures, Metamorphic facies concept, Metamorphism types & products, Phase diagrams and graphic representation of mineral assemblages, Prograde and retrograde metamorphism, Metasomatism, Metamorphic reactions, Elemental exchange–exchange and net-transfer reactions , Equilibrium thermodynamics and Geothermobarometry, Barrovian zones and P-T conditions of isograds, Plate tectonics and metamorphic processes, paired metamorphic belts, Pressure-temperature time paths in regional metamorphic rocks, Polymetamorphism, Archaean, Proterozoic terrains-greenstone-amphibolite-granulite terrains of India
Sedimentary Petrology: Geologic cycle, Definitions and fundamental concepts in Sedimentary Petrology, Sedimentary textures (Granulometric analysis, shape and roundness studies, surface textures), Petrography of rocks of clastic, chemical and biochemical origin (Conglomerates, Sandstone, Mudstone, Limestone & Dolomite), Evaporite, Phosphorite, Chert, Iron and Manganese rich sediments, Sedimentary structures (Physical structures, Biogenic sedimentary structures, Diagenetic structures),Concept of Sedimentary facies association models (Marine, non-marine, and Mixed Depositional Environment), Sedimentation and Tectonics, Paleocurrents & Basin Analysis, Specific Case histories on the sedimentary basins of India, Geochemistry and Isotope Geochemistry: Introduction to Geochemistry – its scope, Origin of elements, Geochemical Classification of the elements, Mobility of chemical elements in geological environment, Fundamentals of Thermodynamics, Reversible and irreversible reactions. Geochemical Cycle, Geochemical data interpretation in Igneous, sedimentary and metamorphic petrology, Law of Radioactivity, Principles Decay schemes and Derivation of equation of age, Introduction to isotope geochemistry, Principles of Mass Spectrometry, Instrumentation for Mass Spectrometry, K-Ar, Ar-Ar, Rb-Sr, Sm-Nd, ReOs, Lu-Hf, U-Th-Pb methods of dating the rocks, Specific case histories.

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AcSIR Academic Centre Code: 28

CSIR-National Geophysical Research Institute **CSIR-NGRI**

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Seismic Methods and Other Geophysical Techniques	**AcSIR-28-PS-AD-002**	**2**

Hydrocarbons: Fundamentals of Hydrocarbon Exploration with special emphasis of Seismic data acquisition, Modeling/Inversion, Seismic data processing; Basic Geological Concepts about sedimentary basins for hydrocarbon generation, migration and accumulation in different traps, Classification and formation mechanism of different type of traps. 1. Seismic Interpretation of different Geological structures for hydrocarbon exploration 2. Seismic Sequence Stratigraphy 3. Direct Detection of Hydrocarbon using Hydrocarbon Indicators. 4. Modern topics in seismic exploration studies. Exploration for Gas Hydrates: Gas-hydrates - Definition; Structure; Morphology; Host rock; Phase curve; Factors on stability of gas-hydrates; Geological control; Petroleum system; Geological, Geochemical and Micro-biological proxies; Energy potential; Seafloor instability, Seismic - Data Acquisition; Data processing; Pre-stack depth migration; Energy Partitioning; AVO modeling; A-B cross plot; Seismic attributes; Attenuation; Inverse-Q Filter; Travel time tomography; Full waveform inversion; Impedance inversion; Modeling of OBS data; Vp/Vs; Rock physics - Biot-Gasmann theory; Effective medium theory; Logs - Sonic; Resistivity; Density; Chloride anomaly Geothermal Energy: Basic concepts of heat flow and heat transfer, Geothermal systems and resources Geophysical, Geological and geochemical techniques for exploration, Thermal energy of the oceans and related topics. Reservoir characterization: Overview of reservoir, Rock and fluid properties, Basics of reservoir rock physics, an overview of seismic inversion, Introduction to Hampson Russell software, Hands on experience on HRS, Geo-statistical simulation of reservoir properties and. Case Studies. Hydrocarbons: Fundamentals of Hydrocarbon Exploration with special emphasis of Seismic data acquisition, Modeling/Inversion, Seismic data processing; Basic Geological Concepts about sedimentary basins for hydrocarbon generation, migration and accumulation in different traps, Classification and formation mechanism of different type of traps. 1. Seismic Interpretation of different Geological structures for hydrocarbon exploration 2. Seismic Sequence Stratigraphy 3. Direct Detection of Hydrocarbon using Hydrocarbon Indicators. 4. Modern topics in seismic exploration studies. Exploration for Gas Hydrates: Gas-hydrates - Definition; Structure; Morphology; Host rock; Phase curve; Factors on stability of gas-hydrates; Geological control; Petroleum system; Geological, Geochemical and Micro-biological proxies; Energy potential; Seafloor instability, Seismic - Data Acquisition; Data processing; Pre-stack depth migration; Energy Partitioning; AVO modeling; A-B cross plot; Seismic attributes; Attenuation; Inverse-Q Filter; Travel time tomography; Full-waveform inversion; Impedance inversion; Modeling of OBS data; Vp/Vs; Rock physics - Biot-Gasmann theory; Effective medium theory; Logs - Sonic; Resistivity; Density; Chloride anomaly Geothermal Energy: Basic concepts of heat flow and heat transfer, Geothermal systems and resources Geophysical, Geological and geochemical techniques for exploration, Thermal energy of the oceans and related topics. Reservoir characterization: Overview of reservoir, Rock and fluid properties, Basics of reservoir rock physics, an overview of seismic inversion, Introduction to Hampson Russell software, Hands on experience on HRS, Geo-statistical simulation of reservoir properties and. Case Studies.

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AcSIR Academic Centre Code: 28

CSIR-National Geophysical Research Institute | CSIR-NGRI

Course 3 : Advanced Course | Physical Sciences | Total Credits 6

Title:	Geohazards and Geological Risk analyses	Course Code	Credits
		AcSIR-28-PS-AD-003	2

Structural Geology: Concept of stress and strain, Stress-strain relationships of elastic, plastic and viscous materials, measurement of strain in deformed rocks, behaviour of minerals and rocks under deformation conditions. Folds, their classification and causes, diapirs and salt domes. Shear zones, recognition of shear zones and faults in the field, mechanics of shearing and faulting, Geometry of thrust sheets, Block faulted and rifted regions. Wrench faults and associated structures. Tectonic mélanges, Dome and basin structures, Structural behaviour of igneous rocks, Foliations and Lineation's, their classification, origin and significance, Petro fabric analysis (micro fabrics), data collection, plotting, symmetry and interpretation, concept of symmetry of fabric of tectonites.

Geotectonics: Tectonic framework of earth's crust, interior of earth, Isostasy, convection currents, Wilson Cycle, Continental Drift: Computer fitting, geological and palaeontological evidences in support of continental drift and in-situ theories. Sea-floor spreading: Hess's concept and evidences of sea-floor spreading. Vine-Mathew's magnetic tape recorder. Plate tectonics: Concept of plate and plate movements, plate model of Morgan, nature of convergent, divergent and conservative plate margins, transpression and trans tension. Plate tectonics in relation to igneous, sedimentary and metamorphic processes and mineralization. Triple junctions, aulocogens, plume theory, island arcs. Nature and origin of earth's magnetic field.

Earthquake hazard: Great earthquakes and damages, Paleo seismology, Seismic source and dynamic rupture modeling, Seismic hazard assessment, Strong ground motion prediction through probabilistic and deterministic analysis, simulation of synthetic accelerograms, Seismic hazard maps, Seismic Micro zonation, Vulnerability analysis, Seismic risk, Geotechnical analysis, Structural geology, Site amplification effects, Liquefaction potential, Earthquake effects on structures, Earthquake resistant design, Landslides, Tsunami genic earthquakes.

Tsunami hazard: Causes of tsunami, tsunami genic zones in the world, tsunami wave Propagation, Shallow water equations, Okada's solution, classical Boussinesq equations, earthquake source parameters as inputs, effects of bathymetry, factors responsible for generation of tsunami, tsunami shoaling and run-up heights, coastal geomorphology, tsunami inundation, tsunami modeling, Bottom Pressure tsunami sensors, tsunami warning system, tsunami forecast.

Avalanches and Volcanic Hazards: Volcanoes: Etymology, Plate tectonics and hotspots, Divergent plate boundaries, Convergent plate boundaries, Hotspots, Volcanic features, Erupted material: Lava composition, Lava texture. Classification of volcanoes, Notable volcanoes, Effects of volcanoes, Volcanoes on other planetary bodies, Traditional beliefs about volcanoes, Panoramas. Types of Volcanic Eruptions: Volcanic Earthquakes, Directed Blast, Tephra, Volcanic Gases, Lava Flows, Debris Avalanches, Pyroclastic Surge, Pyroclastic Flows, Volcanism and Plate tectonics, Magma, Rheology, Magmatic Gases and Triggering of Eruptions, Volcanic Edifices and Deposits, Eruption types, Pyroclastic flows, Magma/water interactions, Subduction Zones, Mid-ocean ridges, Seamounts and volcanic islands, Continental intraplate volcanism, Hazards and disaster mitigation, Volcanoes and climate.

Geotechnical Engineering: Introduction: Geologic Engineering, Soil Mechanics, Geotechnical Engineering, Historical Development of Geotechnical Engineering, Engineering Geology and Groundwater, Physical Properties of Earth, Earth, Rock and Soil, Rock Groups and Weathering, Soil Formations, Transport, & Deposition of Various Types of Soil Deposits, Soil Physical Characteristics, Clay Formation.

Soil Particle Size and Shape and Clay Plasticity, Weight-Volume Relationships, Relative Density, Soil Classification, Water in Soils, Static Water and Its Effects, Static Pressure, Capillary Force, Dynamic Water and Its Effects, Dynamics of fluid flow, Darcy's Law for Flow through Porous Media, Soil Permeability and One-dimensional Flow, Total Stress, Effective Stress, Seepage, Capillary Rise, Quick Condition.

2-D Flow and Flow Net Construction, Soil Stresses, Stresses due to Surface Loads, Stress Distribution, Approximate Solution, Elastic Solution, Influence Charts, Compressibility, Consolidation, and Settlement, Compressibility of Cohesive less Soil, Consolidation of Cohesive Soil, Time-dependent Settlement and Spring Analogy, The Odometer and Consolidation Testing, Determination of Preconsolidation Pressure, Casagrande Construction Method, Settlement Computations.

Time Rate of Consolidation, Terzaghi's One-dimensional Consolidation Theory, Evaluation of Cv (Coefficient of Consolidation), Computation of Rate of Settlement, Soil Strength, Stresses at a Point (Mohr Circle Pole method), Stress-Strain Relationships and Mohr-Coulomb Failure Criteria, Tests for Determining the Shear Strength of Soils, p-q Diagram and Stress Paths.

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AcSIR Academic Centre Code: 28

CSIR-National Geophysical Research Institute | CSIR-NGRI

Course 3 : Advanced Course | Physical Sciences | Total Credits 6

Title: Geomagnetism, Paleo magnetism, Archaeomagnetism	Course Code	Credits
	AcSIR-28-PS-AD-004	2

Elements of geomagnetic field, global pattern, time variations, measurement techniques, spherical harmonic analysis, geomagnetic maps, IGRF, origin, crustal and core fields, secular variations. Magnetic properties of minerals and rocks, magnetic remanence, magnetic chronology, excursions and reversals, polar wander.

Navier-Stokes equation, boundary layer concept, boundary layer instability analysis, Rayleigh –Taylor instability, convection at large Rayleigh number. Dynamo theory, magneto-hydrodynamic equations, energy budget of the core, convection in rotating spherical shell, driving forces, toroidal and poloidal decomposition, tangent cylinder, numerical simulations, control parameters, scaling laws, influence of mantle dynamics.

The Geomagnetic Environment: basic characteristics, field parameters, units of measure, Components of Geomagnetic field and time scales, Observations from surface and satellites, Geomagnetic Indices, Geomagnetic Storms and Disturbances: magnetospheric and ionospheric effects, Geomagnetic reversals: link to paleo magnetism and archeomagnetism, magnetic maps for the Earth's Surface, geomagnetic anomalies. Geomagnetic Coastal Effects: continent ocean transition, Induction effect of geomagnetic variations for study of conductivity structure.

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AcSIR Academic Centre Code: 28

CSIR-National Geophysical Research Institute | CSIR-NGRI

Course 3 : Advanced Course | Physical Sciences | Total Credits 6

Title:	Course Code	Credits
Geophysical Signal Processing , Inverse theory and Computational Methods	AcSIR-28-PS-AD-005	4

Geophysical Signal Processing: Even and odd functions, Fourier transform and its properties, Discrete Fourier transform, Fast Fourier Transform (FFT) algorithm, Z-transform and its relation with Fourier transform, Hilbert transform analytic signal, instantaneous phase and frequency, Definition of Radon transform. Time and frequency sampling Theorem, Nyquist frequency, aliasing, Comb function, stationary time series, Wold decomposition theorem, ergodicity, continuous and discrete data, concepts of signal and noise, cross-and auto-correlations in deterministic and statistical senses, spectrum in terms of correlation functions, computation of spectrum for discrete data, concept of maximum entropy, concepts of windows and criterion for optimum window, different kinds of windows. Principles of digital filtering in time and frequency domains, amplitude and phase characteristics of digital filters, low pass, high pass and band pass filters, Wiener filter, deconvolution, predictive deconvolution, Beam-steering with an array of N detectors, velocity filtering, effects of sampling on gravity and magnetic interpretation, FFT in two or more dimensions, vertical derivatives and their interpretation as filters, Upward and downward continuation as a filtering process.

NGRI 2-487 B: Inverse Theory Introduction- Forward and Inverse problem, what is an inverse problem? An untold inverse: Deconvolution Interpretation of inaccurate, insufficient and inconsistent data Examples Geophysics, Reservoir Engineering, Medicine etc. Linear Algebra- Vectors and Matrices simple operations, Vector spaces, projections and null space, Matrix and Vector norms, Matrix factorization, Inversion, Illposed matrices, Eigen values and eigenvectors physical meaning, condition numbers. Classical Inverse Theory- Existence, stability, uniqueness, Under-determined, Over-determined and mixed-determined problems, least squares and maximum likelihood, Data and Model Norm, Lagrange multipliers, Statistical description, Likelihood, Prior and posterior.

NGRI 2-487 C: Preliminary Statistics and Computational Methods Introduction to Statistical Methods – Mean values and standard deviations, probability, conditional and joint probability, Baye's theorem, Binomial, Normal and Poisson Distributions, Gaussian limit of the binomial distribution, Distribution of several random variables, Continuous distributions, Testing of Hypothesis. - Sampling and Large Sample Test-Chi-square test, Theory of Estimation, Optimization techniques and Time Series Analysis. Random variables, Random numbers, Probability, Probability distribution, distribution function and density functions, Examples of distribution and density functions, Joint a marginal probability distribution, Mathematical expectation, moments, variances, and covariances, Conditional probability, Monte Carlo integration, Importance sampling, Stochastic processes, Markov chain, homogeneous inhomogeneous, irreducible and aperiodic processes, The limiting probability. Numerical computation of derivatives: interpolation, extrapolation of functions, Newton-Raphson Method for finding roots, Numerical solutions of differential equations, Introduction to finite difference and finite element methods for solving partial differential equations, First-order differential equations, Higher order differential equations, Separation of variables, series solutions-Frobenius Method, Greens function, Heat flow or Diffusion Partial Differential Equations.

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CSIR-National Geophysical Research Institute **CSIR-NGRI**

Course 3 : Advanced Course **Physical Sciences** **Total Credits 6**

Title:	Course Code	Credits
Geothermics and Geodynamics	**AcSIR-28-PS-AD-006**	**2**

Concepts in Geothermic: Fundamentals of Heat flow, Heat transfer inside the Earth, Sources of heat, Thermal storage and transport properties of rocks, Heat from radioactivity; relation to heat flow, Heat loss from continents and oceans, Energy budget of the Earth.
Continental Heat Flow: Determination of virgin rock temperatures, geothermal gradient, heat flow, corrections, Measurements of thermal conductivity, diffusivity, Analysis of rocks for U, Th and K abundances, radiogenic heat production, Anisotropy, temperature and pressure dependence in thermal properties, Thermal Structure of Continental Lithosphere.
Oceanic Heat Flow: Oceanic heat flow, Measurement techniques, Age dependence of heat flow, bathymetry and lithospheric thickness, Ocean Cooling Models; Hydrothermal Circulation, Thermal Structure of Oceanic Lithosphere (including subduction zones)
Applications of Geothermic: Heat flow and geodynamics, Geothermal record of climate change, integration with other proxy indicators of climate change, Exploration for geothermal energy resources, Geothermic and hydrology.

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CSIR-National Geophysical Research Institute	CSIR-NGRI

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Groundwater exploration, quality and Modelling	Course Code	Credits
		AcSIR-28-PS-AD-007	2

Water and Environmental Geosciences Introduction: Hydrological cycle, Components of hydrological cycle (Precipitation, Evaporation, Transpiration, Evapotranspiration, Runoff, Infiltration, and groundwater recharge), Characterization of aquifers, Groundwater flow in saturated/unsaturated porous media.

Groundwater Exploration: Basic principles of geophysical methods, i.e. Geo-electrical, Gravity, Seismic, Magnetic and Electromagnetic methods, Ground Penetration Radar, Geochemical methods, Remote sensing and Geographic Information Systems, Soil Gas Radon Emanometry; procedures of data processing and interpretations. Aquifer Parameters Identification: Recharge evaluation using isotopes and tracer's techniques, Lithologically constrained rainfall (LCR) method and Entropy based method; Pumping test analysis, Inverse methods, Electrical resistivity and Multivariate Geostatistical methods for estimation of Hydraulic conductivity, Transmissivity and storavity.

Groundwater Flow Modelling: Basic principles and formulation of groundwater flow equations in saturated media, Methods of solutions: Analytical Methods and Numerical Methods (Finite Difference/ Finite Element), Analysis of Hydrogeological Data for Flow and Mass transport Modeling. Environmental Geosciences: Properties of Potential contaminants and related environment and health hazard: (1) Inorganic and organometallic (Nitrogen, Phosphorous, Salts, Radionucleoid, Arsenic, Cadmium, Lead, Nickel); Organic (Pesticides, Clorinated Hydrocarbons, Pharmaceutical and Personal care products), water sampling, analysis, units in water quality determination, surface water quality processes, groundwater quality processes, Modes of Contaminants transport-Advection, Dispersion and Molecular diffusion, Formulation and methods of solution of non-reactive contaminants transport equation, Dynamics of freshwater-saltwater interface in coastal region.

Remedial methods for removal of soil/water contaminants Advanced: Introduction to software MODFLOW for simulation of ground water flow; MT3D for simulation of contaminants transport, SEWAT for simulation of density dependent transport for Seawater Intrusion, GRACE (Gravity Recovery and Climate Experiment) for estimation of Land water storage variation over land, Decision Support Tools (DST-GW) for estimation of water balance.

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AcSIR Academic Centre Code: 28		
CSIR-National Geophysical Research Institute		CSIR-NGRI
Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Nonlinear dynamics and fractal in earth sciences	AcSIR-28-PS-AD-008	2

CONCEPT OF NON-LINEAR DYNAMICS: Basics of fractal, various definitions of fractal, Random fractal, Brownian Motion, Definition of Chaos, Deterministic Chaos, Logistic Map, Different Routes to Chaos, Taken's theory of embedding dimension, Phase Space, Various methods for estimation of dimension, Concept of Entropy, Determination of Entropy and Liyapunove exponent, Non-linear Forecasting Approaches, Critical Catastrophe Theory and application to Critical Phenomenon. Principal Component Analysis Fractal theory and its applications: Mathematical background, Transformations: rotation, translation, scaling, Basic set theory, Measures and mass distribution, Basic probability theory, Fractal Geometry, Analysis of geometrical objects for fractal behaviour, Self-similar and self-affine, Definition and computation of fractal dimension, Statistical fractal Power law, Testing a time series for fractal behaviour, Hurst coefficient, Variogram, Co-variance ,Multifractal, Few applications of fractal theory in Earth sciences, Scaling power spectrum, b-value computation, Fractal dimension and its relation with some of the physical phenomenon, viz. occurrence of earthquakes, flow in porous media etc. Artificial Neural Networks (ANN): The Brain as a Dynamical System, Neural Dynamics Activations and Signals; Activation Models: Neural Dynamical Systems, Additive Neuronal Dynamics, Additive Neuronal Feedback, Additive Activation Models, General Neural Activations: Cohen-Grossberg and Multiplicative Models. Back propagation algorithm (BPA) ANN. Concept of Bayesian statistics and various aspects of ANN modeling and prediction.

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CSIR-National Geophysical Research Institute		CSIR-NGRI

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Palaeoceanography and Paleoclimatology	AcSIR-28-PS-AD-009	2

Weather, Climate, Components of climate, Climate classification. Insolation, short and long-term changes in insolation. Aerosols: Definition, origin, role in climate change. Greenhouse gases: Introduction, causes of changing concentration, role in climate change.
Origin and evolution of Oceans. Oceanic sediments, Terrigenous, biogenic sediments and their distribution. Sea-Level: factors affecting sea-level changes, Short and long term sea level variability, evidences of sea-level change from marine sediments. Ocean-climate linkage. Effect of topography/ tectonics on climate.
Natural variability in climate. Human influence on climate change. Historical evidence of climate change. Effects of climate change on mankind.
Various dating methods, merits and demerits of various dating methods.
Paleoclimatic/Paleocenographic reconstruction from clay, ice, pollen and spores, diatom, radiolarian, foraminifera, organo-geochemical proxies, corals, spleleotherms, loess-paleosol.

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AcSIR Academic Centre Code: 28

CSIR-National Geophysical Research Institute **CSIR-NGRI**

Course 3 : Advanced Course **Physical Sciences** **Total Credits 6**

Title:	Course Code	Credits
Planetary Geology	**AcSIR-28-PS-AD-010**	**2**

Historical development of planetary exploration. Approaches to planetary geological research and methodologies. Application of remote sensing and rover based studies and astronautics in space exploration.

Fundamentals of astronomy and astrophysics with reference to the Solar System. Galaxies and stars – modes of occurrence and formation theories. Introduction to physics and chemistry of the Solar System. Various models of origin of the Solar System.

Planetary geological mapping and analysis – mapping of material and structural units – digital tools of geological mapping – stratigraphic relationships and elucidation of geologic history.

Tools of geophysics to understand the planetary interior and geodynamics of various planetary bodies.

Exterior geologic processes – the role of atmosphere and surface interaction. Physical and chemical properties of planetary atmospheres – Atmospheric circulation models – causes and consequences of climate change – atmospheric agents of planetary surface modification and space weathering.

Impact cratering – various approaches to study the impact structures – mechanisms of impact cratering, vaporization, melting, shock metamorphism, fracturing and fragmentation. Stages of impact crater growth during contact, compression and modification stages. Morphology of impact craters, complex craters and multi-ring basins – role of atmosphere on projectile history and ejecta evolution – projectile sources and pathways. Impact crater records of Mercury, Venus, Earth, Moon and Mars. Representation of impact crater density data and age determination for various planetary surfaces. Field geological studies at Lonar crater to identify impact crater parts, materials and field relationships.

Volcanism in the inner Solar System. Effusive and explosive volcanism in Mercury, Venus, Earth, Moon and Mars. Volcanoes, morphologic types, modes of formation and conditions. Magmas and lavas and their physical and chemical evolution. Thermal evolution of planetary lithosphere and volcanic history of planets. Field visit to Deccan Traps to understand the basics of physical volcanology.

Tectonic processes in the inner Solar System. Brittle and ductile deformation. Folds, fractures and faults in the planetary surface. Geometry, kinematics and dynamics of tectonic structures. Basics of structural geologic mapping through field studies in the Dharwar craton and southern granulite terrain.

Mineralogy of planetary surface. Remote sensing and laboratory based studies of reflectance spectroscopy for identification of minerals and rocks on Mars and Moon.

Asteroids, comets and meteorites: modes of occurrence, morphology, composition, and formation

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AcSIR Academic Centre Code: 28

CSIR-National Geophysical Research Institute CSIR-NGRI

Course 3 : Advanced Course Physical Sciences Total Credits 6

Title:	Course Code	Credits
Potential Field theory, Gravity and Magnetics	AcSIR-28-PS-AD-011	2

Mathematical and Physical Fields: Continuity, Examples of scalar and vector fields in Physics, Gravity & Magnetic fields due to bodies of standard shapes and Problems related to potential field theory between gravity and magnetic potentials.

Gravitational and magnetic potentials, equi-potential surfaces, forces of attraction - gravity and magnetic, Gauss (divergence) theorem, Laplace's equation, Poisson's equation, Gauss's integral formula.

Gravity method: Reductions of gravity observations, gravity anomalies (Free-air, Bouguer), fractal analysis, Isostatic models, lithospheric flexure, Interpretation of gravity anomalies {(regional/residual separation, forward (anomalies due to regular and arbitrary 2D and 3D geometrical source, solid angle and line integral approach) and inverse (linear and nonlinear) modelling methods)}, computation of excess mass, gravity gradient tensor, Integrated modelling of gravity and geoid. Gravity anomalies over important tectonic domains (rift basins, mountain chains, continental and ocean margins, oceanic ridge, subduction zones), applications to geodynamics.

Magnetic method: Reduction of magnetic anomalies. Interpretation of magnetic anomalies forward (magnetic anomalies of 2D and 3D regular and arbitrary shaped bodies) and inverse modeling), Joint inverse modeling of gravity and magnetic anomalies. Transformations of potential fields (frequency filtering, equivalent stratum, analytic signal, Poisson's relation), ambiguity in interpretation.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 28

CSIR-National Geophysical Research Institute	CSIR-NGRI

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Remote sensing, GIS and Spatial Analysis methods	AcSIR-28-PS-AD-012	2

Introduction to Remote sensing Principals and developments. Different Spatial Data, Resolution and Utility. Spatial Data Processing and Analysis. Introduction to GIS methods. Different components of GIS operations, digitization and analysis. Application of RS & GIS in earth & planetary studies. Landscape analysis and modeling.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

29	CSIR-NIO	3	Advanced Course

Faculty of Study	Course Code	Course Title
Physical Sciences	AcSIR-29-PS-AD-001	Atmospheric Chemistry and Physics
Engineering Sciences	AcSIR-29-ES-AD-001	Coastal Engineering
Physical Sciences	AcSIR-29-PS-AD-002	Coastal Sediment Transport
Physical Sciences	AcSIR-29-PS-AD-003	Integrated Gravity and Magnetism in Ocean Margins & Basins
Chemical Sciences	AcSIR-29-CS-AD-001	Isotope Geology
Physical Sciences	AcSIR-29-PS-AD-004	Marine Micropaleontology
Engineering Sciences	AcSIR-29-ES-AD-002	Marine Robotics & Instrumentation
Physical Sciences	AcSIR-29-PS-AD-005	Ocean Waves and Tides
Physical Sciences	AcSIR-29-PS-AD-006	Quaternary Climatology
Physical Sciences	AcSIR-29-PS-AD-007	Tectonomagmatism in Oceanic Regime
Physical Sciences	AcSIR-29-PS-AD-008	Thermodynamics of North Indian Ocean
Physical Sciences	AcSIR-29-PS-AD-009	Continental Margins and Ocean Basins
Physical Sciences	AcSIR-29-PS-AD-010	Circulation and dynamics of the Indian Ocean
Biological Sciences	AcSIR-29-BS-AD-001	Marine Ecology
Biological Sciences	AcSIR-29-BS-AD-002	Marine Microbiology

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

29 CSIR-NIO

3 *Advanced Course*

Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-29-BS-AD-003	Marine Invertebrate Biology and Ecology
Biological Sciences	AcSIR-29-BS-AD-004	Marine Microalgae
Biological Sciences	AcSIR-29-BS-AD-005	Marine Natural Products
Biological Sciences	AcSIR-29-BS-AD-006	Plankton Ecology
Chemical Sciences	AcSIR-29-CS-AD-002	Marine Chemical Cycling
Mathematical & Information	AcSIR-29-MIS-AD-001	Mathematics and Modeling
Mathematical & Information	AcSIR-29-MIS-002	A First course in Mathematical Modelling
Mathematical & Information	AcSIR-29-MIS-003	Junior Level Mathematics
Mathematical & Information	AcSIR-29-MIS-004	A first course in Calculus and Scientific programming

AcSIR Academic Centre Code: 29

CSIR-National Institute of Oceanography | CSIR-NIO

Course 3 : Advanced Course | Physical Sciences | Total Credits 6

Title:	Course Code	Credits
Atmospheric Chemistry and Physics	AcSIR-29-PS-AD-001	2

The Atmosphere: History and Evolution of the Earth's Atmosphere; Climate; The Layers of the Atmosphere; Pressure in the Atmosphere; Temperature in the Atmosphere; Expressing the amount of a Substance in the Atmosphere; Spatial and Temporal Scales of Atmospheric Processes.
Particulate Matter (Aerosols) in the Atmosphere: Chemical composition and characterization of Tropospheric Aerosol; Cloud Condensation Nuclei (CCN); Size distribution of atmospheric aerosols; Sources of aerosols; Mineral dust, Sea-salts, Carbonaceous particles; Emission Inventories; Biomass Burning; Stratospheric Aerosols. Tropospheric-Stratospheric exchange.
Trace Gases: Atmospheric Lifetime; Sulfur-Containing Compounds; Nitrogen-Containing, Compounds; Carbon-Containing Compounds; Halogen-Containing Compounds; Atmospheric Ozone; Hazardous Air Pollutants (Air Toxics).
Atmospheric Radiation and Photochemistry: Radiation; Solar and Terrestrial Radiation; Energy Balance for Earth and Atmosphere; Beer-Lambert Law and Optical Depth; Absorption of Radiation by Atmospheric Gases; Absorption and Scattering by Carbonaceous Aerosol; Radiative Forcing.
Instruments and Methods of Aerosol Characterization: Aerosol collection using active and passive samplers, Mass spectrometers, Elemental analyses using Ion chromatograph. Light Transmission Method; Thermal Optical Carbon Analysis; Filter Based Techniques; Positive and Negative Artifacts; Absorbance of Aqueous Extracts; Remote Sensing Techniques for aerosol characterization and Quantification, MODIS and CALIPSO Satellite Data sets; LIDAR; Passive Microwave observations of Atmosphere.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 29

CSIR-National Institute of Oceanography	CSIR-NIO

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Coastal Engineering	AcSIR-29-ES-AD-001	3

The course describes various aspects of coastal processes such as wave breaking, near-shore currents, beach and shoreline dynamics, sediment transport, and coastal protection measures.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 29

CSIR-National Institute of Oceanography	CSIR-NIO

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Coastal Sediment Transport	AcSIR-29-PS-AD-002	2

This course covers:Introduction to coastal hydrodynamics: Wind-waves, Tides, Currents (Wave & tide induced, residual currents), Wave-current interaction, Surf zone dynamics: Wave transformation in surfzone & turbulence; Surfzone currents & its distribution, Coastal sediments and bed forms: Sediment Sources & types; Properties sediments (non-cohesive & cohesive); Coastal bed form regimes & dynamics; Bed ripples, hydraulic roughness, friction factors, Initiation of sediment motion: Forces on sediments, Mobility number, Shields parameter; Introduction to boundary layer theory; Depth of closure, Sediment transport modes: Suspended sediment transport; Bed load transport; Total load transport, Sediment transport models: Non-Cohesive sediment transport; Cohesive sediment transport; Total load transport; Longshore sediment transport; Cross shore sediment transport; Shoreline / profile development.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 29

CSIR-National Institute of Oceanography	**CSIR-NIO**

Course 3 : Advanced Course	**Physical Sciences**	**Total Credits 6**

Title:		Course Code	Credits
	Integrated Gravity and Magnetism in Ocean Margins & Basins	**AcSIR-29-PS-AD-003**	**2**

Gravity method: basics, instruments, field procedures, reduction to anomalies, qualitative and quantitative interpretation techniques; Magnetic method: basics, instruments, field procedures, reduction to anomalies, qualitative and quantitative interpretation techniques; Gravity and magnetic signatures associated with various seafloor features- continental margins, aseismic ridges, mid-oceanic ridges, trenches, seamounts, etc.; Integrated forward modelling of gravity and magnetic anomalies for study of crustal structure of the continental margins and adjacent deep-sea basins; Applications of magnetic method for seafloor spreading studies - concept of plate tectonics andseafloor spreading, Vine-Matthew hypothesis, marine magnetic anomalies, geomagnetic polarity reversal timescales, identification of anomalies, mapping of magnetic lineations, spreading rates, plate tectonic reconstruction to understand evolution of ocean basins.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 29

CSIR-National Institute of Oceanography | CSIR-NIO

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Isotope Geology	AcSIR-29-CS-AD-001	2

Fundamental of Stable and radio isotope geochemistry, Application of stable and radio isotope in Ocean sciences. Exposure to stable isotope mass spectrometers at NIO and other laboratories like NCAOR.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 29	
CSIR-National Institute of Oceanography	CSIR-NIO

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Marine Micropaleontology	AcSIR-29-PS-AD-004	2

Introduction to marine microfossils; Sediment sample processing and sorting techniques for microfossil study; Various characteristics of microfossils used as techniques in paleooceanography; Applications of microfossils in paleo-records; Laboratory culturing of foraminifera.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 29

CSIR-National Institute of Oceanography	CSIR-NIO

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:		Course Code	Credits
	Marine Robotics & Instrumentation	AcSIR-29-ES-AD-002	2

Technologies for oceanographic data acquisition- Overview; Mechanical, power and propulsion aspects of autonomous underwater technology, Introduction to robotics for oceanography; Dynamics Modelling, Underwater positioning and Guidance for Marine robots; Communication modes for marine technologies, Electronics hardware for autonomous marine instrumentation, Software for autonomous marine instrumentation, Theory of measuring instruments, Oceanographic sensors.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 29		

CSIR-National Institute of Oceanography	CSIR-NIO

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Ocean Waves and Tides	Course Code	Credits
		AcSIR-29-PS-AD-005	2

Ocean surface waves can be classified based on their nature, period and propagation depth; measured wave data can be subject to wave-by wave method and spectral analysis; third generation wave models such as WAVE WATCH3 and SWAN will be dealt with to understand wave forecasting and hindcasting techniques; waves generated in the south Indian Ocean and northeast Arabian Sea and their interaction with coastal wind seas will be taught; the course also covers wave attenuation and transformation in shallow waters. Equilibrium Tide, Tide producing forces - The Earth-Moon system, Earth-Sun system, Interaction of Lunar and Solar tides, Prediction of tides

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 29

CSIR-National Institute of Oceanography	CSIR-NIO

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Quaternary Climatology	AcSIR-29-PS-AD-006	2

This course covers: Basics and application of stable isotopes in marine biogenic carbonates, Basics and application of biogenic trace metals and organo-chemical proxies, Basics and application of marine inorganic proxies, Application of clay minerals in palaeoclimate studies, Quaternary dating methods , Isotope ration mass-spectrometry, Dust and climate linkage, Possible fate of Holocene interglacial under the influence of anthropogenic stress, Right sampling site in marine sedimentary environment vis-à-vis time-scale of palaeoclimate reconstructions, Past sea-level changes (long-term and short-term) and causes, Evidences for Quaternary sea-level changes with special reference to India, Evidences of climate change. Effects of climate change on human, Activities and findings of IPCC.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 29			
CSIR-National Institute of Oceanography			CSIR-NIO
Course 3 : Advanced Course	Physical Sciences		Total Credits 6
Title: Tectonomagmatism in Oceanic Regime		Course Code	Credits
		AcSIR-29-PS-AD-007	2

This course covers: General tectonics of Plate boundaries and Midplate-seafloor, Generation of Magma, Structural Fabric and Fracture Zones, Magmatism, Divergent, Convergent which convers topic such as Structural Fabric and Fracture Zones and Magmatism. Intraplate: Seafloor crenulations, fissures, fractures, Volcanics of seafloor, Seamounts: Origin, emplacement tectonic, Seamount: Petrology, volcanism & its influence, Sampling Strategy and equipment, Analytical instruments & methods and Integration of Plate Boundary Systematic

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Course 3 : Advanced Course **Physical Sciences** **Total Credits 6**

Title:	Course Code	Credits
Thermodynamics of North Indian Ocean	**AcSIR-29-PS-AD-008**	**2**

Variabilities of sea surface temperature, mixed layer depth, thermocline on different timescales over north Indian Ocean and the role of remote equatorial wind force on its variability, the role of Sea Surface Salinity on the thermodynamics of North Indian Ocean, Formation of Barrier Layer and its seasonal variations, Surface layer temperature inversions over north Indian Ocean: Characteristics, related governing mechanisms, Arabian Sea mini warm pool and its role in regional climate, Upper oceanic heat content and transport mechanism, Surface heat fluxes, heat budget over north Indian Ocean, Thermohaline circulation, water masses, formation and distribution over north Indian, Ocean and their implications on ocean biogeochemistry.

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AcSIR Academic Centre Code: 29

CSIR-National Institute of Oceanography CSIR-NIO

Course 3 : Advanced Course Physical Sciences Total Credits 6

Title:	Course Code	Credits
Continental Margins and Ocean Basins	AcSIR-29-PS-AD-009	2

Lectures:
Continental margins - formation, types, geological features; Continent-ocean boundary; transition zone; Mantle plumes and hotspots - categories, expressions on lithospheric plates, fixity; Major aseismic ridges, plateaus and seamounts in the Indian Ocean; Mid-ocean ridges - geophysical signatures, morphology, ridge segmentation, characteristic of fast, intermediate, slow and ultraslow spreading centres; Ridge jumps, extinct spreading centers, seaward dipping reflectors; triple junctions, migrations; Seafloor spreading, Plate tectonics; Plate motions and reorganization,reconstructions; Satellite gravity, nature of underlying crust, mode of formation; Structure and evolution of the Bay of Bengal; Sedimentary basins, seismic stratigraphy,correlation with drill information, hydrocarbon exploration; Subduction zones - geophysical characters, morphology, accretionary prism; Back arc basins formation, characteristics of back-arc spreading centres and arc volcanism; Ridge and seamounts subduction,generation of earthquakes and tsunami, seismicity;

Practicals:
Differentiation and identification of continental margin types; Identification of ridge jumps and extra crust; Plate reconstruction models generation; GMT plotting techniques; Demonstrating geophysical signatures over continental margins; Seismic signatures over sedimentary basins; Satellite gravity signatures over seamounts,ridges, plate boundaries; Tracing hotspots using plate reconstructions; Identification of marine magnetic anomalies; Inferring the age and nature of the oceanic crust; Inferring seafloor spreading rates and directions; Identifying plate boundaries and types; Earthquake dynamics; Subduction zone dynamics

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AcSIR Academic Centre Code: 29

CSIR-National Institute of Oceanography CSIR-NIO

Course 3 : Advanced Course Physical Sciences Total Credits 6

Title:	Course Code	Credits
Circulation and dynamics of the Indian Ocean	AcSIR-29-PS-AD-010	3

Observed surface circulation of the global ocean and the theoretical framework, Circulation of the Indian Ocean, Mathematical modelling, The conservation laws for fluid flows, The primitive equations, The surface mixed layer, Simplification of the primitive equations: The linear, continuously, stratified, model, The linear, continuously stratified model and the reduced-gravity model, Interior-ocean dynamics, Coastal-ocean dynamics, Equatorial-ocean dynamics, Application to the North Indian Ocean, The vertical structure, Shelf circulation, Data sets and data analysis, Interior-ocean dynamics, Coastal-ocean dynamics, Equatorial-ocean dynamics, Realistic solutions for the Indian Ocean using a simple model, The vertical structure, Shelf circulation

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CSIR-National Institute of Oceanography	CSIR-NIO

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Marine Ecology	AcSIR-29-BS-AD-001	2

Overview of marine ecology; Microbial Ecology of coastal and estuarine ecosystems; Role of microbes in organic matter cycling; Influence of climate change on structure and functioning of ecosystems; Fish Conservation & Management; Microbe-metazoa interactions and bio-communication in the oceans; Life in sediments; Marine bio-invasion ecology; Biofilms/Biofouling; Immune response in Marine Invertebrates; Population connectivity: Benthic pelagic coupling

References:

1. Chemoreception in marine organisms, by Grant P.T., Mackie A. M. Academic Press, New York, 1974
2 Marine biodeterioration: an interdisciplinary study, by Costlow J.D., Tipper R. C. Naval Institute Press, Annapolis, 1984
3. Recent Advances in Marine Biotechnology. Biofilms, Bioadhesion, Corrosion and Biofouling, vol 3 by Fingerman M., Nagabhushanam R., Thompson M.-F. Oxford and IBH Publishers, New Delhi, 1999
4. The Biology of Rocky Shores, by Colin L., Kitching J. A. Oxford University Press, New York, USA, 1996
5. Experimental design and data analysis for biologist, by Quinn G. P. Cambridge University Press. UK, 2002
6. Elements of Marine Ecology. An Introductory Course by Tait R. V. 3rd ed, Butterworths, UK, 1981
7. An introduction to Marine Ecology, by Barnes R. S. K., Huges R. N. 3rd ed.; Wiley-Blackwell, USA, 1999
8. Fundamental of Marine Ecology, by Odum E. P. 3rd ed. W.B. Saunders, Comp. Philadelphia, London, UK,1971
9. Method in Marine Zooplankton Ecology, by Omori M., Ikeda T. Wiley-Blackwell, USA, 1984
10. Phytoplankton Manual, by Sournia A. UNESCO Press, France, 1978

CSIR-National Institute of Oceanography	CSIR-NIO

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Marine Microbiology	Course Code	Credits
		AcSIR-29-BS-AD-002	3

Introduction to marine Microbiology: Microbes and its significance in Oceanography; isolation and identification of marine microbes i.e., bacteria, archaea and fungi; Structure, physiology, nutritional requirements and ecological interactions; extremophiles, Molecular techniques for bacteria, fungi and microbial community analysis; microbial non-culturability.Microbial Process: Microbial loop and its biogeochemical significance; Nitrogen-cycle, Sulfur-cycle, Phosphorus –cycle, Iron- cycle, Microbe mineral interaction; Metal microbe interaction, secondary oil recovery.Industrial/ Pollution Microbiology: Coastal, Industrial, sewage and microbial pollution; eutrophication; water quality; microbial indicators; bioremediation. Large scale production of bacteria and their metabolites, Bio reactors on bioremediation.

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AcSIR Academic Centre Code: 29

CSIR-National Institute of Oceanography	CSIR-NIO

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Marine Invertebrate Biology and Ecology	AcSIR-29-BS-AD-003	3

Lectures:

Introduction to marine invertebrates; Diversity and distribution of marine invertebrates; Ecology of marine invertebrates with reference to different ecosystems; Reproductive and developmental biology and ecology of marine invertebrates; Implications of larval energetics in marine invertebrate's biology and ecology; Marine invertebrate larval dispersal and population connectivity; Physiological ecology of marine invertebrates; Linkages between climate, ocean productivity and recruitment of marine invertebrates; Prey-predator relationship in marine invertebrates; Application of metagenomics in Biodiversity research; Adaptations of marine invertebrates to changing environment.; Anthropogenic impacts on marine invertebrates and their conservation; Marine invertebrates and bioinvasion; Economic and ecological important of marine invertebrates

Practicals:

Culture of phytoplankton in the laboratory; Culture techniques of intertidal marine invertebrates; Culture techniques of pelagic marine invertebrates; Collection and culture of benthic invertebrates

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AcSIR Academic Centre Code: 29

CSIR-National Institute of Oceanography	CSIR-NIO

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title: Marine Microalgae	Course Code	Credits
	AcSIR-29-BS-AD-004	2

Introduction to microaigae; Evolution of photosynthetic organisms; Microalgal taxonomy, diversity, photosynthesis and ecology; Influence of climate change on microaigae; Microalgal fouling; Microalgal culturing, Introduction to sampling, and enumeration of micro-algae

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AcSIR Academic Centre Code: 29

CSIR-National Institute of Oceanography	CSIR-NIO

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:		Course Code	Credits
	Marine Natural Products	AcSIR-29-BS-AD-005	2

Marine natural products (MNPs) and their biomedical potential; Biosynthesis and biotransformation of MNPs; Isolation and purification of MNPs using chromatographic techniques; Structural elucidation of MNPs using spectroscopic techniques; Chemical synthesis of MNPs and their modifications; Biological and toxicological aspects of marine natural product drug discovery; Biomineralized Structures and Biocomposites (skeletal formations, macro- and microscleres, spicules, spines, bristles, cell walls, cyst walls etc.); Natural polymers from marine organisms and preparations of biomaterials; Terpenoids and carotenoids in Marine Organisms: [Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule, biosynthesis and synthesis of the following representative molecules: beta-Carotene and a-Terpeneol]; Steroids in Marine Organisms: [Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry. Isolation, and synthesis of Cholesterol and Testosterone]

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AcSIR Academic Centre Code: 29

CSIR-National Institute of Oceanography **CSIR-NIO**

Course 3 : Advanced Course	**Biological Sciences**	**Total Credits**	**6**

Title:		Course Code	Credits
	Plankton Ecology	**AcSIR-29-BS-AD-006**	**2**

Zooplankton diversity, functional biology in the marine environment, Holoplankton and meroplankton, zooplankton reproduction and life cycle strategies, zooplankton as indicators of water mass movements, Biotic and abiotic factors that regulate spatial and temporal changes in zooplankton, History and distribution of zooplankton in the Indian Ocean, General morphology and anatomy of copepods, Feeding and digestive mechanisms of copepods, Methods used to evaluate diet, feeding rate and trophic role, Methods available for sampling and biomass/abundance measurements of zooplankton, Zooplankton migration and adaptations, Changes in zooplankton with climate change, Impacts of marine pollution on zooplankton

Evolution of marine phytoplankton and their distribution in global oceans, phyto-zooplankton interaction, role of marine phytoplankton in global carbon cycle; distribution of phytoplankton in the Indian coastal waters. Responses of phytoplankton to changing nutrient loadings from anthropogenic sources; the impacts of increasing temperature and CO_2 on marine phytoplankton. Competitive efficiency for carbon fixation among different groups of phytoplankton;Responses of calcifying phytoplankton to ocean acidifications; Phytoplankton as a potential source for commercially important products; role of phytoplankton as a tool for wastewaters treatment.

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AcSIR Academic Centre Code: 29

CSIR-National Institute of Oceanography CSIR-NIO

Course 3 : Advanced Course Chemical Sciences Total Credits 6

Title:	Marine Chemical Cycling	Course Code	Credits
		AcSIR-29-CS-AD-002	3

Elemental sources, cycles and residence times in seawater, Control of seawater composition- removal processes, Elemental Composition, concentrations and behaviours, Oxygen and nutrient cycles, Carbon Cycle in the oceans, Anoxic environments and OMZs of the world oceans – I & II, Composition and behaviour of substances in estuaries, Biogeochemical cycles in estuaries, Global change and marine biogeochemical cycles, Ocean acidification, Processes in the marine boundary layer, Micronutrients (Fe), Reconstructing past using biomarkers in sediments, pH scales in seawater,Carbon dioxide speciation, Dissolved oxygen, Fluxes of gases, Nutrient cycling, Isotopic anomalies, Removal mechanisms, Estuarine systems , Material exchanges at marine interfaces , Micronutrients (Fe), Global Change, Nutrient cycles, Speciation in seawater , Ocean acidification.

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Course 3 : Advanced Course **Mathematical & Information Sciences** **Total Credits 6**

Title:	Mathematics and Modeling	Course Code	Credits
		AcSIR-29-MIS-AD-001	2

1. Introduction to scientific programming, 2. Refresher course in calculus . This course contains ODEs and numerical methods, PDEs and finite-difference methods, Fourier and Laplace transforms and Heat and wave equations.

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Course 3 : Advanced Course **Mathematical & Information Sciences** **Total Credits 6**

Title:	Course Code	Credits
A First course in Mathematical Modelling	**AcSIR-29-MIS-002**	**2**

1. Introduction to scientific programming, 2.A first course in calculus The course includes Mathematical modelling and differential equations, Newton's laws of motion, Decay and growth, Oscillations, Application to ecosystems, Introduction to Numerical Methods, Solving ODEs on a computer, Simulations with an NPZD model.

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CSIR-National Institute of Oceanography **CSIR-NIO**

Course 3 : Advanced Course **Mathematical & Information Sciences** **Total Credits 6**

Title:	Course Code	Credits
Junior Level Mathematics	**AcSIR-29-MIS-003**	**2**

Number System, Permutations and Combinations, Matrices, Introduction to Programming, Functions, Co-ordinate Geometry, Limits and Continuity, Differential Calculus, Integration, Ordinary Differential Equations, Partial Differential Equations, Numerical Analysis and Time Series Analysis

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AcSIR Academic Centre Code: 29

CSIR-National Institute of Oceanography CSIR-NIO

Course 3 : Advanced Course Mathematical & Information Sciences Total Credits 6

Title:	A first course in Calculus and Scientific programming	Course Code	Credits
		AcSIR-29-MIS-004	2

Introduction and numbers; Functions; Area, summation, and the integral; Slopes, the derivative, and the concept of a limit; The fundamental theorem of calculus; The logarithmic and exponential functions and series expansions; Applications; Introduction to Linux; Introduction to Octave; Introduction to programming (*for* and *if* loops); Plotting graphs; "Summation (integration); Computing differences (differentiation); Using user-defined functions; A few general programs for statistics; Euler method to solve Ordinary differential equations;

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30	CSIR-NISTADS	3	*Advanced Course*

Faculty of Study	Course Code	Course Title
Mathematical & Information	AcSIR-30-MIS-AD-001	Science and Technology Systems - India and the World
Mathematical & Information	AcSIR-30-MIS-AD-002	Technology Futures Studies (TFS)

AcSIR Academic Centre Code: 30	
CSIR-National Institute of Science, Technology and Development	CSIR-NISTADS

Course 3 : Advanced Course	Mathematical & Information Sciences	Total Credits 6

Title:	Science and Technology Systems - India and the World	Course Code	Credits
		AcSIR-30-MIS-AD-001	3

The course in “Science and Technology Systems in India visa-vis world” provides interdisciplinary training to research students to students to the dynamics and understanding for evolution of S&T systems for economic development and poverty alleviation in India and across the world. The course will help students to look into historical glimpses on advancements of scientific and technological knowledge which made possible the significant reduction of poverty and improvements in the quality of life in both developed and developing countries throughout the 20th century which further helps the students to understand the close link between economic growth and the strategic approaches of S&T system/policies.

The course will focus on the S&T system of India which besides the core S&T milieu embraces large number of economic sectors as well as social dimensions. The course will provide the scope to study and analyse the following: (1) social and economic development through progress and applications of S&T; (2) management of S&T infrastructure (3) governance of S&T system (4) modes of funding

Topics and Subtopics

1 Science and Technology Policies-Comparative Study/analysis

2 India's Science and Technology Policy and its influence on technology development (Historical perspective of India's Science and Technology Policy)

3 S&T infrastructure and management of development and allocations of Developmental Plan funds to involve S&T and hence management of S&T spills over to sectors/ministries for whom S&T is not the core function

4 Evolution of sectoral policies (e.g. Human resource, health, environment, emerging technologies etc)

5. Science Diplomacy & Scientific Cooperation/Collaborations

6. Science as Culture and Practice; Social Stratification in Science; Scientific Controversies, Public Understanding of Science, Changing structure of science as a social institution in the contemporary period

7. Impact of S&T on society and economy

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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CSIR-National Institute of Science, Technology and Development **CSIR-NISTADS**

Course 3 : Advanced Course **Mathematical & Information Sciences** **Total Credits 6**

Title:	Technology Futures Studies (TFS)	Course Code	Credits
		AcSIR-30-MIS-AD-002	3

Rapid technological development in the past decades has prompted the need for new methods to understand the complex system with advanced resources, approaches and institutions. Technology Futures Studies connects the probable, desirable, and feasible future developments of technologies to the past and the present Future Technology analysis which is concerned with complex dynamic systems and processes include multiple interdisciplinary stakeholders to ensure distributed understanding.

Objective:
The objectives of the proposed course are to provide students with methodological tools necessary for Science Technology and Innovation (STI) planning and policy making. It also gives insight into impact of STI on socioeconomic development and vice versa.

Course Outline
Introduction, Concepts, Approaches, Technology Assessment and Forecasting, Technological Foresight, Role of TFS, Relevance of TFS to the Developing Countries, Major Techniques in Technology Assessment, Historical Surveys, System Analysis, Cross - Impact, Risk Analysis, Major Techniques - Normative and Exploratory Techniques: Delphi, Growth Curves, Trend Extrapolation, Analytical Models, Breakthrough Rate, Scenario Writing, Relevance Tree, Morphological Analysis, Technology Road Mapping, Technology Futures Studies Umbrella Concept for Multiple Methods, Multi¬Actor Context, Participative Approach, Process Management

References:

• Technology Forecasting and Social Change
• International Journal for foresight and Innovation Policy
• Arie Rip, Thomas Misa and John Schot (eds) (1995), Managing Technology in Society: The Approach of Constructive Technology Assessment (Pinter, London).
Arnstein, S.R. and Christakis, A.N. (1976), "Perspectives on Technology Assessment", Methodologies in Perspective, (Science and Technology Publishers, Jerusalem).
Ascher, William (1979), "Problems of Forecasting and Technology Assessment", Technological Forecasting and Social Change 13, 149156, 1979.
Balachandra, R. (1980), "Perceived Usefulness of Technological Forecasting Techniques", Technological Forecasting and Social Change 16, 155166, 1980.
Bowonder, B. (1979), "Appropriate Technology for Developing Countries: Some Issues", Technological Forecasting and Social Change 15, 5567, 1979.
Bowonder, B. (1979), "Impact Analysis of the Green Revolution in India", Technological

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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Faculty of Study	Course Code	Course Title
Engineering Sciences	AcSIR-31-ES-AD-001	Advanced Manufacturing
Engineering Sciences	AcSIR-31-ES-AD-002	Advanced Mechanical Property Characterization
Engineering Sciences	AcSIR-31-ES-AD-003	Advanced Minerology
Engineering Sciences	AcSIR-31-ES-AD-004	Advances in Non-Ferrous Metal Extraction
Engineering Sciences	AcSIR-31-ES-AD-005	Coating Technology
Engineering Sciences	AcSIR-31-ES-AD-006	Mathematical Modeling and Numerical Analysis
Engineering Sciences	AcSIR-31-ES-AD-007	Mechanical Behaviour of Materials
Engineering Sciences	AcSIR-31-ES-AD-008	Microstructural Engineering
Engineering Sciences	AcSIR-31-ES-AD-009	Mineral Processing
Engineering Sciences	AcSIR-31-ES-AD-010	Waste Processing & Recycling

AcSIR Academic Centre Code: 31

CSIR-National Metallurgical Laboratory	CSIR-NML

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title: Advanced Manufacturing	Course Code	Credits
	AcSIR-31-ES-AD-001	3

Casting and solidification; Semi-solid processing, Welding and joining technology: Metal working processes; Forging, rolling, extrusion, wire drawing; Powder processing, Principles of metal forming; Deformation maps; Workability of materials; Sheet metal forming, Forming limit diagram; Thermomechanical processing.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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CSIR-National Metallurgical Laboratory	CSIR-NML

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Mechanical Property Characterization	AcSIR-31-ES-AD-002	4

Multiaxial Fatigue, High strain rate material testing practices; Indentation creep; Dynamic Fracture toughness; Creep-fatigue interaction; Small specimen testing practices.

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AcSIR Academic Centre Code: 31

CSIR-National Metallurgical Laboratory	CSIR-NML

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Minerology	AcSIR-31-ES-AD-003	4

Introduction to Minerals, Crystallography, Optical Mineralogy, Atomic Substitution, Solid Solution, Polymorphism, Isomorphism, Silicate structures, Descriptive Mineralogy, Different Mineral Groups: Silicates (Olivine, Pyroxene, Amphibole, Mica, Feldspar, Garnet), Oxides, Sulfides, Mineral Associations, Mineral Genesis, Process Mineralogy.

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AcSIR Academic Centre Code: 31

CSIR-National Metallurgical Laboratory	CSIR-NML

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Advances in Non-Ferrous Metal Extraction	Course Code	Credits
		AcSIR-31-ES-AD-004	3

Fundamental and applied aspects of pyrometallurgy, hydrometallurgy and electrometallurgy: Pyrometallurgy: Standard Free energy Diagram, Predominance area diagram and Ternary diagram with reference to non-ferrous metal extraction; Pre-treatment (drying, calcination, roasting, etc.), Halidation, Smelting, Metallothermic reduction.
Hydrometallurgy: Thermodynamics and kinetics of hydrometallurgical processes, leaching(including pressure oxidation, bio-oxidation), cementation, precipitation, ion exchange and solvent extraction.
Electrometallurgy : Principles of electrochemistry, Cells and thermodynamic relations, electrowining, electrorefining, Molten salt electrolysis.
Process selection for extraction of non-ferrous metals.
Outline of major competing routes of metal extraction from their ores. Limitations and factors influencing the choice of extraction and refining process i.e. the scientific and technological analysis of extraction processes, Metal Extraction and refining of metals viz.: Aluminum, Copper, Lead, Zinc, Magnesium, Titanium, Uranium and Rare earth metals.

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AcSIR Academic Centre Code: 31

CSIR-National Metallurgical Laboratory CSIR-NML

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Course Code	Credits
Coating Technology	AcSIR-31-ES-AD-005	4

Thin Films: Definition, nucleation and growth of thin films, Application of thin films. Processing of thin films: PVD, PECVD, electron beam evaporation, RF and DC sputtering, Magnetron sputtering, laser ablation. Plasma diagnostics by langmuir probe and OES. Influence of thickness, power, pressure, substrate, temperature and substrate target distance on the growth and microstructure of thin films. Mechanical, adhesion behavior and measurement of thin films, magnetic, optical, texture properties of thin films, method of evaluation of thin films. Surface chemistry and evaluation of thin film; Advanced Patterning Techniques of thin films for devices: lithography, wet chemical, electron beam, laser; Problems and issues of thin films.

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AcSIR Academic Centre Code: 31

CSIR-National Metallurgical Laboratory	CSIR-NML

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Mathematical Modeling and Numerical Analysis	AcSIR-31-ES-AD-006	3

Multi-scale Simulation System, Basic Concepts of Length and Time Scales, Intermolecular Interactions and Potential Energy Surfaces, Theory of Ensembles, Phase Transitions and Relaxation Phenomena, Simulation Methodology: Density Functional Theory (DFT), Molecular Dynamics (MD), Phase Field (PF), Computational Fluid Dynamics (CFD), Finite Element Method (FEM), Introduction and application of QUANTUM ESPRESSO, LAMMPS, DLPOLY, MICRESS, OPEN-PHASE, ANSYS, MATLAB simulation software.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 31

CSIR-National Metallurgical Laboratory **CSIR-NML**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Mechanical Behaviour of Materials	**AcSIR-31-ES-AD-007**	**3**

Introduction to simple concepts of stress and strain tensor; Elastic stress-strain relationship; Strain energy; Mohr's circle; Plastic yielding of material; Yield point; Yield criteria; Yield locus; Flow curve, Concept of crystal geometry; Lattice defects; Modes of deformation: slip and twinning; Critical resolved shear stress for slip; Slip in a perfect lattice; Slip by dislocation movement; Stacking faults; Fundamentals of indentation hardness; Brinell, Meyer, Vicker, Rockwell hardness; Hardness conversion; Relationship between hardness and flow curve; Hardness at high temperature; Engineering stress-strain curve; True stress-strain curve; Strength and ductility measurement in a tension test; Effect of strain rate/temperature on tensile behaviour; Necking criteria; Notched bar and drop weight impact tests; Transition temperature curves; Instrumented impact testing; Introduction to fracture mechanics based design, creep and fatigue behavior of materials.

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AcSIR Academic Centre Code: 31

CSIR-National Metallurgical Laboratory CSIR-NML

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Microstructural Engineering	AcSIR-31-ES-AD-008	4

Evolution of Microstructures, microstructural instability; recovery, recrystalization and grain growth, Thermo-mechanical treatment and evolution of textures. Grain Boundary Characterization; Heat treatment methodology; Structure-property processing correlations.

AcSIR Academic Centre Code: 31

CSIR-National Metallurgical Laboratory **CSIR-NML**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:	**Mineral Processing**	**Course Code**	**Credits**
		AcSIR-31-ES-AD-009	**3**

Mineral characterization, sampling, crushing and grinding, size classification, gravity concentration, magnetic and electrostatic separation and their application in mineral industries, surface chemistry and froth flotation principles, dewatering techniques, size enlargement processes, material balance and data reconciliation.

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AcSIR Academic Centre Code: 31

CSIR-National Metallurgical Laboratory	**CSIR-NML**

Course 3 : Advanced Course **Engineering Sciences** **Total Credits 6**

Title:	**Waste Processing & Recycling**	**Course Code**	**Credits**
		AcSIR-31-ES-AD-010	**3**

Introduction to waste processing and environmental management
Waste generation, its recycling and and managenment (solid & Liquid):
Wastes from mining and mineral industries, Wastes from iron and steel (including ferro-alloys) industries, Wastes from non-ferrous metal industries : such as Aluminum, Copper, Lead, Zinc, Titanium and Chromium. Waste generation from power plants and their recycling status, Bulk utilisation of slag and other wastes using eco-friendly processes. Metallic wastes from non-metallurgical sectors : home appliances and others such as E-waste, Spent batteries, Spent catalysts , Toxicological characterization of liquid effluents, Toxicological characterization of solid wastes Values from wastes – High value materials synthesis

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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Faculty of Study	Course Code	Course Title
Chemical Sciences	AcSIR-32-CS-AD-001	Advanced Polymer Science and Technology
Engineering Sciences	AcSIR-32-ES-AD-001	Advanced Materials Characterization Techniques
Engineering Sciences	AcSIR-32-ES-AD-002	Air Quality Measurement Science and Technology
Engineering Sciences	AcSIR-32-ES-AD-003	Instrumentation for Calibration & Testing
Engineering Sciences	AcSIR-32-ES-AD-004	Optimization Techniques and Finite Element Method in Engineering
Physical Sciences	AcSIR-32-PS-AD-001	Engineering Materials
Physical Sciences	AcSIR-32-PS-AD-002	Advanced Electronic Materials and Semiconductor Devices
Physical Sciences	AcSIR-32-PS-AD-003	Thin Film Physics & Technology
Physical Sciences	AcSIR-32-PS-AD-004	Nanostructured Materials
Physical Sciences	AcSIR-32-PS-AD-005	Superconductivity and Magnetic Materials

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 32

CSIR-National Physical Laboratory	**CSIR-NPL**

Course 3 : Advanced Course | **Chemical Sciences** | **Total Credits 6**

Title:		Course Code	Credits
	Advanced Polymer Science and Technology	**AcSIR-32-CS-AD-001**	**3**

Introduction of conventional, specialty & engineering polymers, functional polymers, copolymers, polymer blends, micro- & nano-composites, conjugated & conducing, polymers, polyacetylene, polyaniline, polypyrrol, polythiophene derivatives & analogues, band structures, doping types, doping mechanisms, charger carriers, charge transport mechanism, conjugatedcopolymers, conjugated polymer blends: synthesis strategies, properties, processing techniques, specialized products, analytical and characterization tools, related metrology, environmental concerns, recyclability and practical applications, organic solar cells, organic light emitting diodes, transistors, display devices, solid state lighting, gas/chemical sensors, biosensors, actuators, healthcare & assistive, devices, electrochromic devices, memory devices, corrosion control, electromagnetic, interference shielding, electostatic charge, dissipation, air/water purification, supercapacitor, lithium ion battery,
theroelectrics etc., Polymer based certified, reference materials (CRMs) and Bhartiya Nirdeshak Dravva (BNDs)

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AcSIR Academic Centre Code: 32

CSIR-National Physical Laboratory	CSIR-NPL

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Advanced Materials Characterization Techniques	Course Code	Credits
		AcSIR-32-ES-AD-001	3

Fundamentals of X-rays and X-ray crystallography, Instrumentation, Bragg's law, Data analysis by different software's, Determination of crystal structures-X-ray, Laue, Single crystal X-ray and powder X-ray methods, Applications & limitations, X-ray fluorescence spectrometry, Wavelength dispersive XRF, Instrumentation, Working procedure, Applications & limitations, Energy dispersive spectroscopy, X-ray photoelectron spectroscopy, Auger electron spectroscopy- Instrumentation, Working procedure, Applications & limitations.
Characterization of crystalline perfection of single crystals & epitaxial films - crystal defects and lattice mismatch, Theoretical aspects of X-ray diffraction, Reflection and scattering, High resolution X-ray diffraction for Bragg and Laue cases, Semi-kinematical theory for epitaxial layers for determination of thickness and composition, Xray reflectometry for determination of density, Thickness and interfacial roughness, Experimental aspects: Monochromators, Point and line focus configurations of X-ray beam, Parabolic graded multilayer mirror, Flow proportional and scintillation detectors, Solid-state pixel detector, High-resolution X-ray diffractometers high resolution X-ray diffraction curves, X-ray topography, X-ray reflectometry, Grazing incidence, X-ray diffractometry for in-plane diffraction, Reciprocal space mapping.
Thermo-gravimetric analysis (TGA), Measuring contact angle, Electron-sample interactions: Secondary electrons, Backscattered electrons, Lenses for electron beams, Lens defects and resolution, Structure of transmission electron microscopes, Mechanism of images formation and contrast, Structure of scanning electron microscopes (SEM, ESEM). Electron emissions sources, Vacuum conditions, Scanning electron microscopy, Conventional transmission electron microscopy, High resolution transmission electron microscopy, Selected area electron diffraction, Bright field and dark field imaging, Electron diffraction patterns, Correlation of image and diffraction pattern, Examples of indexing singlecrystals diffraction patterns, Sample preparation for SEM, TEM: Jet-polishing methods. Ion beam milling technique, Focus ion beam (FIB), Scanning transmission electron microscopy, Lattice scale imaging, Interpretation of high resolution images, Scanning tunneling microscopy, Atomic force microscopy, Helium ion microscope, Other advances techniques like, Holography, Lorentz microscopy.
Spectroscopy techniques: Fourier transform infrared spectroscopy, Raman spectroscopy, Secondary ion mass spectroscopy, Electron paramagnetic resonance spectroscopy, Photoluminescence, Defect structure analysis using microscopy and spectroscopy results, Particle size analyzer.

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AcSIR Academic Centre Code: 32		
CSIR-National Physical Laboratory		CSIR-NPL
Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title: Air Quality Measurement Science and Technology	Course Code	Credits
	AcSIR-32-ES-AD-002	3

Aerosol and gas metrology, national ambient air quality standards (NAAQS), gas measurement techniques, certified reference material, gas mixtures preparation and validation technique, PM10 and PM2.5 measurement techniques and their calibration (gravimetric sampler BAM. TEOM), impactor and cyclone. WINS and VSCC. Andersen sampler, bioaerosol sampling and measurement, particle sizer - counter and calibration, particle size statistics, filter and mask testing, air purifier testing
and CADR, Reynolds number. Stokes's law. Stokes number, D50 cutoff size, isokinetic sampling and measurement of concentration, measurement of velocity, flow rate and pressure, stack sampling, analysis of particulate bound chemicals, AAS and ICP-OES instrumental techniques, VOC measurement techniques, measurementuncertainty in chemical analysis, MU budget estimations and data quality assurance, hands-on training on the parameters of NAAQS.

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AcSIR Academic Centre Code: 32

CSIR-National Physical Laboratory CSIR-NPL

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Course Code	Credits
Instrumentation for Calibration & Testing	AcSIR-32-ES-AD-003	3

Measurement and Instrumentation, Fundamental of measurement systems, Instrument Types and Performance Characteristics, Measurement Uncertainty.
Calibration/Verification of measuring instruments: what need for users; Calibration principles: Calibration system
procedure, Calibration and Testing standards for instruments and transducers; Best practices for handling the measurement instruments. OPAMP
characteristics & circuits, Sensor & transducer characteristics, Instrumentation and Telemetry, quantum instrumentation & metrology. Instrumentation: Industry 4.0
perspective; Instrumentation Design: Need Analysis, product specifications, solution search strengths & weaknesses of instruments.
Performance characteristics & criteria fortransducers selection. Performance test (electrical, impedance, noise, resolution, threshold and environmental test etc).
Need of signal conditioning. Interface to the end i.e. display and storage devices. Computer based instrumentation. Virtual Instrumentation.

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AcSIR Academic Centre Code: 32

CSIR-National Physical Laboratory	CSIR-NPL

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Optimization Techniques and Finite Element Method in Engineering	Course Code	Credits
		AcSIR-32-ES-AD-004	3

Introduction: Introduction to Optimization, Adequate and Optimum Design, Principles of Optimization, Statement of an Optimization Problem, Classification, Formulation of Objective Function, Design Constraints; Classical Optimization Techniques and Multi Variable Unconstrained and Constrained Optimization; Traditional Optimization Techniques: Genetic Algorithms, Simulated Annealing, Geometric Programming; Finite Element Method: Basics and Applications in Engineering systems, Case study of applications in design of force sensor, vibration analysis of machines. Optimum Design of Machine Elements: Functional Requirement, Material and Geometrical Parameters, Loading parameters, design morphology, case study; single degree and two degree of freedom systems, vibration isolation, active and passive vibration absorbers, Acousticc induced vibration: measurement and control.

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AcSIR Academic Centre Code: 32			
CSIR-National Physical Laboratory			CSIR-NPL
Course 3 : Advanced Course	Physical Sciences		Total Credits 6

Title:		Course Code	Credits
	Engineering Materials	AcSIR-32-PS-AD-001	2

Classification of engineering materials, Material properties, Selection of material, Advanced and futuristic materials, Smart materials, Nanomaterials, Phase diagram, Equilibrium & kinetics, Stable & metastable phases, Nucleation and growth, Metals, alloys and solid-solutions ceramics, Polymers, Composites, Crystal imperfections, Defects, Dislocations, Elastic and plastic deformations, Stress-strain curves, Work hardening & dynamic recovery, Strengthening mechanisms, Solidification and crystallization, Recovery, Recrystallization and grain growth, Creep, Fatigue, Fracture, Oxidation, Corrosion, Material processing techniques: Liquid metallurgy, Powder metallurgy, Spray forming.
Secondary processing techniques: Extrusion, Forging, Rolling, Mechanical & metallurgical characterization, Structure-property correlations, Light weight materials, Metal matrix composites, Polymer matrix composites, Ceramic matrix composites, Carbon-based composites, Nanocomposites, Super-hard materials, Dielectric, Ferroelectric and piezoelectric materials, Magnetic materials.

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AcSIR Academic Centre Code: 32		
CSIR-National Physical Laboratory		CSIR-NPL
Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title: Advanced Electronic Materials and Semiconductor Devices	Course Code	Credits
	AcSIR-32-PS-AD-002	3

Energy band diagrams, Theory of semiconductor transport, Quantum hall effect, Colloidal nanoparticles and quantum dots for optoelectronic applications, Mechanical, optical & electrical properties, Nucleation & growth mechanism, Sizefocusing & Ostwald ripening, Hybrid nanocomposite solar cells: Charge & energy transfer (FRET), Excitons, Plasmons-polaritons-polarons: Raman & Rayleigh scattering, Surface-enhanced Raman scattering (SERS), Phase change materials, Ferroelectrics and dielectrics, Semiconductor crystals, Photonic devices and their applications: (i) Photovoltaic devices (i.e., solar cells), (ii) Lightemitting diodes (LEDs) and laser diodes, (iii) Photodetectors, Basic device physics (p-n junction diode, semiconductor contacts, Schottky barriers/diodes), Structures, characteristics and operational principles (based on elemental and compound semiconductors), Latest developments and advanced applications, organic electronics (like solar cells, light emitting diodes, transistors etc).
Practicals: Particle size and size distribution measurement of semiconductor nanoparticles by dynamic light scattering (DLS), Dark and illuminated I-V characteristics of p-n junction diode/solar cell and evaluation of solar cell efficiency, Spectral response and quantum efficiency measurements of solar cells and performance comparison,
Fabrication and testing of organic devices.

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AcSIR Academic Centre Code: 32

CSIR-National Physical Laboratory | CSIR-NPL

Course 3 : Advanced Course | Physical Sciences | Total Credits 6

Title:		Course Code	Credits
	Thin Film Physics & Technology	**AcSIR-32-PS-AD-003**	**3**

Vacuum science & technology for thin film processing, Vacuum systems for thin film growth & characterization, Gas transport and pumping, Thin films growth mechanisms, Kinetic models of nucleation, Thermodynamics aspects of nucleation, Island and coalescence growth, Factors influencing thin film growth, Role of surface energy in thin film growth, Steps in thin film formation, Thin film deposition techniques: Physical vapor deposition (PVD), Evaporation (resistive heating, flash, electron beam, ion beam and pulsed laser), Physics and chemistry of evaporation, Sputtering (mechanisms and yield, dc and rf sputtering, Bias sputtering, Magnetron sputtering, Unbalanced magnetron sputtering), Physics of sputtering and reactions in plasma, Hybrid and modified PVD, Ion plating, Ion beam assisted deposition and processing of thin films, Cathodic vacuum arc deposition, Quasi-continuous theory of arc plasma, Magnetic filtered arc and industrial systems & processes. Chemical vapor deposition (CVD): Reaction chemistry and thermodynamics of CVD, Thermal CVD, MOCVD, Hot wire CVD, Ultrahigh vacuum techniques and processes, Contamination and cleaning, Molecular beam epitaxy: Principal & operation, Knudsen cell, kinetics & thermodynamics, Growth of epitaxial films & nanostructures, Adsorption at surfaces, Atomistic processes in the early stages of thin-film growth, Adatom diffusion on terraces & nucleation of islands, Diffusion & fractal island growth, Surface reconstruction, Adsorbate-induced reconstructions. Reflection high energy electron diffraction: in-situ two & three dimensional growth characterization, Surface crystallography and diffraction, Surface symmetry, Description of overlayer structures, Reciprocal net & electron diffraction, Qualitative consideration, Domains, Steps and defects, Low energy electron diffraction (LEED): Principles, Instrumentation, Qualitative information, LEED Pattern, Spot profile analysis, Quantitative structural information.
X-Ray photoelectron spectroscopy: Principles, Instrumentation, X-Ray sources, Synchrotron radiation, Electron energy analyzers, Spatial resolution, Spectral information and chemical shifts quantification, Depth profiling & imaging, Auger parameter, Applications in catalysis, Polymers, Corrosion and passivation, Adhesion, Superconductors, Semiconductors, Ultraviolet Photoelectron spectroscopy: Concept, Instrumentation and Spectral analysis, Auger electron spectroscopy (AES): Principles, Instrumentation, Electron sources, Electron-energy analyzers, Spectral information, Quantification and depth profiling, Applications in thin films and interfaces, Surface segregation, scanning auger microscopy.
Thin film characterization: Defect analysis, Surface profiler (contact & non-contact mode), Spectroscopic ellipsometer: Concept, thickness and optical parameter (n, k, a) evaluation. Applications of thin films in optical coatings & solar cells.

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AcSIR Academic Centre Code: 32

CSIR-National Physical Laboratory CSIR-NPL

Course 3 : Advanced Course Physical Sciences Total Credits 6

Title:	Course Code	Credits
Nanostructured Materials	AcSIR-32-PS-AD-004	3

Physical scaling laws applied to understanding the properties of materials at the nanometre scale. Self-assembly, surfaces and interfaces in nanotechnology.
Nanostructuring techniques: Nanopolishing, Etching of nanostructures, Lithography procedures: Optical lithography, Electron beam lithography, Ion beam lithography, X-ray, Synchrotron lithography, Focused ion beams, Nanoimprinting. Nanolayers by physical vapor deposition methods, PLD, Sputtering, e-beam evaporation, MBE, Chemical vapor deposition (CVD); Characterization of nanomaterials: Structure, Composition, Defects, Interfaces, Grain boundaries. Characterization of nanostructures by scanning probe microscopy, Near-field optics, Electron microscopy etc. Physics at low dimensions, Heterostructures, Band engineering, Quantum wires, Quantum dots, Effective mass approximation, Quantum wells in heterostructures, Square well of finite and infinite width, Triangular and parabolic quantum wells, Tunneling transport, Potential step, T-matrices, Current and conductance, Resonant tunneling, Tunneling in heterostructures, Effects of electric and magnetic fields, Density of states, Conductivity and resistivity tensors, Quantum correction to conductivity, SD effect, Quantum hall effect, Aharanov-Bohm effect, Nanomagnetism, Surface/interface magnetism, Anophotonics. Electronic devices based on nanostructures, High electron mobility transistors, Resonant tunneling diode, Quantum cascade laser, Single electron transistor, Carbon nanotube and grapheme devices and spintronic devices, Phase transition in nanostructures systems.

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AcSIR Academic Centre Code: 32	
CSIR-National Physical Laboratory	**CSIR-NPL**

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Superconductivity and Magnetic Materials	Course Code	Credits
		AcSIR-32-PS-AD-005	3

Introduction to superconductivity, Thermodynamics of superconducting transition, Two-fluid model London theory Pippard's non localization, Fluxquantization, Superconducting tunneling phenomena and energy gap, Introduction to microscopic theory (Bardeen-CooperSchrieffer) of superconductivity. Type II superconductivity, Mixed state and Ginzburg-Landau theory, Critical currents, Flux-pinning and flux-flow. Applications of superconductivity, Materials requirement for superconducting devices, Superconducting thin films, SQUIDs and Josephson junction based devices, Detectors and bolometers. High current applications, Synthesis methods for wires and tapeconductors, Superconducting magnets, Energy storage. High temperature superconductors: Introduction & their unusual fundamental properties, Electronic and power applications of hightemperature superconductors. Physical properties of materials at low temperatures (specific heat, thermal conductivity, thermal expansion, electrical conductivity, magnetic and mechanical properties). Production of low temperatures, Cryogenic fluids their properties and storage, Transfer devices, Temperature control & measurement, Production of very low temperatures, Vacuum systems as applied to cryogenics. Magnetism: Magnetic moments of a body, Alignment of atomic magnetic moments in a solid, Ferromagnetism, Curie point and exchange integral, Magnetisation and magnetic domains, Temperature dependence of magnetization, Coercive force and hysteresis, Coercivity in fine particles. Ferrimagnetism and antiferromagnetic order, Neutron magnetic scattering magnetism of transition metals, Rare-earths and special oxides (spinels, garnets and perovskites). Magnetoresistance, Tunnel magnetoresistance, Spintronics.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-33-BS-AD-001	Advances in Crop Production System
Biological Sciences	AcSIR-33-BS-AD-002	Biology of Infection
Biological Sciences	AcSIR-33-BS-AD-003	Crop Protection & Insect Toxicology
Biological Sciences	AcSIR-33-BS-AD-004	Genomics and Epigenetics
Biological Sciences	AcSIR-33-BS-AD-005	Molecular Breeding of Plants
Biological Sciences	AcSIR-33-BS-AD-006	Pharmacology and Toxicology
Biological Sciences	AcSIR-33-BS-AD-007	Plant Conservation and Reproductive Biology
Biological Sciences	AcSIR-33-BS-AD-008	Plant-Microbe Interaction
Biological Sciences	AcSIR-33-BS-AD-009	Protein Science and Proteomics
Biological Sciences	AcSIR-33-BS-AD-010	Remote Sensing and GIS
Chemical Sciences	AcSIR-33-CS-AD-001	Isolation and Spectroscopic Techniques
Chemical Sciences	AcSIR-33-CS-AD-002	Advanced Synthetic Organic Chemistry
Chemical Sciences	AcSIR-33-CS-AD-003	Advances in Natural Products

AcSIR Academic Centre Code: 33

CSIR-Institute of Himalayan Bioresource Technology	CSIR-IHBT

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Advances in Crop Production System	AcSIR-33-BS-AD-001	2

Advances in medicinal and aromatic plants production, Growth and development of crops, Soil physico-chemical properties, Soil fertility and productivity, Manures and fertilisers, Soil organic matter, Nutrients function, nutrient use efficiency, IPNMS system, Precision agriculture, Advances in Soil-plant-water Relationship, Physiomorphological behaviour of plants under different environmental conditions, Water use efficiency, Adaptation of plants to water variation, Sustainable and organic agriculture.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title: Biology of Infection	Course Code	Credits
	AcSIR-33-BS-AD-002	2

Host pathogen interaction Infection and infectious process and routes of transmission, Methods of transmission and role of vectors (Mosquitoes, Sand fly) Description and pathology of bacterial diseases e.g. Tuberculosis, description and pathology of parasitic infections e.g. Malaria. Structure and replication of DNA and RNA viruses, Virus-host interactions, pathology of viral infections Infections caused by Flavi- viruses, respiratory viruses, hepatitis viruses, HIV Biology. Immunology Innate and acquired immunity, Components of immune system, T-cell subsets and surface markers, antigen processing and presentation, Antigen-antibody interactions, Host response to viral infection (anti-viral immunity), antiviral compounds, Vaccines and vaccinations, techniques in diagnostic microbiology: Immunological techniques, Serological techniques, Nucleic acid techniques, Biological safety in handling pathogenic bacteria and viruses

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 33	
CSIR-Institute of Himalayan Bioresource Technology	CSIR-IHBT

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Crop Protection & Insect Toxicology	AcSIR-33-BS-AD-003	2

Major pests of crops; Insect host plant relationship, Insecticide resistance; Biopesticides; Integrated pest management; Economic threshold concept and economic consideration; Biological control agents, Integration of different methods of pest management. Classification and mode of action of pesticides; Degradation of pesticides; Evaluation of insecticide toxicity; Pest resistance to insecticides, resistance management & pest resurgence; Safe handling of insecticides, diagnosis, and insecticide-poisoning treatment.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 33

CSIR-Institute of Himalayan Bioresource Technology	CSIR-IHBT

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Genomics and Epigenetics	Course Code	Credits
		AcSIR-33-BS-AD-004	2

Introduction to genomics; Cloning vectors (plasmids, cosmids, BAC, PAC, YAC); Genome Organization (Nuclear, Mitochondrial and Chloroplast Genome); High-throughput genome sequencing and their application in genomics; Overview of model and crop plant genomes (Arabidopsis, Rice and human genomes;etc.). Functional genomics. Forward and Reverse genetics, Gene editing (TALENs, ZFNs, CRISPR-Cas), Metabolic pathways, Metabolic engineering, Gene order (Colinearity, Identification of orthologs, Functional predictions); Fundamental of epigenetics (Chromatin structure; Organization of nucleosome and chromosomes; Epigenetics in plant evolution and stress adaptation, Gene Silencing; Small RNAs and their mechanism of regulation; RNA processing and alternative splicing; Fundamentals and concepts of cell signalling (Signal transduction; Receptors; Anterograde and retrograde signaling, Reactive oxygen species; Major signaling pathways in plants (Light signalling, Circadian rhythm, hormones, elicitors, small molecules), Cell signalling in biotic and abiotic stress tolerance.

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AcSIR Academic Centre Code: 33

CSIR-Institute of Himalayan Bioresource Technology	CSIR-IHBT

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title: Molecular Breeding of Plants	Course Code	Credits
	AcSIR-33-BS-AD-005	2

Introduction to molecular breeding; Techniques in molecular breeding; Morphological and Molecular markers, QTL analysis; Application of molecular breeding in plants, Mapping populations (F2, Back crosses, Recombinant Inbred Lines, Near Isogenic Lines and Doubled Haploid lines, NAM, MAGIC etc). Construction of linkage maps and physical maps, Linkage disequilibrium, QTL mapping (single marker analysis, interval mapping, association mapping), epi-RILs, epi-GWAS, epi-Breeding; epistatic QTLs, map based cloning, Fine mapping, marker-assisted selection, marker-assisted recurrent selection, genomic selection, Gene pyramiding

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AcSIR Academic Centre Code: 33

CSIR-Institute of Himalayan Bioresource Technology	CSIR-IHBT

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Pharmacology and Toxicology	AcSIR-33-BS-AD-006	2

Regulatory Toxicology: Principles and Classification of toxicology, Toxicokinetics, Test for mutagenicity, teratogenicity, phototoxicity, carcinogencity, Toxicogenomics, target organ toxicology and preclinical toxicology; Experimental Toxicology: Common laboratory animals, euthanasia of experimental animals, Ethics moral and laws related to experimental animals, CPCSEA, OECD and ICH guidelines, Food and Drug Administration, determination of LD50 determination, acute, sub-acute and chronic toxicity studies. Good Laboratory Practices (GLP), GLP establishment, GLP audits and inspection, Schedule Y to design non- clinical toxicity studies and clinical development and alternatives to animals; Advanced and Experimental Pharmacology: Principles of Pharmacology, Pharmacokinetics, mechanisms of drug action, neurotransmission in central nervous system and cellular signalling, principles of development of therapeutic proteins, pharmacology of vascular endothelium, chronopharmacology, chiral pharmacology, drug- drug/food-drug/herb-drug interactions; New approaches in drug discovery, high throughput screening, principles and applications of bioassays for in vivo therapeutic evaluation of anticancer, cardioprotective, antiepileptic, antianxiety, nootropic, antidepressant, anti-inflammatory, antidiabetic, wound healing, antiviral and hepatoprotective molecules, in vitro techniques using animal and human cell lines, in vitro cell culture techniques, flow cytometery and cell viability assays and in silico pharmacology, experimental design and data analysis in experimental pharmacology and transgenic animal models.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 33

CSIR-Institute of Himalayan Bioresource Technology	CSIR-IHBT

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Plant Conservation and Reproductive Biology	Course Code	Credits
		AcSIR-33-BS-AD-007	2

Conservation biology: principles and applications; Threats to plant diversity: causes and consequences; Conservation biology of rare and endangered plants: concepts and practical approaches, Conservation at landscape and ecosystems levels: methods and strategic approaches; Plant species loss: assessment of extinction risks: IUCN Red lists: criteria and classification, national red lists, biodiversity hot spots; Current tools and techniques for species distribution assessment; Conservation at species and population level: measurement of genetic diversity, gene flow, reproductive/mating systems; in-breeding and out -breeding depression, effective population size and management of genetic diversity population bottlenecks and maintenance of genetic diversity; Plant conservation methods and strategies: In situ conservation, Ex situ conservation, Recovery, Reintroduction and Rehabilitation of endangered habitats and species; Introduction to Plant Reproductive Biology: Modes and mechanics of reproduction in plants; Floral biology and phenology; Pollen and Pollination Biology; Fertilization and Seed Biology; Recent Trends in Reproductive Biology; Reproductive Biology and Threatened Plants; Case Study, field visit, visit to herbarium, botanical garden, conservatories etc.

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AcSIR Academic Centre Code: 33

CSIR-Institute of Himalayan Bioresource Technology CSIR-IHBT

Course 3 : Advanced Course Biological Sciences Total Credits 6

Title:	Course Code	Credits
Plant-Microbe Interaction	AcSIR-33-BS-AD-008	2

Principles and Concepts in Host-Pathogen Relationship (Recognition of Pathogens and Non-Pathogens, Role of Enzymes, Toxins, Growth Regulators, Phenolics, Phytoalexins, PR Proteins, Elicitors-Defense Strategies); , Signal Transduction, Systemic Acquired Resistance and Induced Systemic Resistance, Defense Genes, Hypersensitive response , Programmed Cell Death, Virus Induced Gene Silencing, R-Gene Expression and Transcription Profiling, Economic Impact of Viral and Viroid Diseases, Molecular Characteristics of virus and virus like pathogens, Movement through Plasmodesmata and Vasculature, Viral Determinants Involved in Phloem Transport of Plant Viruses, transmission of virus and viroid pathogens by insect vectors, Suppressors of silencing encoded by plant viruses

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 33			
CSIR-Institute of Himalayan Bioresource Technology			**CSIR-IHBT**
Course 3 : Advanced Course	**Biological Sciences**		**Total Credits 6**
Title: Protein Science and Proteomics		**Course Code**	**Credits**
		AcSIR-33-BS-AD-009	**2**

Fundamentals of Proteins: amino acids, peptides, Side chains, Physico- chemical proeprties, Proteins as essential biomolecules, Transcription, Translation, Folding, Targeting, Mis-folding, Proteases, Proteasomes, Ubiquitination, Sumoylation, Structural and Functional proteins; Protein Structure: Primary, secondary, tertiary, and quaternary structures; Forces determining protein structure, Covalent modifications of the polypeptide chain; Structural motifs in regulatory proteins: DNA-binding proteins, Zinc finger motif, Helix Turn Helix motif Basic Leucine Zipper motifs etc; Protein Regulation: Enzymes: Mechanism of Catalysis, Kinetics & Regulation; Proteomics: Introduction; Analytical and Comparative proteomics; Methods: Extraction and separation of proteins for proteome analysis: 2DE, 2DIGE, LC; Protein identification: Mass spectrometry, MudPIT; Computational and Bionformatic analysis; Gel and gel-free proteomics; Labelled and unlabelled proteomics; Post- translational modifications; Organelle proteomics; Protein-protein interactions; Techniques for proteome research; High throughput proteomic screening for novel bioactive peptides/proteins/enzymes; Tools and databases: Protein sequence alignment; in-silico structure analysis, Domain search, Databases: Sequence information and analysis: SWISS-PROT, NCBI etc.; Structure information and analysis: Protein Databank (PDB), SWISS-Model, PHYRE; PyMOL

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 33

CSIR-Institute of Himalayan Bioresource Technology	**CSIR-IHBT**

Course 3 : Advanced Course	**Biological Sciences**	**Total Credits 6**

Title:		Course Code	Credits
	Remote Sensing and GIS	**AcSIR-33-BS-AD-010**	**2**

Concept of Electromagnetic Radiation (EMR): Wavelength – frequency – energy relationship of EMR, EMR Wavelength regions and their applications, Interaction of EMR with matter; Remote Sensing Satellites: Geo-stationary and Sun-synchronous satellite, Resolution – Spatial, Spectral, temporal, and radiometric, Types of scanners – Whiskbroom scanner, Push - broom scanners; Image corrections and enhancement: Image Pre- Processing- Geometric corrections, radiometric corrections, Histogram equalization, Image Sharpening, Filtering; Image interpretation and classification: Basic element of image interpretation, Supervised and unsupervised classifications, Advance classification techniques- Artificial neural network (ANN), Spectral angle mapper (SAM); Hyperspectral remote sensing: Hyperspectral sensors, Spectral signature, Spectral library, Hyperspectral data processing; Vegetation indices and its uses; Spatial and non-spatial data, Raster and Vector data; Concept of map scale: Defining Map, Projection system; GIS functions: Digitization, SQL based Quarry, Visualization etc.; GIS software: Open source and licenced software's; Spatial modelling: Ecological Niche Modelling; Navigation

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AcSIR Academic Centre Code: 33

CSIR-Institute of Himalayan Bioresource Technology	CSIR-IHBT

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Isolation and Spectroscopic Techniques	Course Code	Credits
		AcSIR-33-CS-AD-001	2

Spectroscopy Techniques: Introductory and fundamental of IR, UV, Mass Spectrometry and TOF-MALDI. Concept and theory of NMR, 1H- and 13C-NMR, practical aspects of NMR, chemical shift, chemical equivalence and spin-spin coupling, magnetic equivalence, spin systems, pople notation, spin-spin coupling in stereochemistry and structure determination, dynamic effects in NMR spectroscopy, nuclear overhauser effect (NOE), DEPT, two dimensional (2-D) NMR (COSY, HMQC, HMBC, TOCSY, NOESY, ROESY), structure elucidation of natural products (flavonoids, alkaloids, terpenoids, steroids etc.). Advances in Natural Products: Extraction and Isolation Techniques (1C): Flash chromatography, micro wave –assisted and ultrasound extraction techniques, solid phase micro extraction (SPME), solid phase extraction (SPE), supercritical fluid extraction (SFE), single drop micro extraction (SDME): principles, instrumentation, types of solvents, adsorbents and applications, modern isolation techniques.

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AcSIR Academic Centre Code: 33

CSIR-Institute of Himalayan Bioresource Technology | CSIR-IHBT

Course 3 : Advanced Course | Chemical Sciences | Total Credits 6

Title:	Course Code	Credits
Advanced Synthetic Organic Chemistry	AcSIR-33-CS-AD-002	2

Advanced Organic Synthesis and Medicinal Chemistry (1C): Bamford-Stevens reaction, Baylis-Hillman reaction, Biginelli reaction, Corey-Fuchs Reaction, Yamaguchi esterification, Wittig-Horner reaction, Vilsmeier reaction, Ugi reaction, Tsuji-Trost reaction, Sharpless Epoxidation, Seebach Umpolung, Ring Closing Metathesis, Pauson-Khand Reaction, Olefin Metathesis, Enyne Metathesis, Nozaki-Hiyama coupling, Mukaiyama Aldol addition, Click reaction, Hay coupling, Glaser coupling, Fukuyama coupling, Aldol condensation, Mannich, Michael, Claisen-Schmidt condensation, Suzuki- Miyaura, Heck, Stille, Sonogashira, Buchwal-Hartwig reactions, Basic Principals of Medicinal Chemistry, Lipinski rule of five (RO5), Beyond the rule of five (BRO5), Topliss Tree; Overview of drug discovery approach, Structure activity relationship (SAR). Advances in Catalyst and Reagent Chemistry (1C): Advantages, physico-chemical properties of nanoparticles, nanoparticles as heterogeneous catalysts, applications of nanoparticles in coupling, cross-coupling, oxidation and reduction reactions, coupling and cross-coupling reagents, asymmetric synthesis using chiral environments, modern reagents in oxidation and reduction reactions, homo/ heterogeneous catalysts, phase transfer reagents and role of ligands in organic synthesis, protection and deprotection reagents, recent reports in methodology development, scale up processes and mechanistic studies.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 33

CSIR-Institute of Himalayan Bioresource Technology	CSIR-IHBT

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Advances in Natural Products	Course Code	Credits
		AcSIR-33-CS-AD-003	2

Traditional methods and Terpenoids (1C): Medicinal and aromatic plants: primary and secondary metabolites; traditional systems of medicine: use of herbal remedies and potential of drug development from natural products and novel drug templates: paclitaxel, podophyllotoxin, artimisinin etc. Definition, nomenclature, classification of terpenoids, monoterpenoids, iridoids, sesquiterpenoids, diterpenes, triterpenoids, steroids. Isoprene rule, biosynthesis of terpenoids and steroids, mevalonate and non-mevalonate pathways. Essential oils their production, uses and characterization, saponins, sapogenins, steroidal, triterpenoids saponins. General methods of purification, detection and characterization of terpenoids and saponins. Case studies of essential oil, diterpenoids and triterpenoids. Alkaloids and Polyphenols(1C): Definition, nomenclature and physiological action, occurrence, isolation, general method of structure elucidation, degradation, classification based on nitrogen heterocyclic ring role of alkaloids in plants. Structure stereochemistry and biosynthesis of the following: Ephedrine, (+)- Conine, Nicotine, Atropine, Quinine and Morphine. Occurrence, nomenclature, classification of polyphenols and general methods of structure determination, isolation and detection. Polyphenols will cover- lignans, coumarins, flavonoids, chalcones, anthocyanin, proanthocyanin and tannins etc. Biosynthetic pathways for the formation of polyphenols. Case studies of lignans, flavonoids, chalcones, anthocyanin etc.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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Faculty of Study	Course Code	Course Title
Chemical Sciences	AcSIR-35-CS-AD-001	Basic and Applied electrochemistry
Chemical Sciences	AcSIR-35-CS-AD-002	Materials for Radiation Shielding Applications
Chemical Sciences	AcSIR-35-CS-AD-003	Nanostructured materials for Biosensor techniques
Chemical Sciences	AcSIR-35-CS-AD-004	Environmental chemistry
Chemical Sciences	AcSIR-35-CS-AD-005	Green Chemistry
Chemical Sciences	AcSIR-35-CS-AD-006	Ground Water, Geochemical Studies and Water Resources Management
Chemical Sciences	AcSIR-35-CS-AD-007	Materials Characterisation
Chemical Sciences	AcSIR-35-CS-AD-008	Materials for Biomedical Application
Chemical Sciences	AcSIR-35-CS-AD-009	Environmental Sciences and Management
Engineering Sciences	AcSIR-35-ES-AD-001	Powder Metallurgy
Engineering Sciences	AcSIR-35-ES-AD-002	Advanced Polymeric Materials
Engineering Sciences	AcSIR-35-ES-AD-003	Composite Science and Engineering
Engineering Sciences	AcSIR-35-ES-AD-004	Functional and Smart Materials
Engineering Sciences	AcSIR-35-ES-AD-005	Cellular Materials
Engineering Sciences	AcSIR-35-ES-AD-006	Analysis of Metal Forming Processes

35	CSIR-AMPRI	3	*Advanced Course*

Faculty of Study	Course Code	Course Title
Engineering Sciences	AcSIR-35-ES-AD-007	Fatigue and Fracture Evaluation of Materials
Engineering Sciences	AcSIR-35-ES-AD-008	Fiber Reinforced Polymer Composites
Engineering Sciences	AcSIR-35-ES-AD-009	Waste Utilization and Value Addition
Engineering Sciences	AcSIR-35-ES-AD-010	Advanced Geopolymeric and Radiation Shielding Materials
Physical Sciences	AcSIR-35-PS-AD-001	Physics of Thin Films
Physical Sciences	AcSIR-35-PS-AD-002	Crystallography and Diffraction
Physical Sciences	AcSIR-35-PS-AD-003	Materials for Radiation Shielding Applications
Physical Sciences	AcSIR-35-PS-AD-004	Organic Semiconductors
Physical Sciences	AcSIR-35-PS-AD-005	Composite Materials
Physical Sciences	AcSIR-35-PS-AD-006	Advanced Material Characterisation Techniques
Physical Sciences	AcSIR-35-PS-AD-007	Physics and Engineering of Sensor/Energy
Physical Sciences	AcSIR-35-PS-AD-008	Physics and Engineering of Soft Materials

AcSIR Academic Centre Code: 35

CSIR-Advanced Materials and Processes Research Institute CSIR-AMPRI

Course 3 : Advanced Course Chemical Sciences Total Credits 6

Title:	Course Code	Credits
Basic and Applied electrochemistry	AcSIR-35-CS-AD-001	3

Basic electrochemistry concepts, Reference electrodes, Electrochemical Thermodynamics, Kinetics of electron transfer, the Taft equation, Diffusion, Double Layers, electrode Kinetics, the Gibbs adsorption isotherm, the Lippmann equation, infinitely dilute solutions and thermal balance, Electro capillary phenomena, Faradaic vs. capacitive currents, transport properties, potential theory.Electrode kinetics and electrochemical techniques: polarizable and non-polarizable interfaces; current potential relationship; methods of measurement of kinetic parameters; over potential; symmetry factor and transfer coefficient; potentiodynamic, mechanistic criteria; diffusion, activation phenomena. Steady state and potential step techniques; polarography; Classifications ofelectrochemical techniques (Cyclic Voltammetry (CV); Square Wave Voltammetry (SWV), Differential Pulse Voltammetry (DPV), Chrono-techniques; convective diffusion systems: RDE, RRDE, microelectrodes, Electrochemical Impedance Spectroscopy (EIS) - concepts and applications, Spectro-electrochemistry and its applications.
Applied topics: fundamentals of batteries: primary, secondary, reserve batteries; solid state and molten solvent-batteries; fuel cells. Photo-electrochemical solar cells and conversion of solar energy. Corrosion – fundamentals and applications, Electrolysis methods, Electrochemistry of polymers and inorganic solids, basics of Electro-polymerization, Electrophoretic deposition and Electroplating.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 35

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

Course 3 : Advanced Course | Chemical Sciences | Total Credits 6

Title:	Course Code	Credits
Materials for Radiation Shielding Applications	AcSIR-35-CS-AD-002	3

Basics of Radiations: Radiations and its interaction with matter, Importance and Harmful effects of radiations, Types and difference between different types of radiations - X-ray, U.V rays, gamma ray, neutron, microwave, radiowave, alpha & beta particles. Principle and mechanis m of radiation shielding, Radiation shielding materials.

Chemistry of radiation shielding materials: Role and importance of chemicals and processes for making advanced radiation shielding materials, Importance of nanomaterials and waste by products in radiation shielding material. Different types of radiation shielding materials, Characterization of radiation shielding materials and their applications spectrum.

Engineering of radiation shielding materials: Scientific basis for the understanding and development of red mud based synthetic heavy density radiation shielding aggregates, Engineering properties test for synthetic heavy density radiation shielding aggregates, binder material and concrete, Development of Mix design for different grads of radiation shielding concrete. Radiation attenuation test for radiation shielding concrete. Salient advanced features of synthetic shielding aggregate based radiation shielding concrete. Durability test for advanced radiation shielding concrete. Application spectrum of radiation shielding concrete.

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AcSIR Academic Centre Code: 35

CSIR-Advanced Materials and Processes Research Institute CSIR-AMPRI

Course 3 : Advanced Course | Chemical Sciences | Total Credits 6

Title: Nanostructured materials for Biosensor techniques	Course Code	Credits
	AcSIR-35-CS-AD-003	3

Basic concept and Definition of Biosensors, Introduction of biosensors, Background and history of biosensor, classification of biosensors, types of biological recognition, types of transducers, Principles and transduction approaches, Immobilizationtechniques, chemistry of immobilization, Enzyme electrode reactions, basic characteristics of biosensor (Linearity, sensitivity, selectivity, response time, Km value, enzyme activity, binding affinity), biomarkers, Implications of aptamers and peptide nucleic acid (PNA) in biosensor development.

Potential materials/ Nanostructured materials for biosensors, carbon & 2D based material for biosensors, nanotechnology application in diagnostics, electrochemical/ fluorescence/ ramantechniques based biosensor, Microfluidic ("Lab-on-Chip") devices, Micro-fabrication, Microfluidics for miniaturizations, Electro-analytical techniques in clinical chemistry, Multiplex system-based biosensor, Examples and commercial applications of biosensor devices, Commercial lab-on-chip biosensor systems, Future of biosensor devices.

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AcSIR Academic Centre Code: 35

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

Course 3 : Advanced Course | Chemical Sciences | Total Credits 6

Title:	Environmental chemistry	Course Code	Credits
		AcSIR-35-CS-AD-004	3

Environmental analysis & parameters - air, noise, water, and soil pollution. Introduction to industrial wastes, their definition, classification, sources and characteristics. Environmental impact & risk assessment, ambient air quality monitoring & modelling, industrial disaster modelling, its regulations and framework. Air pollutants, their sources and types, air pollution control devices .Global warming, green house gases and their capture.

Water: properties; acid-base reactions, electrochemistry, pH; Eh; Chemical methods in treating water and wastewater; water disinfection.. Soil chemistry: nature and importance; acid-base and ionexchange reactions in soils; colloidal chemistry of inorganic constituents, clays, organic matter and soil humus; adsorption desorption reactions, ion exchange, degradation of pesticides and hazardous substances in soil.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 35

CSIR-Advanced Materials and Processes Research Institute CSIR-AMPRI

Course 3 : Advanced Course Chemical Sciences Total Credits 6

Title:	Course Code	Credits
Green Chemistry	**AcSIR-35-CS-AD-005**	**3**

Green chemistry concepts: Basics of inorganic, organic, physical and biochemistry, Nomenclature (IUPAC), molarity, molality andnormality, types of bonding, Ionic, covalent and non-bonding interactions, Acids and bases, Atomic structure, periodic table and periodic properties, stoichiometry, chemical reactions and kinetics, solvent effects, functional groups in organic compounds, scope and interdisciplinary nature of green chemistry; Environmental factors; Industrial applications of green chemistry, Energy efficiency and atom economy, Catalysis and green chemistry, Alternate reaction media and reaction systems, ionic liquids, Waste reduction at source.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 35

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

Course 3 : Advanced Course | Chemical Sciences | Total Credits 6

Title:	Course Code	Credits
Ground Water, Geochemical Studies and Water Resources Management	**AcSIR-35-CS-AD-006**	**3**

Classification of rocks with respect to water bearing characteristics, geological structures favouring groundwater occurrence, geomorphic units and their influence on occurrence and movement of water resources, hydrological properties of rocks, aquifer and its classification, surface and subsurface water sources, hydrological cycle, Darcy's law, groundwater movement, water table, aquifer test, draw down, flow nets, geomorphic processes and land forms, definition and importance of structural geology with re ference to water resources management, groundwater exploration, geochemical studies, chemical parameters of water

Recharge mechanisms, groundwater recharging techniques for rejuvenation of water resources, watershed development and management, water resources mapping, monitoring and management, water resources contamination, groundwater modelling (procedures, software, applications of modflow, SWAT, GMS, AGPNS, rockworks etc, long term prediction of the effect of future groundwater withdrawals on groundwater levels and contaminants transport movement.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 35

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

Course 3 : Advanced Course **Chemical Sciences** **Total Credits 6**

Title:	Course Code	Credits
Materials Characterisation	**AcSIR-35-CS-AD-007**	**3**

Basic concept, SI units, design of experiments, error and standard deviation, Introduction to materials properties; physical, mechanical, thermal, electrochemical, tribological, rheological, interfacial, magnetic and electrical properties.

Introduction to different microscopy techniques, Resolution, magnification, depth of field, depth of focus, Imaging - theory and concepts.

X-ray microanalysis: EDS, WDS, EPMA (Surface analysis), XRD, EBSD, TEM (Applications to crystallography), X-ray methods (EDS, WDS, XRF, XANES, XPS, EXAFS),Scanning force microscopy (AFM), Spectroscopy (IR, Raman),Thermal techniques; thermal gravimetric analysis (TGA), Differential thermal analysis (DTA), Differential scanning calorimetry (DSC) and Differential Mechanical Analysis (DMA).Sample preparation for different characterisations.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 35

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

Course 3 : Advanced Course **Chemical Sciences** **Total Credits 6**

Title:		Course Code	Credits
	Materials for Biomedical Application	**AcSIR-35-CS-AD-008**	**3**

Biomaterials and Biomimetic materials: Concept of biomaterials and biomimetic materials, Types of biomaterials (polymers, ceramics, metals, composites), Interactions between cells and surface of biomaterials, Modification of biomaterials surface, Concept of biocompatibility and biodegradability, 3D printing of biomaterials, Electrospinning technique for nanostructuring of biomaterials, Concept of hydrogels, Biomedical applications of biomaterials including implants, drug delivery, tissue engineering, wound care management etc.

Antimicrobial materials and Coatings: Antimicrobial agents (antibiotics, metal ion/metal nanoparticles, antimicrobial peptides, antimicrobial polymers), Antimicrobial materials, application of antimicrobial materials in food packaging, textiles, paints and varnishes, implantable devices, drug delivery, self-cleaning surfaces, wound dressings. Antimicrobial hydrogels and their applications, Antimicrobial phytochemicals, Antimicrobial Coatings, Methods to develop antimicrobial coatings, Antimicrobial coatings for medical devices, surgical equipment and high touch surface like doors, glass etc.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 35

CSIR-Advanced Materials and Processes Research Institute CSIR-AMPRI

Course 3 : Advanced Course Chemical Sciences Total Credits 6

Title:	Course Code	Credits
Environmental Sciences and Management	AcSIR-35-CS-AD-009	3

Air: Air pollutants, their sources and types, global warming, green house gases and their capture, air quality monitoring, air pollution control devices. Environmental analysis & parameters - air, noise, water, and soil pollution. Environmental impact & risk assessment, ambient air quality monitoring & modelling, industrial disaster modelling, its regulations and framework.
Water: properties; acid-base reactions, electrochemistry, pH; Eh; Chemical methods in treating water and wastewater; water disinfection. Removal of water pollutants (different processes/ methods of removal of toxic/ heavy metals, impure water/ effluent treatment using different separation techniques, packed bed towers / columns), adsorbents (commercial adsorbents and their application, role of industrial wastes in synthesis and characterization of cost-effective adsorbents, their application for effluent treatment, water purification)
Industrial effluents, their types, sources, measurement and characteristics, environmental pollution monitoring and control – DO, BOD, COD
Assesment and monitoring: Concept and significance, environmental impact studies, rules and acts, water and air pollution (effluents, groundwater contamination, air pollutants, global warming, estimation/modeling & prevention), air and water quality monitoring and modeling, scope of error and precautions, air pollution control devices, industrial effluents and treatments, environmental issues.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

CSIR-Advanced Materials and Processes Research Institute	CSIR-AMPRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Powder Metallurgy	AcSIR-35-ES-AD-001	2

Basic principles and concept, processing steps and techniques, powder production and characterization, mechanical alloying, stages of sintering, driving forces for sintering, mechanism of sintering, solid state and liquid phase sintering, reaction sintering, sintering furnaces (conventional, microwave, SPS etc.) and atmospheres, hot pressing, cold and hot isostatic pressing, self propagating combustion sintering, specialized characterization techniques and standards, parameters controlling properties, sintered products (iron, copper titanium and aluminium base materials/products, MMCs, metal foam, functional materials), sintered product property evaluation and standardization.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 35

CSIR-Advanced Materials and Processes Research Institute CSIR-AMPRI

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Advanced Polymeric Materials	Course Code	Credits
		AcSIR-35-ES-AD-002	2

Concept of nanofillers and polymer nanocomposites, polymer nanocomposites (types, synthesis, characterization, characteristics and applications), functional polymers (synthesis and characterization), introduction of inorganic nanoparticles into functional polymers, surface modification techniques, functionalization of the surface of nanoparticles, shape memory polymers, conducting polymers, magnetic polymers, role of polymers in high-tech areas such as light emitting diode, OSR insatellite communication, photovoltaic etc., polymers for insulation and electronics, laminates and sandwich panels, characterizat ion of some important thermoplastics and thermosets, rheological behaviour, interpretation of information and application potential, liquid crystalline polymers (properties and applications), self reinforced composites. polymer blends and alloys, theories of polymer miscibility, various commercial blends and their applications, reactive blending

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 35

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

Course 3 : Advanced Course | Engineering Sciences | Total Credits 6

Title:	Course Code	Credits
Composite Science and Engineering	AcSIR-35-ES-AD-003	2

Concept of Composite materials, Micromechanics of composites, Rule of mixture, Various types of composites, Classification based on Matrix Material, Classification based on reinforcements, Reinforcements/Fibres, Types of fibres, Whiskers and Flakes, Mechanical properties of reinforcements, Synthesising techniques, Processing of Advanced composites, Casting, Liquid Metal Infiltration, Solid State diffusion, Liquid phase sintering, Metal matrix composites, Carbon composites, Polymer matrix composites, Ceramic Matrix Composites, Natural/Bio composites, Functionally graded composites, , Hybrid composites, Processing and characteristics of nanocomposites.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 35			
CSIR-Advanced Materials and Processes Research Institute			CSIR-AMPRI
Course 3 : Advanced Course	Engineering Sciences		Total Credits 6
Title: Functional and Smart Materials		Course Code	Credits
		AcSIR-35-ES-AD-004	2

Basic concept and approach, stimuli, shape memory effect, response to thermal, magnetic, electrical, piezoelectric, and others effects, creation of functional and smart materials with preset properties, generation of shape memory effect, structure, phase transformation and properties, specific property characterization, interpretation of information, smart materials (shape memory alloys and polymers, piezoelectric, magnetostrictive, pH-sensitive, halochromic, chromogenic, surface active & biomimitic materials, ferrofluids, electro and magneto rheological material etc.), material development, application potential (energy sector, information technology, health, lab-on-a-chip etc.), principles of ferrofluids, synthesis, characterization, properties and applications.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 35

CSIR-Advanced Materials and Processes Research Institute	CSIR-AMPRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Cellular Materials	Course Code	Credits
		AcSIR-35-ES-AD-005	2

Definition and classification, concepts and design, general characteristics, applicable constitutive laws and equations, foam and foaming, chemistry & physical formation, foaming ingredients, factors controlling cell fraction and morphology, types (metallic, ceramic & polymeric, open cell, closed cell, syntactic etc.), selection criteria, properties, synthesizing techniques, (liquid metallurgy, powder metallurgy and others), characterization, property controlling parameters, application potential (noise attenuation, energy absorption, damping, packaging, thermal insulation, heat exchanger, Honey comb structures, foam core sandwich panels, biomedical implants, electromagnetic shielding, hydrogen storage, fuel cells etc.)

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 35

CSIR-Advanced Materials and Processes Research Institute CSIR-AMPRI

Course 3 : Advanced Course | Engineering Sciences | Total Credits 6

Title:	Course Code	Credits
Analysis of Metal Forming Processes	AcSIR-35-ES-AD-006	2

Stress-strain relations in elastic and plastic deformation, yield criteria for ductile metals, work hardening and anisotropy in yielding, flow curves, elements of theory of plasticity, formulation of plastic deformation problems, application of theory of plasticity for solving metal forming, problems, effect of temperature and strain rate in metal working processes, effects of friction and lubrication in cold and hot working, fundamentals, and analysis of important forming processes- forging, rolling, wire drawing, extrusion, sheet metal forming processes like deep drawing, stretch forming, bending, introduction to finite element simulation of forming processes.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 35

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

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:		Course Code	Credits
	Fatigue and Fracture Evaluation of Materials	**AcSIR-35-ES-AD-007**	**2**

Fatigue, high cycle fatigue, low cycle fatigue, constant amplitude fatigue cycle, variable amplitude fatigue cycle, Overview of conventional stress, strain and energy based life approaches, cyclic stress stain curve, fatigue crack initiation and crack growth analysis, Paris equation. Introduction to fracture mechanics, different modes of fracture, Griffith criteria, linear elastic fracture mechanics, , elastic-plastic fracture mechanics, Stress concentration factor, Stress intensity factor (K), crack tip opening displacement (CTOD), j-integral, threshold stress intensity factor, fracture toughness, stretch zone width (SZW), application of finite element method in fatigue and fracture evaluation.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 35

CSIR-Advanced Materials and Processes Research Institute CSIR-AMPRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Fiber Reinforced Polymer Composites	AcSIR-35-ES-AD-008	2

Introduction to polymeric composite materials, reinforcing materials (fibres, natural fibres whiskers and particles), glass fibres, fibre reinforced plastics, polymer based composite materials (comparison of different materials with composites, hybrid and sandwich type composites, principles of composite reinforcement, effect of fibrous reinforcement on properties, types of reinforcement such as natural, glasses, carbon/graphite, aramid fibres, high strength and high modulus fibers), surface treatment and various forms of fibres, thermosetting and thermoplastic materials for the composites and their selection for a particular application, processing and production techniques like hand-layup, bag moulding, filament winding and pultrusion prepegs, their manufacture and characterization. sheet moulding and dough moulding compounds and their processing, preform and resin transfer mouldings.
Introduction to natural fibres, extraction of sisal fibres, grading of sisal fibres, physical properties of sisal fibres, types of jute fibres, jute and sisal fibre properties, jute fibre polymer composite development, sisal fibre polymer composite development.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 35

CSIR-Advanced Materials and Processes Research Institute CSIR-AMPRI

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:		Course Code	Credits
	Waste Utilization and Value Addition	AcSIR-35-ES-AD-009	2

Industrial wastes (red mud, fly ash, slag, low grade minerals, stone dust etc.), different category of wastes,their source of generation and their methods of handling, environmental impact, audit, acts and regulations, global policy, regulation, waste management, municipal solid wastes, management and disposal, processes/ methods of waste utilization for different environmental applications such as decontamination of ground water, recycling, solidification/ stabilisation, immobilisation, detoxification, vitrification of toxic waste, management of hazardous and toxic waste, natural products, renewable resources, biodegradable polymers, conversion of wastes into value added materials, application potential (land use planning by reclamation of wastelands, overburden areas/mine spoil dumps, ash-back haulregions, etc for agriculture, horticulture, forestry, and other useful purposes, agriculture, construction, transportation, general engineering etc.) Introduction to industrial wastes, types, sources and characteristics, different rules and acts, classification of hazardous waste, its characteristics, waste recycle & reuse, solidification and stabilisation, waste to material approach using industrial waste, disposal of industrial wastes, chemistry of silica and silicon, ceramic, geopolymers and their applications, theory and principles of synthesis, characterization and applications of radiation shielding materials

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 35

CSIR-Advanced Materials and Processes Research Institute CSIR-AMPRI

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Geopolymeric and Radiation Shielding Materials	AcSIR-35-ES-AD-010	3

Advanced Geopolymeric Materials :
Introduction to geopolymers, basics of cement, comparison of geopolymers and cement, chemistry of geopolymers, terminology, types of geopolymers, hybrid inorganic organic geopolymers, lingo-silico-aluminous materials, cellulose, hemicellulose and lignin, difference between geopolymers and organic polymers, conceptual model for geopolymerisation, preparation of geopolymers by conventional and advanced process, comparison of geopolymers prepared by conventional and advanced process, characterization of geopolymers, factors affecting geopolymerisation, application of geopolymers, role of Si-Al ratio in formation of geopolymers and their application, Egypt pyramids. Chemical durability of geopolymers. Engineering of Geopolymers: Scientific basis for the understanding and development of construction materials, Advanced Geopolymeric mortar and Concrete, Engineering properties tests for aggregates, binder material and geopolymer mortar and concrete, Durability test for geopolymer concrete. Modern concrete construction practices. Development of Mix design for different grades of geopolymer concrete. Ligno-Silico-Aluminous based superplastisizer for geopolymer concrete. Salient advanced features of geopolymer concrete. Raw Materials used in formation of geopolymers: Sea water and sea sand, conventional coarse and fine aggregates, fly ash, metakaolin, red mud, blast furnace slag ,copper mine tailings, brine sludge and other industrial wastes. Applications of geopolymeric materials: Construction,coating, prefabricated materials, aviation, radiation shielding, high temperature applications drug delivery waste water
treatment, Advanced Radiation Shielding Materiala.
Basics of Radiations : Radiations and its interaction with matter, Importance and Harmful effects of radiations, Types and difference between different types of radiations- X-ray, U.V rays, gamma ray, neutron, microwave, radio wave, alpha & beta particles. Principle and mechanism of radiation shielding, Engineering of radiation shielding materials: Scientific basis for the understanding and development of red mud based synthetic heavy density radiation shielding aggregates, Engineering properties test for synthetic heavy density radiation shielding aggregates, binder material and concrete, Development of Mix design for different grads of radiation shielding concrete and other building materials. Radiation attenuation test for radiation shielding Materials. Application spectrum of radiation shielding Materials.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 35

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

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Physics of Thin Films	**AcSIR-35-PS-AD-001**	**2**

Thin films-introduction: Thin films and their importance, Physical and chemical vapour deposition, Sputter coating, DC and RF sputtering, Magnetron sputtering, Ion beam sputtering, Pulsed laser ablation, Plasma enhanced chemical vapour deposition, Vacuum arc, Chemical vapour deposition (CVD), Relationships between deposition parameters and film properties, Applications of thin films.
Physics of thin films: Steps in thin film growth, Thin film growth models and growth modes, Nucleation and growth, Coalescence processes. Epitaxial growth, Vacuum requirements for film growth, Effect of stress, Applications and emerging technologies.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 35

CSIR-Advanced Materials and Processes Research Institute CSIR-AMPRI

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Crystallography and Diffraction	AcSIR-35-PS-AD-002	2

Symmetry and periodicity of crystals, Bravais lattices, Point groups and space groups, Miller indices, Reciprocal lattice, Scattering factor, Stereographic projection, Basics of X-rays, Production and detection of X-rays, X-ray diffraction, X-ray diffraction methods, Diffractometer measurements, Determination of crystal structure, Precise lattice parameter determination, Qualitative phase analysis, Quantitative phase analysis, Crystallite size and residual strain analysis by X-rays, Texture determination by X-rays.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 35

CSIR-Advanced Materials and Processes Research Institute CSIR-AMPRI

Course 3 : Advanced Course Physical Sciences Total Credits 6

Title:	Course Code	Credits
Materials for Radiation Shielding Applications	**AcSIR-35-PS-AD-003**	**2**

Radiations: Radiations and its interaction with matter, Importance and harmful effects of radiations, Types and difference between different types of adiations: X-ray, U.V rays, Gamma ray, Neutron, Microwave, Radiowave, Alpha & Beta particles. Principle and mechanism of radiation shielding, Radiation shielding materials.

Chemistry of radiation shielding materials: Role and importance of chemicals and processes for making advanced radiation shielding materials, Importance of nanomaterials and waste by products in radiation shielding material. Different types of radiation shielding materials, Characterization of radiation shielding materials and their applications spectrum.

Engineering of radiation shielding materials: Scientific basis for understanding and development of red mud based synthetic heavy density radiation shielding aggregates, Engineering properties test for synthetic heavy density radiation shielding aggregates, binder material and concrete, Development of mix design for different grads of radiation shielding concrete, Radiation attenuation test for radiation shielding concrete.

Salient advanced features of synthetic shielding aggregate based radiation shielding concrete, Durability test for advanced radiation shielding concrete. Application spectrum of radiation shielding concrete.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 35

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

Course 3 : Advanced Course | Physical Sciences | Total Credits 6

Title:	Course Code	Credits
Organic Semiconductors	AcSIR-35-PS-AD-004	2

Organic semiconductors: General features, Physics of Organic semiconductors, Optical properties, Electrical properties: Injection and transport, Structural properties, Structure property relationship, Basic ideas of doping fabrication processes, Thermal evaporation, Vapor phase deposition, Solution processing: Spincoating, Dipcoating, Doctor blade, Layer by layer, Langmuir -Blodgett technique, Organic single crystals, Device fabrication, Major devices and characterizations,
OLED: External quantum efficiency, Current efficiency, Power efficiency, Chromaticity, lifetime,
OSC: Power conversion efficiency, Fill factor, IPCE,
OTFT: Estimation of mobility, Contact resistance, Subthreshold swing,
Memory Devices: Capacitive, Resistive and FET type memories, Sensors, Optical and electrical improving performance of devices: Guidelines for substrate preparation, Interface modification, Post-fabrication treatment, Purification of materials, Encapsulation, Outcoupling in OLEDs, Light concentrators in solar cells.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 35

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

Course 3 : Advanced Course — **Physical Sciences** — **Total Credits 6**

Title:	Course Code	Credits
Composite Materials	**AcSIR-35-PS-AD-005**	**2**

Concept of composite materials, Various types of composites, Classification based on matrix material, Classification based on reinforcements: Reinforcements/fibers ,Types of fibres, Whiskers and flakes, Mechanical properties of fibres, Metal matrix composites, Processing of advanced composites, Casting, Solid state diffusion, Liquid metal infiltration, Liquid phase sintering, Carbon composites, Polymer matrix composites, Processing and characteristics of nanocomposites, Hybrid composites, Ceramic matrix composites, Natural/bio composites.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 35	
CSIR-Advanced Materials and Processes Research Institute	**CSIR-AMPRI**

Course 3 : Advanced Course	**Physical Sciences**	**Total Credits 6**

Title:		Course Code	Credits
	Advanced Material Characterisation Techniques	**AcSIR-35-PS-AD-006**	**2**

Introduction to different microscopy techniques, Resolution, magnification, Depth of field, Depth of focus, Imaging: Theory and concepts,
X-ray microanalysis: Surface analysis techniques, Crystallographic techniques, X-ray methods, Scanning probe microscopy, vibrational spectroscopy, Thermal analysis, Sample preparation for different characterisations.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 35

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

Course 3 : Advanced Course	**Physical Sciences**	**Total Credits**	**6**

Title:	Course Code	Credits
Physics and Engineering of Sensor/Energy	**AcSIR-35-PS-AD-007**	**2**

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, Nanowires-FET sensing system, Micro electro-mechanical systems (MEMS), Nanomachines, Advanced carbon nanotube/graphene structures for sensing applications.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 35

CSIR-Advanced Materials and Processes Research Institute	CSIR-AMPRI

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title: Physics and Engineering of Soft Materials	Course Code	Credits
	AcSIR-35-PS-AD-008	2

Introduction to soft materials, types, structure and properties of soft materials, Synthesis methods and analysis, Chemical exfoliation of layeredmaterials, Liquid crystals, Graphene oxide liquid crystals structure, Defects and applications, Rheology of soft materials,

Layered material composites: Thin film, Foam and segregated structures, Fabrication and applications.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-36-BS-AD-001	Biology & Chemistry of Natural Products
Biological Sciences	AcSIR-36-BS-AD-002	Biology of Macromolecules
Biological Sciences	AcSIR-36-BS-AD-003	DNA-Nanoscience
Biological Sciences	AcSIR-36-BS-AD-004	Genome and Gene Regulation
Biological Sciences	AcSIR-36-BS-AD-005	Microbes and Environment
Biological Sciences	AcSIR-36-BS-AD-006	Microbial Diversity and Habitat Ecology
Biological Sciences	AcSIR-36-BS-AD-007	Mineral Bioprocessing
Biological Sciences	AcSIR-36-BS-AD-008	Plant Environment Interactions
Biological Sciences	AcSIR-36-BS-AD-009	Taxonomy and Speciation
Biological Sciences	AcSIR-36-BS-AD-010	Waste Management
Chemical Sciences	AcSIR-36-CS-AD-001	Advanced Materials Chemistry
Chemical Sciences	AcSIR-36-CS-AD-002	Advanced Chemistry for Hydro & Electrometallurgy
Chemical Sciences	AcSIR-36-CS-AD-003	Luminescent Organic Compounds
Chemical Sciences	AcSIR-36-CS-AD-004	Chemistry at Surfaces & Interfaces
Chemical Sciences	AcSIR-36-CS-AD-005	Advanced Coating Techniques+E191

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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36	CSIR-IMMT	3	Advanced Course

Faculty of Study	Course Code	Course Title
Chemical Sciences	AcSIR-36-CS-AD-006	Functional Supramolecular Chemistry
Engineering Sciences	AcSIR-36-ES-AD-001	Advanced Topics in Materials Engineering
Engineering Sciences	AcSIR-36-ES-AD-002	Agglomeration and Direct Reduction of Iron Ore
Engineering Sciences	AcSIR-36-ES-AD-003	Biological Wastewater Treatment
Engineering Sciences	AcSIR-36-ES-AD-004	Comminution and Classification
Engineering Sciences	AcSIR-36-ES-AD-005	Computation & Programming
Engineering Sciences	AcSIR-36-ES-AD-006	Data Science & Data Analytics
Engineering Sciences	AcSIR-36-ES-AD-007	Design, Simulation and Optimisation of Mineral Processing Plants
Engineering Sciences	AcSIR-36-ES-AD-008	Signal Processing for Intelligent Sensor
Engineering Sciences	AcSIR-36-ES-AD-009	Surface Phenomena and Its Application
Engineering Sciences	AcSIR-36-ES-AD-010	System Design for Process Control
Physical Sciences	AcSIR-36-PS-AD-001	Quantum Materials and Technologies
Physical Sciences	AcSIR-36-PS-AD-002	Advanced Material Chemistry
Physical Sciences	AcSIR-36-PS-AD-003	Advanced Coating Techniques
Physical Sciences	AcSIR-36-PS-AD-004	Smart Materials for Energy Harvesting/ Applications

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

Faculty of Study	Course Code	Course Title
Physical Sciences	AcSIR-36-PS-AD-005	Molecular Semiconductors and Devices
Physical Sciences	AcSIR-36-PS-AD-006	Signal Processing for Intelligent Sensors
Physical Sciences	AcSIR-36-PS-AD-007	Mineralogy & Mineral Chemistry
Physical Sciences	AcSIR-36-PS-AD-008	Surface & Interface Chemistry
Physical Sciences	AcSIR-36-PS-AD-009	Advanced Topics in Material Engineering

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology CSIR-IMMT

Course 3 : Advanced Course Biological Sciences Total Credits 6

Title:	Course Code	Credits
Biology & Chemistry of Natural Products	AcSIR-36-BS-AD-001	3

Classification of metabolites - primary & secondary metabolites, Various classes of secondary metabolites - Alkaloids, Terpenoids, Steroids, Saponins, Flavonoids, Tannins etc., Extraction procedures for natural products, Purification and Isolation of pure compounds by chromatographic techniques, Structural elucidation of known/new compounds/NCEs by spectroscopic techniques, Structural modification of natural products

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 36	
CSIR-Institute of Minerals & Materials Technology	CSIR-IMMT

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Biology of Macromolecules	Course Code	Credits
		AcSIR-36-BS-AD-002	3

Cell Biology: Basic concept: life forms from prokaryotes to eukaryotes, Structure and function of Cell and Cell organelles, Nucleic acids and proteins; Molecular aspects of cell division and cell cycle, Chromatin structure; Organization of nucleosome and chromosomes, Chloroplast and Mitochondrial Genome Organization. Bacterial and Algal genome organization. Biomolecules and pathways: Basic macromolecular structure: DNA, RNA, protein, lipids and carbohydrates, Synthesis and degradation of macromolecules, Relation between sequence, structure and function, protein folding and flexibility, important metabolic pathways and regulation. Enzymology: Enzyme activity, kinetics, Single substrate, bisubstrate reactions, Determination of Km. Enzyme inhibition: Reversible and irreversible inhibition, Competitive, Non-competitive and uncompetitive inhibition, receptor binding and regulation, allosteric regulation. Genomics and proteomics: DNA replication in Prokaryotes and Eukaryotes, Genetic code: RNA transcription and processing, Transcriptional regulation in prokaryotes and eukaryotes, Protein synthesis, protein modifications and secretion, Regulation of protein synthesis, Biological structure databases, Computer modelling of proteins and nucleic acid based on sequence data.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology	CSIR-IMMT

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
DNA-Nanoscience	AcSIR-36-BS-AD-003	3

Nucleic acid structure: Organization of the genome, the structure of DNA, key features of the double helix, structural flexibility, Geometry of DNA, forces stabilizing the nucleic acid structure, (denaturation, renaturation, base paring, base stacking, hydrophobic interaction, ionic interactions), Fractionation of nucleic acids, modified oligonucleotides, overview of nucleic acid function, polymerase chain reaction, nucleic acid sequencing. Self-assembled DNA nanostructure: Self-assembly of DNA, DNA origami, DNA-templated nanomaterials and nanowires, G-quartet, G-quadruplex, G-wire, DNA aptamers, Nanofabrication and surface biofunctionalization, Characterization of self-assembled DNA nanostructures (UV-Vis spectroscopy, AGE, PAGE, polymerase chain reaction, circular dichroism spectoscopy) Imaging of DNA nanostructure, (Atomic force microscope, fluorescence microscopy), Metal-DNA interaction, DNA nanotubes. Application of DNA nanomaterials: DNA nanostructure for biosensing applications, DNA-based lithographic patterned surface, measuring pH changes using DNA nanoswitch, specific targeting and delivery of DNA nanoparticles, DNA-based diagnostics and therapeutics, DNA nanostructure-based gene regulation and gene silencing, Delivery of miRNAs, siRNAs, antisense oligonucleotides, DNA nanomaterials as carrier molecule, mapping DNA-protein interaction.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 36	
CSIR-Institute of Minerals & Materials Technology	**CSIR-IMMT**

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Genome and Gene Regulation	**AcSIR-36-BS-AD-004**	**3**

Genome anatomy: Genomes of prokaryotes and eukaryotes, genetic organization of the prokaryotic genome, operons (lac, mal, ara, trp). genetic and physical maps: RFLP, SSLP, SNPs, restriction mapping, FISH, STS. Chromatin modifications and genome expression, genome replication, Molecular phylogenetics, Gene location, experimental techniques for gene isolation. Studying DNA: DNA structure, Enzymes for DNA manipulation: DNA polymerase, nucleases, Restriction endonucleases, ligases, End-modification enzymes. DNA cloning, cloning vectors, Mutation, repair and recombination, Polymerase chain reaction, DNA sequencing. Transcriptomes: Transcription complex, Bacterial RNA polymerase, promoter sequences, Coding and non-coding RNA, synthesis of bacterial and eukaryotic RNA, mapping of end of transcripts, transcriptional regulation, termination of transcription, sythesis and processing of non-coding RNAs, degradation of mRNAs, S1 mapping, primer extension, Run-on and run-off transcription. Proteomes: Ribosome structure, initiation, elongation and elongation of translation, protein folding, proteolytic cleavage, chemical modification, protein degradation, purifying and studying proteins, DNA-protein interactions, Gel mobility shift, DNase footprinting, Flowcytometry MALDI-MS/MS/TOF, LC-ESI-MS/MS.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

CSIR-Institute of Minerals & Materials Technology	CSIR-IMMT

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Microbes and Environment	AcSIR-36-BS-AD-005	3

Environmental (soil, water and air) pollution – source, effect and fate, Management of pollutants, Environment monitoring methodologies , Control of pollutants, Microbes and polluted environment, Biogeochemical cycling, Microorganisms in biodeterioration, Microbial bioremediation, Metabolic networks of microbial systems, Biosensors – reporter and marker genes, Geomicrobiology, Microbial cell as a factory, Synthetic biology, Systems biology.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

CSIR-Institute of Minerals & Materials Technology	CSIR-IMMT

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Microbial Diversity and Habitat Ecology	AcSIR-36-BS-AD-006	3

Introduction to microbial lineages, Techniques of studying culturable and unculturable microbes, Methods in microbial taxonomy, Microbial phylogeny, Structure and function of microbial communities, Genomic methods to identify microbial structure-function relationship, Methods of studying uncultured microbes, Plant-microbe interactions, Mineral-microbe interaction, Microbial metagenomics, Environmental sampling and statistical analysis, Instrumentation in microbial diversity study, Latest sequencing technologies, Assignments and discussions.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology CSIR-IMMT

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Mineral Bioprocessing	AcSIR-36-BS-AD-007	3

Introduction to chemolithotrophic and heterotrophic nutrition of microbes. Chemical and electrochemical aspects of bioleaching. Understanding of role of microbes in biogeochemical cycles of Fe, Mn, Si, P etc. Bioleaching of valuable metals from ores/minerals. Role of microorganisms and their attachment to ore in bio-flotation and bio-beneficiation.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 36	
CSIR-Institute of Minerals & Materials Technology	CSIR-IMMT

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Plant Environment Interactions	AcSIR-36-BS-AD-008	3

Introduction to environment: classification, components of environment; Ecology and ecosystems; Symbiotic relationships; Plant responses to abiotic & biotic stresses; Plant - soil interactions. Environment and Sustainable Development. Environment Pollution in National and Global Perspectives, Environmental pollution and its effect on plants, Sources and Fate of Pollutants in the Aquatic Ecosystems, Energy Resources and Conservation, Plant adaptation to Environmental stress, Environmental Degradation and Restoration, Biomonitoring of Environmental contaminants, Environmental Impact Assessment & Auditing

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology	CSIR-IMMT

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Taxonomy and Speciation	Course Code	Credits
		AcSIR-36-BS-AD-009	3

Unit-I: Taxonomy of plants: History of plant taxonomy and classification of angiosperms, International Code of Botanical Nomenclature, Modern trends in Taxonomy: (a) Numerical taxonomy, chemo-taxonomy, cyto-taxonomy, and (b) Palynology, embryology, anatomy and palaeo-botany, Relevance of Herbaria & Botanical Gardens, Systematics of Pteridophytes and Gymnosperms (General characters, classification, important families), Systematics of non-vascular plants, Plant descriptors, systematic of some selected families in Dicots & Monocots, Methods and techniques in plant taxonomy and herbarium. Unit –II: Molecular Systematics and speciation: Species concept , Speciation in plants, Molecular Systematics: Concepts and applications , Molecular markers in plant systematics, Procedures for collecting and sampling of plant materials , Molecular Phylogenetics , Phylogenetic Inferences, Phylogeography: concepts and case studies in plants

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology	CSIR-IMMT

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Waste Management	AcSIR-36-BS-AD-010	3

Definition and classification of waste; Problems related to wastes, Challenges and needs of waste management; 4R principals of waste management; Characterisation of waste for better waste management; Emerging dimensions of waste management, Disposal Methods of different types wastes; Integrated Waste Management; Technologies for waste management; Resource recovery from wastes, Biological methods of waste management, Chemical & Thermal treatments of wastes, Hazardous waste and their management, Concept of zero waste, Sustainable waste management, Life Cycle Assessment (LCA) of waste management, Waste management in mining and industries, Case studies related to waste and their management plan, Waste audits, Waste management laws, rules and regulations, Basel Convention.

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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology **CSIR-IMMT**

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Materials Chemistry	**AcSIR-36-CS-AD-001**	**3**

Synthesis and methodology:

Synthesis of various types of materials such as nanomaterials and nanocomposites, functional and layered materials, hybrid materials mesoporous organosilica (PMS), functionalization of mesoporous silica, titania, zirconia, ceria, iron oxide, metal-organic frame work and other oxide, sulphide and phosphate based materials by wet chemical, sol-gel, radiolysis, microwave, combustion, sonochemical, Hydrothermal and solvothermal, template assisted. Nanoparticle fabrications through different phases i.e., nucleation, aggregation, agglomeration, Ostword ripening.

Properties:

Chemical, Structure and texture, optical, magnetic and electronic properties.

Applications:

Catalysis, photocatalysis, electrocatalysis, fuel cells, energy generation and storage, sensors and biosensors, pollution control and abatement.

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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology — CSIR-IMMT

Course 3 : Advanced Course — **Chemical Sciences** — **Total Credits 6**

Title:	Course Code	Credits
Advanced Chemistry for Hydro & Electrometallurgy	**AcSIR-36-CS-AD-002**	**3**

Leaching: Atmospheric leaching, Pressure leaching, Bio leaching, Optimisation of process parameters,
Solid liquid separation: Concepts of solid liquid separation, Thickening and thickener design, Counter-current decantation, Flocculation, Filtration and centrifugation,
Solvent Extraction: Basic principle of solvent extraction, Partion coefficient and distribution ratio, Separation coefficient, Types of extractants and extraction mechanism of metals,
Membrane Separation Technique: Salient features of membrane separation, Different types of membrane separation, Supported liquid membrane, Extraction mechanism of liquid membrane, hollow fiber membrane, Reverse osmosis, Nano-filtration, Ultra-filtration,
Transport equations.
Electro Chemistry: Principles of Electrowinning, Effect of impurities on electrowinning, electrorefing, Preparation of energy materials, electro organic Chemicals, Electro-inorganic Chemicals, Fused salt electrolysis.

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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology	CSIR-IMMT

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Luminescent Organic Compounds	Course Code	Credits
		AcSIR-36-CS-AD-003	3

Concepts and principles, classical definitions to modern views, nature's adaptations to synthetic aspects:-phosphors and organics.

Electronic excitation and molecular excited States, Solvent Effects, Deactivation of excited States:- Sensitization and Inhibition, Emission patterns:- Fluorescence, phosphorescence and delayed luminescence, quenching phenomena:- static and dynamic, Photophysical processes and their perturbation:- electron transfer, charge transfer, energy transfer, quantum yield, structural features of luminophors, classification of organic luminophors.

Design principles and synthesis:-a supramolecular approach, computational approaches of structure-function correlation, band gap modulation. Organic luminescent compounds in Chemiluminescent and electrochemiluminescent compositions, Chemical sensors:- chromogenic, fluorogenic, electroluminescent, charge and energy storage devices, energetic materials, molecular electronics, optoelectronic devices, organic light emitting diodes, dye sensitization in solar cells, functionalisation and luminescent hybrid materials.

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CSIR-Institute of Minerals & Materials Technology	CSIR-IMMT

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Chemistry at Surfaces & Interfaces	**AcSIR-36-CS-AD-004**	**3**

Surface phases: Surface energy, surface tension, surface excess. Free liquid surfaces,Surface Wetting: contact angles, Young's equation.
Surface charge: electrical double layer, Zeta potential Amphiphilic aggregation and phase behaviour, Colloids and colloidal stability.
Hard materials and surfaces: Structure of surfaces, the surface chemical bond, physisorption, chemisorption.
Adsorption: adsorption kinetics and isotherms, adsorption to liquid interfaces, Gibb's isotherm surface reactions, Analytical methods for analysis of surfaces interfaces and colloids, The surface chemical bond: physisorption, chemisorption, interfacial solvation
Surface chemical reactions: the structure and properties of molecular films; preparation strategies, surface modification, self-assembled monolayers. examples from catalysis.

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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology	CSIR-IMMT

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Advanced Coating Techniques+E191	Course Code	Credits
		AcSIR-36-CS-AD-005	3

Vacuum Technology and Process Applications

Application of Vacuum, Introduction on molecular-kinetic theory of gases, Sorption phenomena in vacuum, Condensation and evaporation, Physical processes in vacuum, Production of Low, medium and high vacuum by using different pumps. (From Atm to 10-8 mbar), Introduction to Rotary, Diaphragm, Diffusion, Adsorption, Turbo-molecular, Cryo, Ion pumps.

Thin and Thick Film deposition techniques: Physical methods: Thermal and electron beam evaporation, sputtering (RF/DC), Pulsed laser deposition, etc.

Chemical methods: Chemical and electrochemical methods, Electroplating, Electrophoretic deposition, Electrodeposition, spin coating, Dip coating etc.

Categorization of coatings:

Classifications of coating, Role of interfaces (single layer/multilayer), types of reinforcements in coatings: metal matrix composite (MMC), polymer matrix composite (PMC) and ceramic matrix composite (CMC), their properties and applications.

Coating characterization:

Grazing Incidence-X-ray Diffraction, X-ray reflectivity, Thickness profiling (optical/Stylus), sheet resistance, Adhesion-scratch (pencil Hardness) test, etc.

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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology — CSIR-IMMT

Course 3 : Advanced Course — Chemical Sciences — Total Credits 6

Title:	Course Code	Credits
Functional Supramolecular Chemistry	AcSIR-36-CS-AD-006	3

Introduction to supramolecular chemistry and functional nanomaterials. Definition and examples of the main intermolecular forces used in supramolecular chemistry. Scope of the course and the topic.
Self-assembly processes in organic systems. Crown-ethers, Catenanes, rotaxanes, pseudorotaxanes. Synthetic strategies for their preparation. Main supramolecular forces involved in such assemblies. Examples of each type.
Self-assembly processes in metal-containing compounds. Self-assembly of metal nanoparticles (via H-bonding and electrostatic forces). Using the co-ordination bond to prepare large supramolecular assemblies. Cages, macrocycles, catenanes including porous polymeric materials such as metal-organic frameworks (MOFs) and covalent-organic frameworks (COFs).
Porous Nano-capsules, containers and frameworks. Discussion of main synthetic strategies for their preparation. Examples of each type. Potential uses of such assemblies.
Molecular switches and machines. Use of supramolecular forces to assemble components that respond (on-off) to external stimuli. Supramolecular chemistry of polymeric materials and in the solid state. Self-assembled monolayers. Molecularly imprinted polymers

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AcSIR Academic Centre Code: 36	
CSIR-Institute of Minerals & Materials Technology	CSIR-IMMT

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Advanced Topics in Materials Engineering	Course Code	Credits
		AcSIR-36-ES-AD-001	3

Sputtering; etching; DBD; plasma spraying; thermal plasma dissociation; power characterization; ball milling; compaction and sintering; density and porosity measurement; microstructural characterization.

Plasma processing:Introduction to plasma; Thermal and non-thermal plasma; Breakdown voltage and Paschen’s law; Kinetic theory of gas; Vacuum techniques and pressure measurement; Glow discharge plasma; DC, RF and MW plasmas; Plasma etching and deposition of thin films; Sputtering and other physical vapor deposition (PVD) methods; Plasma chemistry. Chemical vapor deposition (CVD) and plasma activated CVD; Plasma melting, smelting and synthesis; Thermal plasma spraying; Dielectric barrier discharge plasma; Plasma applications in industry and medicine.

Powder Metallurgy:Introduction to powder metallurgy; Methods of fabrication of metal powders & their characterization; Powder compaction (single action, double action, CIP); Powder injection moulding; Sintering (Solid state sintering, liquid phase sintering, activated SSS & LPS); Applications & Some case studies.

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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology CSIR-IMMT

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:		Course Code	Credits
	Agglomeration and Direct Reduction of Iron Ore	AcSIR-36-ES-AD-002	3

Brief introduction on characterisation, beneficiation of Indian iron ores, basic conceptual commercial process flowsheet development, Agglomeration process like briquetting, sintering and pelletisation, brief description on briquetting and sintering, Introduction to pelletization: world scenario, resources and production, deposits, production and demand for iron and steel, Concept of pelletization process: raw materials and their preparation (iron ore, binder, additives, preparation), formation of green pellets, mechanisms.

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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology **CSIR-IMMT**

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Biological Wastewater Treatment	**AcSIR-36-ES-AD-003**	**3**

Introduction to Wastewater: Sources, types and characteristics, introduction of some important wastewater parameters - Biological Oxygen Demand, Chemical Oxygen Demand, Total Organic Carbon, Total nitrogen – Total organic nitrogen, Total Kjeldal nitrogen, ammonium, nitrate, nitrite, Total phosphorous – Organic, inorganic and dissolved.
Preliminary and Primary Treatment Operations: Screens, Grit Chambers, Skimming Tank, Primary and Secondary Sedimentation Tanks.
Secondary treatment: Physical, Chemical & Biological treatment of primary effluent.
Introduction to Biological Wastewater Treatment: Overview of biological wastewater treatment, objectives of the treatment, role of micro-organisms, types of biological processes for wastewater treatment, suspended and attached growth systems.
Aerobic Suspended and attached Growth Biological Treatment Systems: Aerobic biological oxidation, Complete Mix activated sludge, Extended Aeration system, Oxidation Ditch systems, intermittently aerated and decanted systems, Oxygen activated sludge, Oxidation ponds, stabilization ponds, Introduction to attached growth systems, Trickling Filter, Oxygen transfer and utilization, rotating biological contactors, Bio-Towers.
Anaerobic Decomposition: Mechanism of anaerobic fermentation – a multistep process, Microbiology and biochemistry of anaerobic processes, substrate inhibition, optimal anoxic environment, kinetic constants, , standard rate, high rate and multistage anoxic digesters.
Natural Treatment Systems with focus on Constructed Wetlands: Development of natural treatment systems, fundamental consideration in the application of NTS, Slow Rate systems, rapid infiltration systems, Overland flow systems, constructed wetlands, Floating aquatic plant treatment systems.
Emerging Advanced Treatment Systems: Introduction to Bio electrochemical systems- Focusing Microbial fuel cell, hybrid Constructed Wetlands-Microbial Fuel cell. Onsite Sanitation: Slow sand filters, Electrochemical treatment processes, Ozonation, Advanced oxidation processes- various types of oxidizing agents.

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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology | CSIR-IMMT

Course 3 : Advanced Course | Engineering Sciences | Total Credits 6

Title:	Course Code	Credits
Comminution and Classification	AcSIR-36-ES-AD-004	3

Crushing; Fundamentals of size reduction, comminution laws, drop shatter tests and shatter index, single particle breakage and packed bed breakage. Primary and secondary crushing - Jaw, Gyratory, Cone, Roll crushers, Hammer mills and Rotary breakers, High compression rolls; their design construction operation maintenance and performance aspects.
Grinding; Grinding mill principles, design constructions and their operations, Mill liners. Open and closed circuit grinding, Ball mill, Rod mill, Pebble mill and Autogenous mills. Application of these mills for specific processing requirements, Effect of these process parameters on mill performance. Fluid energy mills, Effect of size on liberation, Different methods of particle size analysis and graphical representation. Modelling of communication process. Recent developments in comminution energy reduction.
Classification; Industrial screening; design, selection, operation and maintenance of different types of industrial screens. Dry and wet screening, Pre-scrubbing and other processes to improve screening efficiency.
Hydrocyclone Classification; construction, operation and maintenance application of different types of classifiers, efficiency, solid and water balance calculations

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AcSIR Academic Centre Code: 36			
CSIR-Institute of Minerals & Materials Technology			CSIR-IMMT
Course 3 : Advanced Course	Engineering Sciences		Total Credits 6
Title: Computation & Programming		Course Code	Credits
		AcSIR-36-ES-AD-005	3

Notions of syntax and semantics of programming languages, Program design practices, Problem Solving Expression, Use case diagram, Data types, Control functionality including: branching & iteration, Order of execution, RDBMS, Evolution of Data, Structure Query Language: Querying and managing data.

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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology CSIR-IMMT

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Course Code	Credits
Data Science & Data Analytics	AcSIR-36-ES-AD-006	3

Introduction to Data Science, Methods of Data Collection and Cleaning, Python Fundamentals, Programming with Python, Python for Data Science, Visualization in Python, Control Flow & Functions, Array Computations, Data Manipulation & Visualisation, Web Scraping, Introduction to Artificial Intelligence, Introduction to Machine Learning, Linear models for Regression & Classification, Non-linear Models, Learning types, Support Vector Machine, Deep Learning.

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CSIR-Institute of Minerals & Materials Technology CSIR-IMMT

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Design, Simulation and Optimisation of Mineral Processing Plants	AcSIR-36-ES-AD-007	3

Description of beneficiation processes of different types of ores like iron ore, coal, sulphide ores etc.; development of conceptual process flowsheet; material and energy balance. Design of mineral processing equipment: tumbling mill, hydrocyclone, vibrating screen, pump box, flotation cell, flotation column, thickener and filtration unit.

Elementary discussion on simulation and modeling of processes; simulation of the processes using MODSIM, UCMAC simulators, numerical analysis of simulation, sequential method of simulation, practical application of plant optimization.

Electrostatic Separators; Principle of electrostatic separation, types of separators and their application

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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology **CSIR-IMMT**

Course 3 : Advanced Course **Engineering Sciences** **Total Credits 6**

Title:	Course Code	Credits
Signal Processing for Intelligent Sensor	**AcSIR-36-ES-AD-008**	**3**

Part-I Fundamentals of Digital signal processing Sampled data systems; Z-Transform; Digital Filtering; Digital Audio Processing Linear Filter Applications; Part-II Frequency Domain Processing Fourier Transform Spectral Density; Wave Number Transforms; Transforms; time-frequency analysis; Part-III: Adaptive system Identification and Filtering Linear Least Squared Error Modelling; LMS; RLS and its variants; Block adaptive filters Part-IV: Soft computing based intelligent sensor Part-V: Signal Processing Applications Noise Reduction Techniques: Sensors and Transducers; Intelligent Sensor Systems; Sensor nonlinearity compensation; Making sensing independent of environment change; Soft sensor

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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology | CSIR-IMMT

Course 3 : Advanced Course | Engineering Sciences | Total Credits 6

Title:	Course Code	Credits
Surface Phenomena and Its Application	AcSIR-36-ES-AD-009	3

Flotation: Introduction, principle of flotation, history, flotation science and engineering. Surface chemistry, particle surface and its modification, surface energy of mineral and coal particles, surface activation, solubility of minerals in water, reaction between mineral surface and dissolved components, molecular adsorption, ionic adsorption, specific adsorption, surface wettability and contact angle, zeta potential, adsorption of reagents, floatability test of minerals, mineralization of air bubbles in flotation, formation of gas bubbles on a mineral particles, combined bubble attachment to a mineral surface, bubble-particle interaction, aeration and froth formation, types of froth and stability of froth.

Flotation reagents for minerals and coal: Collector, frother, activator, depressant, dispersant, wetting reagents and pH regulator.

Factors affecting flotation: Effect of mineralogical characteristics, effect of petrography constituents of coal, effect of particle size and shape, effect of pulp density, effect of pulp temperature, effect of composition of process water, effect of reagent dosage, effect of feed rate and effect of slimes.

Flotation kinetics and release analysis.

Flotation practice and machines: Flotation process, pulp preparation, conditioning, aeration, different types of flotation cells, factors affecting the size of the flotation cell, determination of number of cells and size, auxiliary flotation equipment and design of flotation circuit.

Column flotation: Introduction, basic design and operation, effect of design and process variables, advantages over the flotation cell and hydrodynamics study by axial dispersion model.

Rheology: Fundamentals, effect of surface properties, effect of particle and fluid properties, effect of chemical additives and its application.

Flocculation: Mass flocculation, selective flocculation, sedimentation and design of thickener.

Filtration: Principle of filtration, effect of surfactants in filtration process, types of filtration equipment.

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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology CSIR-IMMT

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title: System Design for Process Control	Course Code	Credits
	AcSIR-36-ES-AD-010	3

Measurement techniques and instruments for various processes; Functional elements of control system; Design and analysis of SISO/MIMO feedback control system; Feed forward and adaptive control strategies; Functional Analysis: fundamental and common non-linearities; Phase plane analysis, limit cycles and linearization; Stability concept methods, disturbances and analysis; P, PI, PID control analysis, design implementation, comparison and applications; Virtual instrument design approach for industrial control; Introduction to microcontrollers family architecture, programming; Interfacing techniques for memory, I/O devices, peripherals; Modern control concepts: static and dynamic optimization, self-tuning control, sliding mode control; Typical applications and project case studies

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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology	**CSIR-IMMT**

Course 3 : Advanced Course	**Physical Sciences**	**Total Credits 6**

Title:		Course Code	Credits
	Quantum Materials and Technologies	**AcSIR-36-PS-AD-001**	**3**

Condensed matter physics: Crystal structure, Reciprocal lattice, X-Ray diffraction, Crystal binding, Lattice vibrations and phonons, Free electron theory of metals, Band theory of solids, Magnetism and superconductivity.
Basics of quantum mechanics: De Broglie waves and the wave-particle duality, Heisenberg uncertainty principle, Schrödinger equation, Particle in one dimensional potential well, Simple harmonic oscillator, Hydrogen atom. Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics.
Advanced quantum materials, Associated properties and applications:
Phase transitions, Metal-insulator transition, Mott insulators, Charge density wave compounds, Strongly correlated electron systems, Structurally driven metal-insulator transition, Electric/pressure/magnetic field induced metal-insulator transition. Semiconducting materials (solar cell, thermoelectrics, LED etc.), 2D Materials, Heterostructure materials (Oxides, Non-oxides etc.), Superconductors, Spintronics: Magneto resistance materials (GMR, CMR, TMR etc.), Multiferroics, Topological insulators, Ultra cold atoms.

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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology CSIR-IMMT

Course 3 : Advanced Course Physical Sciences Total Credits 6

Title:	Advanced Material Chemistry	Course Code	Credits
		AcSIR-36-PS-AD-002	3

Synthesis and methodology: Synthesis of various types of materials such as nanomaterials and nanocomposites, Functional and layered materials, Hybrid materials mesoporous organosilica (PMS), Functionalization of mesoporous silica, titania, zirconia, ceria, iron oxide, metal-organic frame work and other oxide, sulphide and phosphate based materials by wet chemical, Sol-gel, radiolysis, Microwave, Combustion, Sonochemical, Hydrothermal and Solvothermal, Template assisted. Nanoparticle fabrications through different phases i.e., nucleation, aggregation, agglomeration, Ostword ripening. Properties: Chemical structuree and texture, Optical, magnetic and electronic properties. Applications: Catalysis, photocatalysis, electrocatalysis, fuel cells, energy generation and storage, Sensors and biosensors, Pollution control and abatement.

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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology	CSIR-IMMT

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Coating Techniques	AcSIR-36-PS-AD-003	3

Vacuum technology and process applications
Application of Vacuum, Introducing on molecular-kinetic theory of gases, Sorption phenomena in vacuum, Condensation and evaporation, Physical processes in vacuum, Production of Low, medium and high vacuum by using different pumps. (from Atm to 10-8 mbar), Introduction to rotary, Diaphragm, diffusion, Adsorption, Turbo-molecular, Cryo, Ion pumps.
Thin and Thick Film deposition techniques:
Physical methods: Thermal and electron beam evaporation, sputtering (RF/DC), Pulsed laser deposition, etc.Chemical methods: Chemical and electrochemical methods, Electroplating, Electrophoretic deposition, Electrodeposition, spin coating, Dip coating etc.
Categorization of coatings: Classifications of coating, Role of interfaces (single layer/multilayer),
Types of reinforcements in coatings: Metal matrix composite (MMC), Polymer matrix composite (PMC), Ceramic matrix composite (CMC), their properties and applications.
Coating characterization: Grazing incidence-X-ray diffraction, X-ray reflectivity, Thickness profiling (optical/Stylus), Sheet resistance, Adhesion-scratch (pencil Hardness) test, etc.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology CSIR-IMMT

Course 3 : Advanced Course Physical Sciences Total Credits 6

Title:	Course Code	Credits
Smart Materials for Energy Harvesting/ Applications	AcSIR-36-PS-AD-004	3

Smart materials, Magnetic materials, Central concepts of magnetism, Classification-ferromagnetic, Antiferromagnetic and paramagnetic materials, Theory and properties, Magnetization processes, Temperature dependence of saturation magnetization, Coercivity and Hysteresis, Magneto-caloric effects, Energy related applications of magnetism, Magnetic Refrigeration, Dielectrics and Ferroelectrics: Fundamentals, Dielectric dispersion and loss, Dielectric constant and Polarizability, Relaxation phenomena, Classifications: Ferroelectric, piezoelectric and pyroelectric crystals, Properties, Structural phase transitions, Critical phenomena, Lattice dynamics, Energy harvesting properties, Thermoelectric Materials, Seebeck effect, Peltier effect, Thomson effect, Transport properties, Electron and phonon transport, Scattering mechanisms, Thermal conductivity, Thermoelecric transport parameters and energy conversion efficiency, Enhancing the Figure of merit, Overview of thermoelectric devices and applications, Waste heat recovery properties and applications, Experimental techniques, Structural properties, Electrical, magnetic and thermal transport properties, Spectroscopy.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology **CSIR-IMMT**

Course 3 : Advanced Course **Physical Sciences** **Total Credits 6**

Title:	Course Code	Credits
Molecular Semiconductors and Devices	**AcSIR-36-PS-AD-005**	**3**

Introduction to new semiconducting materials: Length and energy scales, overview of fabrication techniques and possibilities, applications of low-dimensional physics.
Electronic properties in low-dimensional systems, Band engineering, Heterostructures, 2D electron gas, Band theory at the interfaces.
Molecular systems: Self-assembly, Conjugated polymers, electronic structure and devices. Transport in carbon nanotubes and graphene, Single-molecule transport. Nanocrystals, Nanorods, 2D semiconductors, Chalcogenides.
Transport, Variable range hoping, Quantum transport in 1D wires, Eigenstates, Conductance, Field effect transistor, Ways to estimate mobilities, Electrons in magnetic fields, Hall effects, Dynamic transport theory.
Devices: Logic devices, Field effect transistor, Electrochemical transistor, Light emitting field effect transistors, High frequency devices.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology **CSIR-IMMT**

Course 3 : Advanced Course	**Physical Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Signal Processing for Intelligent Sensors	**AcSIR-36-PS-AD-006**	**3**

Fundamentals of digital signal processing, Sampled data systems, Z-transform, Digital filtering, digital audio processing linear filter applications, Frequency domain processing fourier transform spectral density, Wave number transforms, Transforms, Time-frequency analysis.

Adaptive system identification and filtering linear least squared error modelling, LMS, RLS and its variants, Block adaptive filters

Soft computing based intelligent sensor, Signal processing applications & noise reduction techniques, Sensors and transducers, Intelligent sensor systems, Sensor non-linearity compensation, Making sensing independent of environment change, Soft sensor.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology **CSIR-IMMT**

Course 3 : Advanced Course **Physical Sciences** **Total Credits 6**

Title:	Course Code	Credits
Mineralogy & Mineral Chemistry	**AcSIR-36-PS-AD-007**	**3**

Process mineralogy, Liberation Studies using QEMSCAN, Mineral chemistry using EPMA, Identification of mineral phases through XRD.
Geochemistry: Chemical composition of the Earth, elementary statistics for geochemistry; major, minor and trace elements including rare earth elements, element partitioning between minerals and melts; petrogenesis, Geochemical Classification of elements, Geochemical differentiation, Isomorphism, Polymorphism, Atomic substitution and Geochemical cycle.
Analytical Geochemistry: Chemical analysis of rocks and minerals, Digestion techniques, Preparation of standards, Estimation of major oxide percentages using spectrophotometric/ flame photometric and titrimetric methods, Preparation of calibration curves, Gravimetric estimation of silica and R203, Determination of noble metals, Introduction to neutron activation analysis, Principles of ICP, XRF & AAS analysis.

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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology	CSIR-IMMT

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Surface & Interface Chemistry	Course Code	Credits
		AcSIR-36-PS-AD-008	3

Surface phases: Surface energy, Surface tension, Surface excess, Free liquid surfaces
Surface Wetting: Contact angles, Young's equation.
Surface charge: Electrical double layer, Zeta potential
Amphiphilic aggregation and phase behaviour, Colloids and colloidal stability.
Hard materials and surfaces: Structure of surfaces, Surface chemical bond, Physisorption, Chemisorption.
Adsorption: Adsorption kinetics and isotherms, Adsorption to liquid interfaces, Gibb's isotherm surface reactions.
Analytical methods for analysis of surfaces, interfaces and colloids.
Surface chemical bond: Physisorption, Chemisorption, Interfacial solvation.
Surface chemical reactions: Structure and properties of molecular films, Preparation strategies, Surface modification, Self-assembled monolayers. Examples from catalysis.

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AcSIR Academic Centre Code: 36

CSIR-Institute of Minerals & Materials Technology | CSIR-IMMT

Course 3 : Advanced Course | Physical Sciences | Total Credits 6

Title:	Course Code	Credits
Advanced Topics in Material Engineering	AcSIR-36-PS-AD-009	3

Sputtering, Etching, DBD, Plasma spraying, Thermal plasma dissociation, Power characterization, Ball milling, Compaction and sintering, Density and porosity measurement, Microstructural characterization.
Plasma processing: Introduction to plasma, Thermal and non-thermal plasma, Breakdown voltage and Paschen's law, Kinetic theory of gas, Vacuum techniques and pressure measurement, Glow discharge plasma, DC, RF and MW plasmas, Plasma etching and deposition of thin films, Sputtering and other physical vapor deposition (PVD) methods, Plasma chemistry, Chemical vapor deposition (CVD), plasma activated CVD, Plasma melting, smelting and synthesis, Thermal plasma spraying, Dielectric barrier discharge plasma, Plasma applications in industry and medicine.
Powder Metallurgy: Introduction to powder metallurgy, Methods of fabrication of metal powders & their characterization, Powder compaction (single action, double action, CIP), Powder injection moulding, Sintering (solid state sintering, liquid phase sintering, activated SSS & LPS), Applications & some case studies.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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37	CSIR-IIIM	3	*Advanced Course*

Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-37-BS-AD-001	Formulation, Drug Delivery & Pharmacokinetics
Biological Sciences	AcSIR-37-BS-AD-002	Biodiversity & Climate change
Biological Sciences	AcSIR-37-BS-AD-003	Cancer Biology & Neuropharmacology
Biological Sciences	AcSIR-37-BS-AD-004	Industrial Microbiology
Biological Sciences	AcSIR-37-BS-AD-005	Infectious Diseases
Biological Sciences	AcSIR-37-BS-AD-006	Microbes in Drug discovery
Biological Sciences	AcSIR-37-BS-AD-007	Molecular model and simulations
Biological Sciences	AcSIR-37-BS-AD-008	Pharmacology & Toxicology
Biological Sciences	AcSIR-37-BS-AD-009	Plant Biotechnology & Agronomy
Chemical Sciences	AcSIR-37-CS-AD-001	Natural & synthetic product chemistry
Chemical Sciences	AcSIR-37-CS-AD-002	Drug Discovery
Chemical Sciences	AcSIR-37-CS-AD-003	Secondary metabolism of medicinal plants
Chemical Sciences	AcSIR-37-CS-AD-004	Advanced Pharmacology & Toxicology

AcSIR Academic Centre Code: 37

CSIR-Indian Institute of Integrative Medicine	CSIR-IIIM

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Formulation, Drug Delivery & Pharmacokinetics	AcSIR-37-BS-AD-001	2

Pre-formulation considerations in the pharmaceutical product development, Introduction and classification of dosage form, Basic considerations in sterile product development and quality control parameters, Basic concepts in oral drug delivery, Novel formulation approaches for therapeutic agents, Biopharmaceutics and Drug Delivery Systems, Drug Disposition (ADME), Bioavailability and Bioequivalence, Pharmacokinetics and Therapeutic drug monitoring, Drug-drug interactions and cancer chemotherapy.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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CSIR-Indian Institute of Integrative Medicine | CSIR-IIIM

Course 3 : Advanced Course | Biological Sciences | Total Credits 6

Title:		Course Code	Credits
	Biodiversity & Climate change	AcSIR-37-BS-AD-002	2

Biodiversity & Climate change: Understanding the physiological response of plants under a climate change scenario.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 37

CSIR-Indian Institute of Integrative Medicine	**CSIR-IIIM**

Course 3 : Advanced Course	**Biological Sciences**	**Total Credits 6**

Title:	**Cancer Biology & Neuropharmacology**	**Course Code**	**Credits**
		AcSIR-37-BS-AD-003	**2**

Hallmarks of cancer, Anti-cancer agents, Chemical carcinogensis, Drug resistance in cancer, Cancer Stem cells, Autophagy and Apoptosis, Role of Cancer Genomics in Target Discovery, Role of Cell signalling and Epigenetic pathways in Cancer development and progression, Detection and Diagnostics in Cancer, Cancer Therapeutics. Structure and functions of Nervous System: Energy metabolism of the brain, Membrane transport and intracellular trafficking, Neurotransmission and cellular signaling, Introduction to Neurodegenerative Diseases: Parkinson, Alzheimer and Huntington, Role of Inflammation in neurodegenerative diseases, Blood brain barrier, Modeling of Neurodegenerative diseases.

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CSIR-Indian Institute of Integrative Medicine	CSIR-IIIM

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Industrial Microbiology	Course Code	Credits
		AcSIR-37-BS-AD-004	2

Antimicrobials and drug discovery: Antimicrobial resistance: An overview of the history and development of antimicrobials, Introduction and impact of antimicrobial resistance, Antimicrobial agents-Antibiotics, Anti-fungal, Anti-viral, antiprotozoan; Antibiotic classification and mechanisms of their action, Evolution and molecular mechanisms of antimicrobial resistance, multi-drug resistance, superbugs, Global emergence of antimicrobial resistance, Factors contributing the emergence of antimicrobial resistance. Antimicrobial susceptibility testing (AST)- types and limitations. New methods for antimicrobials: Antimicrobial Discovery and Developments: Antimicrobials and their usage in human medicine, veterinary, and plant/animal agriculture. Biochemistry and molecular genetics of Antimicrobial resistance, Requirements to novel antimicrobial or alternatives, antibiotic resistance breakers or antibiotic adjuvants, antimicrobial peptides, drug-repurposing, natural products as a source for novel antimicrobials, Screening and development approaches for new microbial natural product, High-content screening methods, antimicrobial in-vitro and in-vivo screening Assays.

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AcSIR Academic Centre Code: 37

CSIR-Indian Institute of Integrative Medicine	CSIR-IIIM

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Infectious Diseases	Course Code	Credits
		AcSIR-37-BS-AD-005	2

General Principles of Infectious Diseases: Nature and pathogenesis of Microbes. The mechanisms of microbial escape. Host defense and anti-microbial immune responses (including vaccines and vaccination). Infections of Global Impact: Bacterial, fungal, protozoal and viral infections overview. Diagnosis and therapeutics, Mechanism of antimicrobial drug resistance, Tuberculosis: Overview, Diagnosis and Therapeutics. Mycobacterium tuberculosis adaptation to survive in a human host, Emerging antimicrobial drug targets. Emerging and Resurgent Infections: Viral hemorrhagic fevers; Japanese encephalitis; Chikungunya; Dengue SARS-CoV-2 & SARS; Other neglected infectious diseases.

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AcSIR Academic Centre Code: 37

CSIR-Indian Institute of Integrative Medicine	CSIR-IIIM

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Microbes in Drug discovery	Course Code	Credits
		AcSIR-37-BS-AD-006	2

Microbial Diversity and Applications: Microbial nutrition and growth. Microbial ecology and diversity. Extremophiles: Introduction, Diversity, Habitat, Physiology and applications of Acidophilic, Alkaliphilic. Thermophilic, Psychrophilic, Barophilic, Halophilic microorganism and Microorganism resistant to radiations. Microbial diversity of NW Himalayas. Endophytes and marine microbes and their prospects in natural product drug discovery. Isolation, characterization and identification of microbes. Long term preservation of microbes. Introduction to fermentation technology. Types of bioreactors, Up-stream / down-stream processing. Fermentation Types and their applications with special emphasis on the products of healthcare industry. Introduction, sources and classification of enzymes; enzyme activity and specific activity; Monomeric and oligomeric enzymes; Specificity of enzymes; effect of pH & temperature; Enzyme kinetics, Enzyme Inhibition; Investigation of active site structure and allosteric enzymes; Application of enzymes; enzyme immobilization; case studies on enzyme based processes. Development of recombinant clones for overproduction of enzymes and metabolites, development of expression systems in bacteria and yeasts. Fungal secondary metabolism; Induced production of secondary metabolites in fungi; Microbial Volatile Organic products (VOCs); Activation of cryptic biosynthetic pathways.

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CSIR-Indian Institute of Integrative Medicine | CSIR-IIIM

Course 3 : Advanced Course | Biological Sciences | Total Credits 6

Title:		Course Code	Credits
	Molecular model and simulations	AcSIR-37-BS-AD-007	2

Chem-informatics and its application; General features of molecular mechanics force fields, Energy minimization: derivative & non-derivative methods, Protein flexibility and molecular dynamics, Protein folds and fold based classification of proteins, Strategies for ligand based drug design, Strategies for structure based drug design, Lead optimization strategies, Fragment based drug design.

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AcSIR Academic Centre Code: 37

CSIR-Indian Institute of Integrative Medicine CSIR-IIIM

Course 3 : Advanced Course Biological Sciences Total Credits 6

Title:	Course Code	Credits
Pharmacology & Toxicology	AcSIR-37-BS-AD-008	2

Introduction to General Pharmacology, Principles of Pharmacology, Pharmacodynamics, Defined Animal models, Principles, methods and applications of In vivo Imaging, Animal experimentation, Biology of laboratory Animals, Advancements in animal model systems, Laws, regulations and policies affecting the use of Laboratory animals. Laboratory Animal Biosecurity (Prevention, control and eradication). Importance of health and genetic monitoring of experimental animal models. Introduction to Toxicology, Principles of Toxicology, Role of Toxicology in Drug Discovery, Preclinical Toxicology, Mutagenesis and Carcinogenesis, System Toxicology, Teratology, Drug Biotransformations

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AcSIR Academic Centre Code: 37

CSIR-Indian Institute of Integrative Medicine	**CSIR-IIIM**

Course 3 : Advanced Course	**Biological Sciences**	**Total Credits 6**

Title:		Course Code	Credits
	Plant Biotechnology & Agronomy	**AcSIR-37-BS-AD-009**	**2**

Plant Biodiversity: Aims, objectives and dynamics of Plant biodiversity, Bio-geographic regions of plant biodiversity in India and world, Diversity within different plant groups, bioprospection, Biodiversity and traditional knowledge, assessment of biodiversity, Role of Biosphere Reserve, National Parks, Wild Life Sanctuaries, Species distribution and endemism, Sustainable uses of Biodiversity, Ecosystem function and ecosystem processes, Ecological niche, Consequence for biodiversity loss, protecting and restoring healthy forest ecosystems and IUCN categorization of national and regional flora. Plant genetic resources conservation and exploration, Diversification of high value medicinal and aromatic plants in the existing cropping system of India against the climate changes. Aquatic Ecology and Biodiversity.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 37

CSIR-Indian Institute of Integrative Medicine	CSIR-IIIM

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title: Natural & synthetic product chemistry	Course Code	Credits
	AcSIR-37-CS-AD-001	2

Natural products chemistry: Traditional system of Indian medicine, Isolation of bioactive metabolite from natural resources, Advanced separation techniques and their applications, Dereplication of natural product using hyphenated techniques, Advanced spectroscopy techniques for identification of complex natural product, Peptides,Carbohydrates and Polysaccharides, Biosynthesis of natural products (terpenes, steroids, flavonoids), Chemical ecology. Advanced organic chemistry: Methods of asymmetric synthesis and their applications in total synthesis, Retrosynthetic analysis, Catalysis, Stereochemistry, Green and sustainable chemistry, Tool of green chemistry, Concept of atom economy.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 37

CSIR-Indian Institute of Integrative Medicine	**CSIR-IIIM**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	**Drug Discovery**	**Course Code**	**Credits**
		AcSIR-37-CS-AD-002	**2**

Medicinal chemistry of natural products and its importance in drug discovery, SAR studies, pharmacokinetics and metabolism, drug targets, target validation, high throughput pharmacological screening, hit and lead identification/optimization, Safety-Tox studies, animal models, Drug delivery and pharmaceutical formulations, process chemistry, toxicology, regulatory and clinical trials. Case study of drug discovery and development related to onclogy/infectious diseases or neurodegenerative diseases.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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CSIR-Indian Institute of Integrative Medicine CSIR-IIIM

Course 3 : Advanced Course Chemical Sciences Total Credits 6

Title:	Course Code	Credits
Secondary metabolism of medicinal plants	AcSIR-37-CS-AD-003	2

Secondary metabolism of medicinal plants: Role of glucosinolates in biotic and abiotic stress tolerance in plants, Diversity and distribution of secondary metabolites and secondary metabolism pathways, Biological significance of plant secondary metabolites and molecular approaches to modulate secondary metabolism in plants, Plant Metabolic engineering, some examples of successfully engineered plant secondary metabolites of human interest, Brief role of transcription factors and plant transporters in plant secondary metabolism using specific examples of terpenoids, alkaloids etc., Basics of plant cell signaling, post-translational modification, proteasome pathway, Tools for identification of signaling components (mutants, protein-protein interaction, sub-cellular localization etc.) in plants, Biosynthesis of phytohormones and transport of phytohormones, Auxin signaling, cytokinin signaling, GA signaling, ABA signaling, Strigolactones, Ethylene signaling, Jasmonate mediated signaling, Brassinosteroid signaling, Significance of plant secondary metabolites, Plant secondary metabolites of pharmacological significance, Different classes (phenylpropanoids, alkaloids, terpenoids, glucosinolates etc.) of plant secondary metabolites, Molecular basis of biosynthesis of plant secondary metabolites, Regulation of plant secondary metabolism, Omics approaches for identification of genes involved in plant secondary metabolism, Sites of biosynthesis and accumulation of secondary metabolites, Transport of plant secondary metabolites.

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AcSIR Academic Centre Code: 37

CSIR-Indian Institute of Integrative Medicine CSIR-IIIM

Course 3 : Advanced Course Chemical Sciences Total Credits 6

Title:	Advanced Pharmacology & Toxicology	Course Code	Credits
		AcSIR-37-CS-AD-004	2

Introduction to General Pharmacology, Principles of Pharmacology, Pharmacodynamics, Defined Animal models, Principles, methods and applications of In vivo Imaging, Animal experimentation, Biology of laboratory Animals, Advancements in animal model systems, Laws, regulations and policies affecting the use of Laboratory animals. Laboratory Animal Biosecurity (Prevention, control and eradication). Importance of health and genetic monitoring of experimental animal models. Introduction to Toxicology, Principles of Toxicology, Role of Toxicology in Drug Discovery, Preclinical Toxicology, Mutagenesis and Carcinogenesis, System Toxicology, Teratology, Drug Biotransformations.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-38-BS-AD-001	Advances in physiological and Molecular Responses to Plant Stress
Biological Sciences	AcSIR-38-BS-AD-002	Advances in Plant Microbes Interactions
Biological Sciences	AcSIR-38-BS-AD-003	Cellular and Molecular Pathology
Biological Sciences	AcSIR-38-BS-AD-004	Eco-restoration
Biological Sciences	AcSIR-38-BS-AD-005	Ethnobotany, Traditional Knowledge and Phytopharmaceuticals
Biological Sciences	AcSIR-38-BS-AD-006	Genome Editing System and Applications
Biological Sciences	AcSIR-38-BS-AD-007	Microbial Biotechnology
Biological Sciences	AcSIR-38-BS-AD-008	Molecular and Cell Biology
Biological Sciences	AcSIR-38-BS-AD-009	Molecular Markers and Breeding
Biological Sciences	AcSIR-38-BS-AD-010	Plant-Insect Interactions
Chemical Sciences	AcSIR-38-CS-AD-001	Nanomaterials in Photocatalysis & Sensor Applications
Chemical Sciences	AcSIR-38-CS-AD-002	Energy & Environment
Chemical Sciences	AcSIR-38-CS-AD-003	Polymers and their Composites
Chemical Sciences	AcSIR-38-CS-AD-004	Applied Catalysis
Chemical Sciences	AcSIR-38-CS-AD-005	Small Molecule Activation

Faculty of Study	Course Code	Course Title
Chemical Sciences	AcSIR-38-CS-AD-006	Synthetic methods for organic chemists
Chemical Sciences	AcSIR-38-CS-AD-007	Organic Reaction Mechanisms
Chemical Sciences	AcSIR-38-CS-AD-008	Asymmetric Synthesis
Chemical Sciences	AcSIR-38-CS-AD-009	Fluoro-organic chemistry
Chemical Sciences	AcSIR-38-CS-AD-010	Modern Spectroscopic Techniques
Engineering Sciences	AcSIR-38-ES-AD-001	Advanced Design of Concrete Structures
Engineering Sciences	AcSIR-38-ES-AD-002	Advanced Welding Processes
Engineering Sciences	AcSIR-38-ES-AD-003	Bioprocess Engineering
Engineering Sciences	AcSIR-38-ES-AD-004	Fluid Power and Application
Engineering Sciences	AcSIR-38-ES-AD-005	Geotechnical Engineering
Engineering Sciences	AcSIR-38-ES-AD-006	Heterogeneous Catalysis and Surface Reaction
Engineering Sciences	AcSIR-38-ES-AD-007	Pavement Design, Analysis and Evaluation
Engineering Sciences	AcSIR-38-ES-AD-008	Process Engineering and Economics
Engineering Sciences	AcSIR-38-ES-AD-009	Separations Processes
Engineering Sciences	AcSIR-38-ES-AD-010	Solar Energy Engineering of Thermal Processes

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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38 CSIR-NEIST 3 *Advanced Course*

Faculty of Study	Course Code	Course Title
Physical Sciences	AcSIR-38-PS-AD-001	Physics of Earth and Planetary Geodynamics
Physical Sciences	AcSIR-38-PS-AD-002	Advanced Seismology and Computational Modeling
Physical Sciences	AcSIR-38-PS-AD-003	Seismological Processes
Physical Sciences	AcSIR-38-PS-AD-004	Electrical Methods for Geophysicists
Physical Sciences	AcSIR-38-PS-AD-005	Gravity and Magnetics
Physical Sciences	AcSIR-38-PS-AD-006	Geomorphology & Neotectonics
Physical Sciences	AcSIR-38-PS-AD-007	Stratigraphic Principles of Sedimentation
Physical Sciences	AcSIR-38-PS-AD-008	Physical Geology
Physical Sciences	AcSIR-38-PS-AD-009	Numerical Methods and Computer Programming
Physical Sciences	AcSIR-38-PS-AD-010	Seismic Prospecting

AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology CSIR-NEIST

Course 3 : Advanced Course Biological Sciences Total Credits 6

Title:	Advances in physiological and Molecular Responses to Plant Stress	Course Code	Credits
		AcSIR-38-BS-AD-001	2

Plant stress physiology: basic concepts and approaches in plants, Major abiotic stress factors affecting the plants: drought, salinity, high temperature, low temperature, oxidation, heavy metals, UV radiation, Physiological responses of plants to abiotic stress: photosynthesis, photorespiration, phytohormones, carbon balance, transpiration, Molecular responses of plants to abiotic stress: gene regulation, signaling, cellular responses, stress response pathways, Integrated physiological and molecular approaches to improve abiotic stress tolerance and sustained plant productivity.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology	CSIR-NEIST

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Advances in Plant Microbes Interactions	Course Code	Credits
		AcSIR-38-BS-AD-002	2

Biology and Ecology of Plant Pathogens and Endophytes. Biology and ecology of major group of plant pathogens viz. fungi, bacteria, viruses, nematodes and mollicutes and endophytes. Concepts of plant diseases, etiology, microbial communities, virulence and resistance, population biology, disease development and epidemiology.Genetics of Host Pathogen interaction and Mechanism of Host Defence. Genes and plant diseases, genetics of resistance and pathogenicity, recognition mechanisms in host pathogen interaction. Pathogenesis and host defence, passive and active defence mechanisms-structural and biochemical defences, systemic acquired resistance.Advances in Plant Disease Management. Introduction to biology of the pathogens that cause plant diseases, disease diagnosis. Topics include principles and practices of plant disease management including physical methods, regulatory methods, biological and chemical methods, host resistance and integrated plant disease management (IPDM).Biotechnology of Edible and Medicinal Mushroom. Prospects of edible and medicinal mushrooms, biochemistry of mushroom fructification, nutritive and medicinal values, spawn and spawn preparation, agro-technology, pest and diseases, genetic improvement.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology — CSIR-NEIST

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Cellular and Molecular Pathology	AcSIR-38-BS-AD-003	2

Basics of cell biology and cellular physiology(Organization of cell structure- Organelles, Cell membrane and its components, Biomolecular and biochemical components of cells, classification of cell types- cell types as structural components tissue and organ, functional classification of cell types, biochemical process of cell, cellular dynamics and homeostasis) Cellular stress and cell Injury(Detrimental factors- endogenous and exogenous factors, carcinogens, chemical and biological toxins, cell stress, heat shock, cellular oxidative damage, acute and chronic inflammation, markers)Cellular defence, cell survival and cellular adaptations (Cell cycle, cell growth, autophagy, differentiation, migration, tissue repair, wound healing, fibrosis) Cell death, mechanisms and regulations (Irreversible cell damage factors, apoptosis, necroptosis, necrosis) Cellular aging (cell senescence, cell immortalization, pluripotency and stem cell)Mammalian cellular pathologies (non-communicable diseases)(Cellular and molecular pathological basis of diseases - nutritional disorders, developmental disorders, cancer, metabolic disorders – diabetes & hypertension, autoimmune disease, neurological disease and disorders) Mammalian cellular pathology (infectious diseases)(Cellular and molecular pathological basis of infectious diseases –bacterial diseases, viral diseases, fungal diseases, parasitic diseases) Mammalian cellular Signaling pathways and their deregulations(Major cellular signaling pathways, components of basic cellular pathways, growth factor receptor and kinase signaling pathways, G-protein coupled receptor signaling pathways, cytokine receptor signaling pathways, PI3K/AKT/MAPK cell signaling pathway)Biomarkers and therapy of cellular pathology (Genetics, host-environment interactions, genetic/biochemical and other biomarkers of cellular pathology, therapeutic classes and approaches to cellular pathology- natural/synthetic/allopathic/biological/chemical, homeopathic/Ayurvedic/traditional practices) Tools and techniques in cellular pathology(In silico, molecular, genetic, biochemical, histological, animal models based assays and techniques, qualitative and quantitative diagnosis).

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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CSIR-North East Institute of Science & Technology	CSIR-NEIST

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Eco-restoration	AcSIR-38-BS-AD-004	2

Ecology and nature of environmental degradation of ecosystems due to natural and manmade activity and different measures adopted for ecological restoration, Phenocopies and Ecotypes; genetic Assimilation and natural selection; Phenotypic Accommodation; Evolutionary considerations; Developmental mechanisms of phenotypic accommodation; Reciprocal accommodation, Niche construction, Biotransformation and Bioremediation: Microbial biotransformation, biodegradation of petroleum, xenobiotics, bioremediation and phyto-remediation, production of microbial enzymes and fermentation, physico-chemical parameters for maximum enzyme production, enzyme purification, characterization and immobilization of enzymes, enzyme use for biotransformation, chiral synthesis.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology	**CSIR-NEIST**

Course 3 : Advanced Course	**Biological Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Ethnobotany, Traditional Knowledge and Phytopharmaceuticals	**AcSIR-38-BS-AD-005**	**2**

Ethnobotany, Interdisciplinary nature of Ethnobotany, Cross cultural Ethnobotany, Ethnobotany and medical botany, Methods of ethnobotany, Ethnobotany and plant taxonomy, Ethnobotany, Traditional Knowledge and Plant Folk Medicine of NE India, Validation of Ethnobotanical Knowledge, Bioprospection, Phytopharmaceuticals, Botanical Drugs, Ethnobotany and Drug Development, Biopiracy, Documentation and development of database, TKDL.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology	CSIR-NEIST

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Genome Editing System and Applications	AcSIR-38-BS-AD-006	2

Introduction to genome editing, Methods of genome editing and their pros and cons: Zinc Finger Nucleases (ZFNs), Transcription Activator-Like Effector Nucleases (TALENs), Mega-nucleases and CRISPR-Cas, CRISPR-Cas: history, basic principles, types and strategies, sgRNA design for efficient CRISPR-Cas genome editing: Bioinformatic tools, target gene identification, pre-CRISPR analysis, off target effects, Multiplex CRISPR-Cas genome editing for improvement of genetic traits: technology overview and recent successful case studies, Applications of genome editing technologies in medicine, agriculture and environmental care, Biosafety, ethical aspects and regulatory guidelines of genome editing.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology | CSIR-NEIST

Course 3 : Advanced Course | Biological Sciences | Total Credits 6

Title:	Course Code	Credits
Microbial Biotechnology	AcSIR-38-BS-AD-007	2

Microbial Cell structure, microbes for industrial and agriculture application, bioactive metabolites for pharmaceutical and industrial lead/hits, DNA fingerprinting, DNA sequencing, Molecular characterization of genes and traits responsible for biological activity, cell signalling, multi-omics and microbes, enzyme production, characterization and applications. Exploitation of microbes for bioremediation & biotransformation, Microbe and agriculture.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 38			
CSIR-North East Institute of Science & Technology			**CSIR-NEIST**
Course 3 : Advanced Course	**Biological Sciences**		**Total Credits 6**
Title: Molecular and Cell Biology		**Course Code**	**Credits**
		AcSIR-38-BS-AD-008	**2**

Introduction to molecular and cell biology, Biomolecules and replication: DNA, RNA, Protein, Central dogma of molecular biology, Molecular and cellular evolution: organisomal, bacterial, Darwin theory, Hady-Weinberg law, C-value paradox), Prokaryotic and eukaryotic cell system: techniques for cell study including histology, karyotyping, live cell imaging, FISH, Flow Cytometry, 3D cell imaging, Protein sorting, secretion and intra-cellular trafficking: PM, Golgi, ER, endosomes and vacuole, Gene cloning and expression in heterologous system: classical cloning, gateway cloning, virtual cloning through Vector NTI, Loss-of-function and Gain-of-function analysis of genes.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 38			
CSIR-North East Institute of Science & Technology			CSIR-NEIST
Course 3 : Advanced Course	Biological Sciences		Total Credits 6

Title:	Molecular Markers and Breeding	Course Code	Credits
		AcSIR-38-BS-AD-009	2

Genome Organization Organellar genome and Nuclear Genome: Unique sequences, Repeat DNA sequences, Classification of Repeat DNA (Tandem repeats, Interspersed repeats, Micro-satellites, Minisatellites, midi-satellites, VNTRs), The dynamic genome: Polymorphisms and Sources of Genetic variation, Oveview of Genetic Markers: Phenotypic Markers, Biochemical markers, DNA based markers Molecular marker and DNA fingerprinting techniques: Concepts, classification and methodologies: Hybridization based markers (viz. Restriction Fragment Length Polymorphism, Oligonucleotide fingerprinting), PCR based markers (viz. DNA Amplification Fingerprinting, Arbitrarily Primed PCR, Randomly Amplified Polymorphic DNA, SSRs, STMS, SCARs, Inter-SSRs, Multiple Arbitrary Amplicon Profiling, Amplified Fragment Length Polymorphism, electively Amplified Microsatellite Polymorphic Loci, Inter retrotransposon amplified polymorphism, retrotransposon-microsatellite amplified polymorphism, Diversity Array Technology (DArTs), SNPs and SNP based assays for high-throughput genotyping, EST based markers, Sequencing by Hybridization (SBH), Molecular Markers and Assessment of genetic diversity: Principles of Numerical taxonomy, binary matrix to phonetic dendograms, Structure analysis, Case Studies and examples, Molecular Markers for genome mapping: Marker Assisted Selection (MAS), gene introgression and pyramiding, BSA Genotyping for Physical mapping: Fingerprinting for BAC assembly, Types of Mapping populations in Plants: F2 populations, RILs (recombinant inbred lines), Backcross lines, NILS (Near Isogenic Lines), HIF (Heterogenous Inbred Families), AILs (Advanced Intercross Lines), Other Application of Molecular Markers: Genotyping tools as plant variety protection, hybrid purity tests, diagnostics (transgenics, forensics) Other Mapping tools and Methodologies: Introduction to Cytogenetic maps, Radiation Hybrid Maps, HAPPY mapping, Physical Maps, Comparative/Synteny mapping. Next-generation molecular breeding, speed breeding.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology	CSIR-NEIST

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Plant-Insect Interactions	Course Code	Credits
		AcSIR-38-BS-AD-010	2

Herbivore-Plant Interaction. Tritrophic interactions of plant-insect &parasitodids,Plant defence Secondary plant metabolites, Botanical Pesticides past , present and future Plant-Pollinator interactions. Insect as pollinator- Honey bee & Butterfly as pollinator- Honeybee & crop production pollination Biology Butterfly as environmental indicator. Butterfly biodiversity, Host range, conservation Herbivoresinduced plant defence. Induced biosynthesis of plant defense compounds-use of plant signal in agricultural crops- Transgenic plants.Insect behaviour. Manipulation of insect behaviour for insect pest management- Evolution of insect behaviour.Novel methods of Insect-pest management. IPM- Concept & Evolution, Ecology of pest- IPM of major pests, Resistance, Biocontrol/Biocides, Molecular approaches in Insect-pest Management.

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CSIR-North East Institute of Science & Technology	CSIR-NEIST

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Nanomaterials in Photocatalysis & Sensor Applications	Course Code	Credits
		AcSIR-38-CS-AD-001	2

Advanced Oxidation Processes, History of the photocatalysis phenomenon, Basic principal of photocatalytic phenomenon, Advanced nanoarchitectures for photocatalytic applications, Semiconductor nanomaterials in photocatalysis, Use of 2D light absorbers in photocatalysis, 2D Materials in Photocatalysis, 2D nanocomposite materials and their photocatalytic properties. Water pollutant removal by photocatalysis phenomenon. Catalytic sensors and its basic understanding, Nanomaterials: A promising candidate for artificial enzymes, Classification, Catalytic Mechanisms and Applications, Nanozymes in Sensing, Biosensors and their fundamentals, Immuno sensors, Enzymatic immune sensors, Low cost diagnostics: paper microfluidics and lateral flow assays.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 38			
CSIR-North East Institute of Science & Technology			CSIR-NEIST
Course 3 : Advanced Course	Chemical Sciences		Total Credits 6

Title:	Energy & Environment	Course Code	Credits
		AcSIR-38-CS-AD-002	2

Energy scenario, Non-renewable and renewable energy sources; Description of renewable sources and their importance. Technologies for biomass energy conversion, Solar energy, Wind Turbines, Geothermal Technologies; Applications; Sustainable sources of hydrogen; Fuel cell technologies; Hydrogen storage and distribution; Applications and feasibility assessment; Science, technology and policy of energy conservation; Strategies for enhancing role of renewable energy. Coal mining and environmental issues; Acid mine drainage; Management of acid mine drainage; Biomass in energy applications; Green house gases; Aerosol and air pollution.

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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology	CSIR-NEIST

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Polymers and their Composites	AcSIR-38-CS-AD-003	2

Introduction; Classification of polymers; Chemistry of polymerization Techniques (addition, condensation, bulk, solution, (mini) emulsion, dispersion, suspension etc.,) & characterization (GPC, DSC, UTM, DMA, NMR, SEM, TEM etc.,); Controlled Radical Polymerization, Stereochemistry of Polymers; Biodegradable Polymers; Polymer Rheology Polymer Particles; Polymers structure and properties. Introduction of thermoset & thermoplastic; polymer blend composites and their application; Polymer processing: introduction; plastics, elastomers & fibres; compounding; processing techniques and their industrial applications.

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CSIR-North East Institute of Science & Technology	CSIR-NEIST

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Applied Catalysis	AcSIR-38-CS-AD-004	2

Haber-Bosch process for ammonia and its future direction, Zeigler-Natta catalysts, Wilkinson catalyst, Ring Opening Polymerization for Industry, Hydrogenation catalysis, Industrial Hydroformylation catalysis reaction, Catalyst for coal liquefaction and gasification.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology | CSIR-NEIST

Course 3 : Advanced Course | Chemical Sciences | Total Credits 6

Title:	Course Code	Credits
Small Molecule Activation	AcSIR-38-CS-AD-005	2

C-H Bond activation, Oxygen activation, Nitrogen fixation, Hydrogen activation, Carbon activation, Water activation, Carbon monoxide and Carbon dioxide activation, Methane activation, Methanol to value added materials, NHC, Nitrile to amide, NH activation, Remote functionalization.

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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology — CSIR-NEIST

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Synthetic methods for organic chemists	AcSIR-38-CS-AD-006	2

Formation of carbon-carbon bond employing various kinds of organometallic reagents, C-C double bonds through different reactions, oxidation, reduction through various kinds of reagents, functional group interconversion, by substitution including protection and deprotection, alkylation of enolates, and other carbon nucleophiles, reaction of carbon nucleophiles with carbonyl compounds, electrophilic addition to CC multiple bonds, reactions of C-C multiple bonds, Retrosynthesis, disconnection, synthons, linear and convergent synthesis, umpolung of reactivity and protecting groups.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology CSIR-NEIST

Course 3 : Advanced Course Chemical Sciences Total Credits 6

Title:	Organic Reaction Mechanisms	Course Code	Credits
		AcSIR-38-CS-AD-007	2

Basics, concept of Aromaticity, How to write an organic reaction mechanism, Popular name reactions, Reactive intermediates: Generation, stability, structures and reactivity of carbocation, carbaion, carbene, radicals, benzyne, nitrene, Types of mechanism: classification, limitations examples of aliphatic nucleophilic substitution - aliphatic electrophilic substitution -aromatic nucleophilic substitution - aromatic electrophilic Substitution - types of radical reactions - molecular rearrangements oxidation and reduction; Electrophilic reactions-Friedel crafts reaction, Riemer Tiemenn reaction, Beckmann rearrangements; nucleophilic reactions- aldol condensation, perkin reaction, benzoin condensation;free radical reactionhalogenation of alkane, addition of HBr on alkene in presence of peroxide;allylic halogenation - using N-Bromo Succinamide (NBS), thermal halogenation of alkene CH3 – CH = CH2.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology	**CSIR-NEIST**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	**Asymmetric Synthesis**	**Course Code**	**Credits**
		AcSIR-38-CS-AD-008	**2**

Strategies for the preparation of optically pure compounds; Stereoselective, Enantioselective and Diastereoselective reactions; Stochiometric asymmetric synthesis-chiral auxiliaries, Evans Alsdol and modified versions; Catalytic asymmetric synthesis; Asymmetric Dihydroxylation; Asymmmetric Aminohydroxylation; Asymmetric Hydrogenation; Asymmetric allylation, propargylation, and alkylation; Chiral Organocatalysis; Cascade reactions by organocatalysis; Transition Metal based catalysis; Asymmetric amplification and autocatalysis.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology — CSIR-NEIST

Course 3 : Advanced Course — Chemical Sciences — Total Credits 6

Title:	Course Code	Credits
Fluoro-organic chemistry	AcSIR-38-CS-AD-009	2

Importance of fluorine in organic compounds, Strategies to introduce fluorine/ trifluoromethyl group into organic molecules, Preparation of fluorinated reagents, Preparation of fluorinated carbon materials and their uses, Known fluorinated drugs and their mode of action, Overview on CFCs, HCFCs, HFCs, their preparation and applications, Halon susbsitutes, Harmful effects of fluorine and inorganic fluorides.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology	**CSIR-NEIST**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	Modern Spectroscopic Techniques	Course Code	Credits
		AcSIR-38-CS-AD-010	**2**

Proton magnetic resonance spectroscopy, Structural assignment by employing NMR techniques, Carbon-13 NMR spectroscopy, Introduction COSY, HSQC, HMBC, NOESY, ROESY, Structural elucidation using 2D-NMR methods Multinuclear NMR spectroscopy, Periodic table of NMR, Heteronuclear double resonance experiments, Magnetization transfer and signal enhancement, NMR of diamagnetic and paramagnetic compounds, Multidimensional NMR: 2D NMR, 1H-1H correlations, Heteronuclear Correlation Spectroscopy, 2D Exchange (EXSY), 2D NOESY, ROESY, DOSY Structure elucidation of small molecules, Ultraviolet and visible light spectroscopy, FTIR spectroscopy, Mass Spectroscopy, Fluorescence spectroscopy, HPLC, GCMS, ESR Spectroscopy and other techniques.

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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology	**CSIR-NEIST**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:	**Advanced Design of Concrete Structures**	**Course Code**	**Credits**
		AcSIR-38-ES-AD-001	**2**

Limit state design of beams, slabs and slender columns- design of wall/strip footing- design of rectangular footings-eccentrically loaded rectangular footing- circular footings-detailing combined footings rectangular and trapezoidal (design principles only)- design of cantilever retaining wall without surcharge-detailing - design principles of counterfort retaining wall and detailing- Circular slabs-simply supported, fixed and partially fixed subjected to UDL design of water tanks-design philosophy and requirements-joints, design of rectangular and circular water tanks, Pre-stressed concrete-concept of prestressing- materials- methods of prestressing – prestressing systems- losses of prestress. analysis of prestressed beams (rectangular and I-sections) at stages of transfer and service.
Introduction of Reinforced Concrete Beams and Slabs: Short-term deflection of beams and slabs, deflection due to imposed loads and applied loads; estimation of crack width in reinforced concrete members, factors affecting crack width in beams, mechanisms of flexural cracking; Analysis of flat grid floors, rectangular grid floors by Timoshenko's plate theory, stiffness matrix method; Proportioning of flat slabs, determination of bending moment by direct design method, design for punching shear; Design of Reinforced Concrete Members for Fire Resistance: grading and classifications, effect of high temperature on steel and concrete, effect of high temperatures on different types of structural members, analytical determination of the ultimate bending moment, capacity of reinforced concrete beams under fire; Ductile detailing of frames for seismic forces: general principles, factors that increase ductility, specifications of materials for ductility, ductile detailing of beams – requirements, ductile detailing of columns and frame members with axial load (P) and moment (M); Design of rectangular bunkers, circular bunkers and silos; Chimney design factors, stresses due to self-weight, wind and temperature, combinations of stresses.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology | CSIR-NEIST

Course 3 : Advanced Course | Engineering Sciences | Total Credits 6

Title:	Course Code	Credits
Advanced Welding Processes	AcSIR-38-ES-AD-002	2

Introduction to advanced welding processes; micro-joining and nano-joining, wire bonding; fundamentals and types of laser welding including hybrid processes, magnetically impelled arc welding; advanced gas tungsten arc welding; flux cored arc welding; electron beam welding; pressure welding; ultrasonic welding; explosive welding; diffusion bonding; friction stir welding; electromagnetic pulse welding; high velocity projectile impact welding; fundamentals of welding automation, welding sensors and data acquisition; principles of robotic welding; weld distortion and defects - causes and remedies; residual stresses; inspection and testing of weldments.

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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology | CSIR-NEIST

Course 3 : Advanced Course | Engineering Sciences | Total Credits 6

Title:	Course Code	Credits
Bioprocess Engineering	AcSIR-38-ES-AD-003	2

Microbial growth, substrate utilization, and product formation kinetics: Quantification of cell growth, growth patterns and kinetics in batch culture, environmental factors affecting growth kinetics, heat generation by microbial growth, unstructured non-segregated model, models for transient behavior, kinetics of product formation; Mass balance and yield concepts: Yield and maintenance coefficients, calculation based on elemental balances, degree of reduction, theoretical predictions of yield coefficients.

Sterilization: introduction and the kinetics of death, batch and continuous sterilization of media, air sterilization, various type of sterilization equipment, sterilization of media by membrane filters; design of fermentation media; aseptic transfer.

Aeration and agitation: types of impellers and sparger, oxygen transfer rate, oxygen uptake rate, volumetric oxygen transfer rate (kL,a), measurement of kLa, power requirement for agitation in gaseous and non-gaseous systems.; rheology of fermentation fluids, mixing and scale-up. Operating considerations for bioreactors: Choosing the cultivation methods; Batch, fed-batch, repeated fed-batch, CSTR, CSTR with recycling, multistage CSTRs, and PFR.

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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology	**CSIR-NEIST**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:	**Course Code**	**Credits**
Fluid Power and Application	**AcSIR-38-ES-AD-004**	**2**

Introduction to fluid power, Application of fluid power, , Components of fluid power system, Pneumatic system, Hydro forming of metal components, Fluid power industry, Physical properties of hydraulic fluids, Conservation of Energy, Energy and power in hydraulic system, Losses in hydraulic system (Energy, power & Electrical losses), Laminar and turbulent flow, Reynolds number, Darcy’s equation, The moody diagram, Hydraulic valve, pumping theory, Hydraulic circuit design and analysis, Computer analysis and simulation of fluid power system, Ancillary hydraulic devices, Accumulators, Pressure intensifiers, Sealing devices, Maintenance of hydraulic systems, Fluid logic control system.

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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology	CSIR-NEIST

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Geotechnical Engineering	Course Code	Credits
		AcSIR-38-ES-AD-005	2

Introduction to basic Geotechnical engineering: Subsoil investigation using SPT, SCPT, DCPT and Plate load tests, analysis of data, shear strength, consolidation characteristics, and settlement analysis. Ground improvement Techniques: Soil improvement, dynamic compaction, Lime stabilization, Cement stabilization, organic and inorganic stabilizers, , Blasting, drains, Lime columns, Soil grouting, soft soils, embankments on soft soils, stage construction Vertical sand drains, Prefabricated vertical drains (PVD), Fiber drains, Instrumentation techniques, piezometers, settlement gauges, inclinometers, Field tests on soft soils, Stone columns, wet and dry methods, soil nailing, pull out tests, construction process, design methods, case studies. Stability of slopes and earth retaining structures: Earthen embankments, specifications, case histories, Finite and infinite slopes, Method of slices, Bishop’s method, Factor of safety, submerged case, sudden drawdown case, steady seepage case, long-term and short-term stability, gravity walls, cantilever walls. Geosynthetic materials for highway applications: Geotextiles, woven, nonwoven, Geo ties, Geogrids, Properties, applications, Reinforced earth walls, Mechanism, Reinforcements oil interaction, Analysis and design checks, Internal and external stability, Tests for soil reinforcement, Field applications, software applications. Environmental Geotechnics: Utilization of Waste materials, Reduction of carbon footprint, Hazardous waste containment, slurry wastes, Liners, Stability of landfills, landfill construction, Design aspects, Barriers.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Heterogeneous Catalysis and Surface Reaction	**AcSIR-38-ES-AD-006**	**2**

General introduction to catalysis and its application, General steps involved in catalytic reactions, Rate law, mechanism and rate limiting step, data analysis for reactor design, turn over frequency, yield, selectivity and catalytic deactivation. Catalyst characterization- Total surface area, metal surface area, metal dispersion.

Catalysis and catalytic reactors: Design of reactors for gas-solid reactions, heterogeneous data analysis for reactor design, catalyst deactivation, multiphase catalytic reactors, kinetic and mass-transfer limited zones, External diffusion effects: External diffusion effects on heterogeneous reactions – mass transfer fundamentals, binary diffusion, external resistance to mass transfer, correlations for the mass transfer coefficient, the shrinking core model

Internal diffusion effects: Internal diffusion effects on heterogeneous reactions, diffusion and reaction in catalysts, Thiele modulus, weiz-prater criterion, mear's criterion, internal effectiveness, overall effectiveness, estimation of mass transfer and reaction limited regimes, hatta number.

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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology	CSIR-NEIST

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Pavement Design, Analysis and Evaluation	AcSIR-38-ES-AD-007	2

Introduction: Types, components and comparison of pavements, Different pavement design approaches, General framework for pavement design, Concept of pavement performance, Factors affecting design / performance of pavements, Structural and Functional failures of pavements; Stresses and deflections in flexible pavements: Stresses and deflections in homogenous masses; layer theories; wheel load stresses, ESWL computation, Repeated loads and EWL factors; Vehicle types, Axle configurations, Contact shapes and contact stress distributions, Concept of standard axle load, Vehicle damage factor, Axle load surveys, Lateral placement characteristics of wheels, Estimation of design traffic, Flexible pavement design methods; Specifications of materials, choice, construction method and field control checks for various specifications of subbase, base, binder and surface course layers and mix design methods. Stresses in rigid pavements: Types of stresses and causes, general considerations in rigid pavement analysis, EWL; Rigid pavement design: Design of CC pavements, Types of joints in cement concrete pavements and their functions, joint spacing; design of joint details; Cement concrete pavement layers: Specifications and method of cement concrete pavement construction, quality control aspects; Equipments/Machineries in highway construction: Equipments for excavation, grading and compaction. Equipment for bituminous, cement concrete, stabilized and composite pavements. Earthwork construction, problems, quality control aspects. Drainage: Design and construction of drainage systems for road pavements, drainage materials, procedures and guidelines. Maintenance and rehabilitation of flexible and rigid pavements: Routine, periodic and preventive maintenance of pavements, maintenance of shoulders and drainage; Hill Roads: Special problems in construction and maintenance of hill roads; landslides, causes, investigations and remedial measures; Concept of Pavement Management System (PMS) and modelling of pavement deterioration.

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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology	**CSIR-NEIST**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:	**Process Engineering and Economics**	**Course Code**	**Credits**
		AcSIR-38-ES-AD-008	**2**

Introduction to process industries, capital and interest, economics and the process engineer, Meaning of Project Engineering, various stages of project implementation, Relationship between price of a product and project cost and cost of production, EVA analysis. Elements of cost of production, monitoring of the same in a plant, Meaning of Administrative expenses, sales expenses etc. Introduction to various, components of project cost and their estimation. Introduction to concept of Inflation, location index and their use in estimating plant and machinery cost. Various cost indices, Relationship between cost and capacity. Williams sixth-tenth factor, Economic balance in evaporation, Economic analysis for variable feed and product, grades, variable recovery, Debt: Equity ratio, Promoters' contribution, Shareholders' contribution, source of finance, time value of money. Concept of interest, time value of money, selection of various alternative equipment or system based on this concept. Indian norms, EMI calculations. Depreciation concept, Indian norms and their utility in estimate of working results of project. Working capital concept and its relevance to project, Cumulative cash flow analysis Break-Even analysis, incremental analysis, various ratios analysis, Discounted cash flow analysis, Process Selection, Site Selection, Feasibility Report

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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology	CSIR-NEIST

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Separations Processes	Course Code	Credits
		AcSIR-38-ES-AD-009	2

Separation Process Principles, Relative volatility, Maximum and minimum Boiling Point Azeotropes, Flash Distillation, bubble point and dew point, Ternary Liquid-Liquid Systems, Differential Batch Distillation, Binary Distillation, McCabe Thiele Technique: Operating lines for enriching and stripping sections; q lines for the feed, counting off stages, optimum feed location, limiting cases of total reflux and minimum reflux, Absorption in Packed Towers : Graphical Equilibrium Stage Method for Trayed Towers, Algebraic Method for Determining the Number of Stages, Rate Based Method for Packed Columns, Packed-Column Efficiency, Capacity and Pressure Drop, Concentrated Solutions in Packed Columns, Column breakthrough study, ASPEN Module for solving complex distillation problems, Importance of separation processes in chemical and biochemical industries, graphical techniques to analyze separation processes, modeling and simulation in separation processes, systematic approaches to solve problems related to separation processes, application of solvents in separation processes.

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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology **CSIR-NEIST**

Course 3 : Advanced Course **Engineering Sciences** **Total Credits 6**

Title:	Course Code	Credits
Solar Energy Engineering of Thermal Processes	**AcSIR-38-ES-AD-010**	**2**

Fundamentals of Solar Energy Engineering- Solar constant, solar radiation, estimation of solar radiation falling on plane and titled surface. • Solar Radiation Collection- Analysis of flat plate water heating collector, collector efficiency and heat removal factor, analysis of evacuated tube collector, Analysis of air heating collector, Thermal testing of solar collector, thermal performance of concentrating collector, CPC collector, Central Receiver Collector, design of thermal system by f-chart method. • Heating & Cooling- Concept of active and passive building heating, solar absorption cooling, solar desiccant cooling. • Solar Electricity Generation- Photovoltaic conversion, PV generator characteristics and models, design procedure, Thermal conversion system • & technology. • Energy Storage- Energy storage in solar process systems, water storage, stratification, packed bed storage, phase change storage. Approaches to Passive Design, Solar-Load Ratio Method, Design Method: Direct Gain, Collector-Storage Walls, Hybrid Systems: Active Collection with Passive Storage etc.

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Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology — CSIR-NEIST

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Physics of Earth and Planetary Geodynamics	AcSIR-38-PS-AD-001	3

Theories of origin of Universe, Earth as a unique planet, Solar system and laws of universe, Kepler's laws in planetary system, Physics of the Earth and tectonic forces, Theory of tectonics, earth and tectonic plates, Models of mantle convection: Single and double layered convection.

Different structures on Earth: Oceanic lithosphere- ridges, transform faults, trenches and oceanic islands; Continental lithosphere: Cratons, Sedimentary Basins, Continental margins and Rift zones. Orogeny, epeirogeny and isostasy. Major tectonic masses on Earth and theory of their formation, Tectonics of India and consequences to world geodynamics, Paleomagnetism and history of plate tectonics, Mantle petrology and chemical composition. Silicate phase transitions and correlation with mantle discontinuities. Structure of the lower mantle and core.

References:

1. Fundamentals of geophysics – by William Lowrie, Willey Pub
2. Geodynamics – Edited by: Peter M. Atkinson, Giles M. Foody, Stephen E. Darby, and Fulong Wu, CRC Press
3. Geodynamics of the Lithosphere: An Introduction –by Kurt Stuwe, Springer
4. Geodynamics of Northeastern India and the Adjoining Region: by D.R. Nandy. Published by Scientific Book Centre

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology CSIR-NEIST

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Seismology and Computational Modeling	AcSIR-38-PS-AD-002	3

Seismology and inner earth, Wave theory and laws of wave propagation, Characterization of earth waves and their significant contributions, Core-mantle-crust phases and ray path theories, Seismic tomography and principles, Fourier transformation, Hilbert transformation, Linear and nonlinear inversions, Numerical methods for solving non-linear equations, Computational methods for seismology, Numerical solution of integral equations (finite difference methods, A method of degenerate kernels, Method of invariant imbedding, Method using generalized quadrature), Seismic anisotropy and importance in geodynamics, Methods of measurements, Basics of seismic attenuation, Recent advancements in seismology.

References:

1. Numerical methods – by Balagurusamy, Mc Graw Hills
2. Applied Geophysics – by W M Telford, L P Geldart, R E Sheriff, Cambridge Univ. press

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CSIR-North East Institute of Science & Technology **CSIR-NEIST**

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Seismological Processes	AcSIR-38-PS-AD-003	3

Elasticity theory and seismic waves: Elastic, anelastic and plastic behavior of materials, Stress matrix, Strain matrix, Elastic constants, Generalized Hooke's law, Different types of elastic waves and their propagation characteristics, equations of motion of seismic body waves, Attenuation and dispersion of seismic waves, Free oscillations of the earth.
Instruments: Amplitude and phase characteristics of seismometers, Shortperiod, longperiod and broad band seismometers, Analysis of seismograms and identification of various phases on the seismograms, Basic principle of strong motion instrument.

Ray characteristics and related parameters for horizontally and spherically stratified earth, Basic principles of seismic tomography and receiver function analysis, Location of the epicenter of an earthquake, Global seismicity, Elastic rebound theory, Faultplane solutions and related interpretation, Reflections and refractions in the earth's interior, Models of the earth's internal structure.

Earthquake monitoring and prediction: Seismic networks and arrays, standalone and telemetry systems, Study of microearthquakes and induced seismicity, Earthquake prediction: Dilatancy theory, Short-term, middle-term and long term prediction.

References:
1. An Introduction to Seismology, Earthquakes, and Earth Structure, Author: Seth Stein, Michael Wysession, Publisher: Blackwell Publishing
2. Principles of Seismology, Author: Agustín Udías, Publisher: Cambridge University Press

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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology	**CSIR-NEIST**

Course 3 : Advanced Course	**Physical Sciences**	**Total Credits 6**

Title:	**Electrical Methods for Geophysicists**	**Course Code**	**Credits**
		AcSIR-38-PS-AD-004	**2**

Low frequency electrical properties of soils and rocks: Resistivity & induced Polarization methods, Electromagnetic methods: Case studies of electrical and electromagnetic methods in environmental and engineering studies.

High frequency electrical geophysics: High frequency electrical properties of soils and rocks, Ground penetrating radar (GPR) method, Case Studies of ground penetrating radar in environmental and engineering studies.

References:

1. Introduction To Geophysical Prospecting, Author: Dobrin M B, Publisher: McGraw Hill
2. Basic Exploration Geophysics, Author: Anand Patel, Publisher: Scitus
3. Field Geophysics, Author: John Milsom, Publisher: John Wiley

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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology CSIR-NEIST

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Gravity and Magnetics	Course Code	Credits
		AcSIR-38-PS-AD-005	2

The Earth's gravitational field and its relation to gravity, Gravitational effects over subsurface bodies having discrete shapes, Instruments for measuring gravity on land, at sea and into the boreholes, Gravity measurements on land, at sea and airborne gravity surveys. Magnetism of the earth, Magnetic susceptibility of rocks, Magnetic effects from buried magnetic bodies, Instruments used for magnetic measurements, Magnetic surveys on land, Marine and airborne magnetic data collection.

References:

1. Introduction To Geophysical Prospecting, Author: Dobrin M B, Publisher: McGraw Hill
2. Basic Exploration Geophysics, Author: Anand Patel, Publisher: Scitus
3. Field Geophysics, Author: John Milsom, Publisher: John Wiley

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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology	CSIR-NEIST

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Geomorphology & Neotectonics	Course Code	Credits
		AcSIR-38-PS-AD-006	2

Energy flow in geomorphic system and landforms, Structural control & landscape evolution, Dynamic equilibrium and topographic response to tectonic and climatic forcing, Fluvial geomorphic systems, Quaternary geomorphology, Methods & techniques of applications of geomorphology, Tectonic geomorphic marker & dating techniques, tectonics & topography, River terrace genesis.

References:

1. Tectonic Geomorphology – by Douglas W Burbank & Robert S Anderson, Wiley Blackwell
2. Tectonic Geomorphology of Mountains – by William B Bull, Blackwell Publishing
3. Geomorphology and Global Environmental Change – by Christine Embleton-Hamann,
4. Global Geomorphology – by Prof Michael Summerfield, Prentice Hall

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AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology	**CSIR-NEIST**

Course 3 : Advanced Course	**Physical Sciences**	**Total Credits 6**

Title:	**Stratigraphic Principles of Sedimentation**	**Course Code**	**Credits**
		AcSIR-38-PS-AD-007	**2**

Stratigraphic principles & units, Nature of stratigraphic records, Geochronology and chronostratigraphy, Vertical and lateral succession of strata, Nomenclature & classification of lithostratigraphic units, Formal stratigraphic units, Depositional processes & sedimentary structures, Sedimentary environments: Terrestrial, coastal, marine and facies, Lithostratigraphy and facies relationships, Composition, classification and diagenesis of sedimentary rock.

References:

1. Principles of Sedimentary Basin Analysis – By A D Miall, Springer
2. Principles of Sedimentology & Stratigraphy – By Sam Boggs, Jr, Pearson Prentice Hall
3. Applied Stratigraphy – edited by Eduardo A.M. Koutsoukos, Springer

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AcSIR Academic Centre Code: 38	
CSIR-North East Institute of Science & Technology	**CSIR-NEIST**

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:		Course Code	Credits
	Physical Geology	**AcSIR-38-PS-AD-008**	**2**

Planet earth & geological processes, Early history of earth & geological records, Continental drift, Sea-floor spreading, Plate tectonics and continent & ocean building processes, Concept of isostasy, Minerals and rocks, Igneous, sedimentary and metamorphic rocks, Geological time, Weathering and erosion, Mechanical & chemical weathering, Understanding the Earth's interior, Geological structures, Climate change, Geological resources.

References:

1. Physical Geology – by Steven Earle
2. Textbook of Geology – by PK Mukherjee
3. Physical Geology: exploring the Earth – by James S Monroe, Reed Wicander, Richard W Hazlett

AcSIR Academic Centre Code: 38

CSIR-North East Institute of Science & Technology CSIR-NEIST

Course 3 : Advanced Course Physical Sciences Total Credits 6

Title: Numerical Methods and Computer Programming	Course Code	Credits
	AcSIR-38-PS-AD-009	1

Solution of algebraic and transcendental equations, bisection and Newton-Raphson methods, solution of simultaneous linear equations, matrix inversion method, interpolation, Newton and Lagrange formulae, numerical differentiation, numerical integration, Simpson, trapezoidal and Gaussian quadrature methods, least square curve fitting, straight line and polynomial fits, numerical solution of ordinary differential equations, Euler and Runga-Kutta methods, finite element and finite difference methods.

Digital computer: Architecture and working, low level and high level languages, overview of compilers, interpreters and operating systems, problem solving on a computer, algorithms and flow charts, integer and floating point arithmetic, Fortran preliminaries: constants, variables, data types and expressions, built in functions, executable and nonexecutable statements, assignment, control and input /output statements, subroutines and functions, operations with files.

References:

1. Sastry : Introductory Methods of Numerical Analysis
2. Jain, Iyengar & Jain : Numerical Methods for Scientific and Engineering Computation
3. Raja Raman : Numerical Analysis
4. Raja Raman : Fundamentals of Computers
5. Raja Raman : Fortran Programming
6. Ram Kumar : Programming with Fortran77

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CSIR-North East Institute of Science & Technology	CSIR-NEIST

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title: Seismic Prospecting	Course Code	Credits
	AcSIR-38-PS-AD-010	1

Historical Development and Background of Refraction and Reflection Methods, Difference between Refraction and Reflection Surveys, Propagation of Seismic Waves in Linear and Nonlinear medium, Waveforms and their characteristics, N Layered case, continuous increase of velocity.

Seismic data enhancement and Test Shooting, Explosive and Non Explosive sources of Seismic Energy for P-Wave, Seismic source energy For S-Wave, Seismic operation on Land, Common Depth Point technique, Special weathering shot and Noise analysis, Broad Side shooting, Elevation, Weathering and Dynamic Corrections In Refraction and Reflection Data, Random and Non Random Noise, Grouping of Geophones, Data Acquisition for Vertical Seismic Profiling, Deep Seismic Sounding, Diffraction Method of Data Interpretation.

Sampling Theorem and Analysis of Seismic signals, Convolution, Correlation Techniques and Inverse Filtering of Seismic Data, Interpretation of Shear Wave Data, Hidden Layer Problem, Sequence of Seismic Processing, Seismic Inversion, Determination of Average Seismic Velocities, Tomography, Synthetic Seismograms.

Different Types of Display of Digital and Magnetic Recordings, Wiggle Trace, Variable Area and Variable Density Records, Analysis of Multiples and Ghost Reflections, Processing of Seismic Data, Imaging, 2D, 3D and 4D Seismics, Time and Depth Sections, Record Surface and Reflection Surface, Vertical and Horizontal Resolution.

Mapping of Geological Structures (Faults, Reef, Pinchouts, Anticlines), Migration Techniques (Classical and Modern), Wave Equation Migration, Time and Depth Migration, Depositional Sequence and Pit Falls of Seismic Interpretations, Seismic Stratigraphy and Sequence Analysis, Seismic Facies Analysis, Reflection Character Analysis, Bright Spots, Seismic Lithologic Modelling, Vp/Vs and Lithology, Gas Detection using AVO Analysis.

References:
1. Clarbout : Fundamentals of Geophysical Prospecting
2. 2. Telford et. al. : Applied Geophysics
3. Dobrin & Savit : Introduction to Geophysical Prospecting
4. Waters : Reflection Seismology
5. Sheriff & Geldart : Exploration Seismology

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-39-BS-AD-001	Advances in Food Processing and Technology
Biological Sciences	AcSIR-39-BS-AD-002	Bioprocesses Fermentation and Environmental Biotechnology
Biological Sciences	AcSIR-39-BS-AD-003	Disease Biology
Biological Sciences	AcSIR-39-BS-AD-004	Molecular Biology of Industrial Organisms
Chemical Sciences	AcSIR-39-CS-AD-001	Advanced Organic Chemistry
Chemical Sciences	AcSIR-39-CS-AD-002	Advanced Photochemistry, Photophysics and Instrumentation
Engineering Sciences	AcSIR-39-ES-AD-001	Advanced Materials Characterisation for Engineers
Engineering Sciences	AcSIR-39-ES-AD-002	Advanced Materials Processing for Engineers
Engineering Sciences	AcSIR-39-ES-AD-003	Chemical and Food Process Engineering
Physical Sciences	AcSIR-39-PS-AD-001	Advanced Materials Characterisation
Physical Sciences	AcSIR-39-PS-AD-002	Advanced Materials Processing

AcSIR Academic Centre Code: 39

CSIR-National Institute for Interdisciplinary Science and Technology	CSIR-NIIST

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Advances in Food Processing and Technology	Course Code	Credits
		AcSIR-39-BS-AD-001	3

Thermal processing of foods:Principle, Classification- Cooking, blanching, pasteurization, sterilization, evaporation, extrusion, drying, Equipments and Applications; Separations and concentration methods in food processing: General Principle and application- Evaporation, Membrane processing, Reverse osmosis, Nanofiltration, Ultrafiltration, pervaporation, freeze drying; Extraction- liquid-liquid & solid liquid, Super critical extraction, Osmotic dehydration, Sedimentation, Equipments and Applications; Size reduction and its application in food industry- Size reduction, Size measurement, Dry and wet grinding, Slicers/dicers, Pulpers and granulators, Milling, Size separation; Food emulsions: Basics and examples, Homogenizers and colloid mills- Principles, types and applications; Mixing and kneading - Equipment and applications. Advances in food Processing- Minimal processing, Hurdle technology, High pressure technology, Irradiation, Microwave, Cryogenics, Ohmic heating, Pulsed electric heating, Ultrasound processing, Applications; Basic packaging machinery, Can sealing, Bottle washing, Filing and sealing, Powder fillers Liquid fillers, Foam – fill and seal systems; Sterilization techniques. Food safety regulations; Functional food and nutraceuticals –Development, potential role in human health, validation and regulations, bioactives and health, Oriental traditional philosophy and food function, Ayurnutrigenomics: Traditional Knowledge Inspired Approach Toward Personalized Nutrition Irradiation, Microwave, Cryogenics, Ohmic heating, Pulsed electric heating, Ultrasound processing, Applications; Basic packaging machinery, Can sealing, Bottle washing, Filing and sealing, Powder fillers Liquid fillers, Foam – fill and seal systems; Sterilization techniques. Food safety regulations; Functional food and nutraceuticals –Development, potential role in human health, validation and regulations, bioactives and health, Oriental traditional philosophy and food function, Ayurnutrigenomics: Traditional Knowledge Inspired Approach Toward Personalized Nutrition.

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AcSIR Academic Centre Code: 39

CSIR-National Institute for Interdisciplinary Science and Technology | CSIR-NIIST

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Bioprocesses Fermentation and Environmental Biotechnology	AcSIR-39-BS-AD-002	3

Introduction to Bioprocess Technology: - Microbial metabolites -an overview (primary & secondary). Factors affecting growth and metabolite production, raw materials and media formulation, microbial growth kinetics, sterilization, death kinetics. Types of fermentation (Submerged & Solid state). Process design for fermentative production of metabolites, Design of experiments (DOE) concepts in bioprocess optimization- Fractional Factorial and RSM Methods and Data analyses using software. Transport phenomena in bioprocess: Mass transfer, Oxygen transfer, Heat transfer -mechanisms of heat transfer, concepts of mass transfer, oxygen transfer rate Measurement of KLa, specific oxygen uptake rate. Engineering aspects in bioreactor designing: Concepts of fluid flow, Impellers, flow patterns, mixing mechanism and scale up of mixing mechanism. Concepts and considerations in process scale up and scale down. Bioreactors: Introduction, Bioreactor configurations, sterile operations, Batch, Fed Batch and Continuous modes, defining yields and productivities, Fermentation kinetics, Bioreactor for submerged and solid state fermentations. (STRs, Fluidized bed, packed columns, airlift etc). Bioprocess Control: Online measurements and PID controls, monitoring and analyses of variables. Downstream Processing: Unit operations in downstream processing - chromatographic techniques, dialysis, reverse osmosis, ultra filtration, electrophoresis, electro dialysis, crystallizations, Concentration, filtration, flocculation, precipitation, drying, monitoring of downstream processing and process integration. Industrial Microbiology: Characteristics of industrial microorganisms, industrial applications of microbial biotechnology (production of ethanol, enzymes, antibiotics, amino acids, organic acids, Biofertilizers, Biopesticides). Industrial Strain improvement, classical mutations, protoplasmic fusion, auxotrophic mutants, role of metabolic engineering in industrial biotechnology. Biological waste (solid/liquid/air) treatment systems; Anaerobic digestion, Aerobic composting, activated sludge process, MBBR, SBR, MBR, UASB, Onsite wastewater treatment systems, Eco engineering systems/Constructed wet lands, Gas biofilter.

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AcSIR Academic Centre Code: 39

CSIR-National Institute for Interdisciplinary Science and Technology CSIR-NIIST

Course 3 : Advanced Course | Biological Sciences | Total Credits 6

Title:	Course Code	Credits
Disease Biology	AcSIR-39-BS-AD-003	3

General Introduction: Disease causes and body's mechanism to prevent it (General Immunity). Oxidative Stress and Inflammation: Oxidants and antioxidants in biology and medicine, Methods of measurements of oxidative stress and total antioxidant capacity, Antioxidants and immune system, Redox reactions and signal transduction in disease conditions, Dietary antioxidants, Oxidative stress/antioxidants and metabolic syndrome. Inflammation-etiology and types, acute, subacute and chronic, Immune system, cell types and their contribution to inflammation, health benefits and health disadvantages of inflammation, inflammatory cytokines, signal transduction and receptors involved, nutrition and inflammation, anti-inflammatory diets and phytopharmaceuticals. Diabetes: Introduction to Diabetes Mellitus. Preclinical and Clinical Methods for Evaluating Antidiabetic Activity of Plants, in vitro Models for Assessing Antidiabetic Activity. Plant metabolites and other Antioxidant Polyphenols in alleviating diabetic complications. Insulin Secretion in Type II Diabetes, cellular effects of insulin, insulin signaling pathways, regulation mechanisms. Cellular Effects of Elevated Glucose Concentrations, regulation by Insulin and an Insulinomimetic Approach to Lowering Blood Glucose Levels, Insulin resistance, its importance in diabetes and tissues affected, Obesity and its link to diabetes. Metabolic Aspects of Glycogen Synthase Activation and its role in the pathogenesis of Insulin Resistance and Hypoglycemia,' Role of Oxidative stress, ER stress, AGE, Inflammation etc in the pathogenesis of diabetes and its complications. Mechanisms of Diabetic Complications. Drugs currently used in the treatment of Diabetes its proposed mechanism of action and reported side effects, therapeutic potential of recombinant gene transfer studies Cancer: General introduction-types, causes, staging and treatment methodologies. Immunity and cancer, dysregulation, mechanism, immunesuppression, immune tolerance, immune and cancer cell interactions, immunotherapy. Cancer stem cells, origin, hypothesis, concept, signaling pathways. Cancer chemotherapy, types of cell death-apoptosis and necrosis, targeted therapy, cell signaling pathways, chemotherapy drug targets, Cancer biomarkers and diagnosis, Cancer drug discovery, phytopharmaceuticals as anticancer molecules, identification of lead molecules, target identification in cancer cells, combined approaches (in vitro, in vivo and in silico). Cancer metastasis- primary and secondary tumor, angiogenesis, epithelial to mesenchymal transition, anoikis, Epigenetics and cancer Acetylation/methylation in DNA and histones, Metagenomics and cancer, Diet and cancer. Cardiovascular Diseases: General background of heart: anatomy; structure and function, Cardiac metabolism in health and disease, The pathophysiology of cardiac hypertrophy and heart failure, Ischemic heart disease and its consequences, Blood pressure regulation and pathology, Various cardiac drugs and their mode of action, Phytochemicals and metabolic syndromes. NAFLD and Obesity: Cellular and molecular basis of genesis, various types of drugs and their mode of actions, Importance of phospholipid metabolism in NAFLAD.

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AcSIR Academic Centre Code: 39

CSIR-National Institute for Interdisciplinary Science and Technology	CSIR-NIIST

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Molecular Biology of Industrial Organisms	Course Code	Credits
		AcSIR-39-BS-AD-004	3

Advanced molecular tools used to characterize and identify bacterial species. Molecular tools used to characterize microbial communities; bacterial whole genome analysis, metagenome assembled genomes, metagenome libraries for functional screening, environmental shot gun sequencing and meta-omics for understanding the ecological functions of microbes. Translation: Genetic Code, Ribosome Structure, tRNAs, Aminoacyl tRNA synthetase, Initiation, Elongation, Termination; Translational Control. Protein Structure – Primary, Secondary, tertiary and Quaternary structure, Ramachandran Plot, basics of protein sequence analyses and structure prediction. Software for molecular visualization and structure studies/representation. Structure-function relations and their implications is Industrial biotechnology. PCR, RTPCR, Primer/Degenerate Primer design, Various Blottings, 2DGE, siRNA techniques, CRISPR -Cas 9, Gene expression analyses and interpretations. Gene Cloning -prokaryotic and eukaryotic, cloning strategies –shot gun cloning, PCR cloning, cDNA cloning. Cloning Vectors-plasmids, viral vectors, cosmids, fosmids, BAC vectors, YAC vectors, shuttle vectors and expression vectors. Common host organisms and tools used for genetic engineering Concept of metabolic engineering Genomics -Functional and comparative, Applications of genomics. Defining a strain, Ideal characteristics of strain, different strain improvement Techniques-Mutation, Recombination, r-DNA technologies and its applications for industrially relevant microbes. Regulation of Gene Expression: Prokaryotes: Operon Concept, Positive and Negative Regulation, Catabolite Repression, Riboswitches. DNA Replication: Prokaryotic DNA Polymerase I, II and III, Eukaryotic DNA Polymerases, Fidelity and Catalytic Efficiency of DNA Polymerases, Okazaki Fragments, Replication Origin, Primosomes, Concurrent Replication Mechanism Involving Leading and Lagging Strands of DNA; Problems associated with linear replicons. Mutations and Repair.

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AcSIR Academic Centre Code: 39

CSIR-National Institute for Interdisciplinary Science and Technology	**CSIR-NIIST**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Advanced Organic Chemistry	**AcSIR-39-CS-AD-001**	**3**

Organic reaction mechanism with advanced and classic examples related to electrophilic, nucleophilic substitutions, radical reactions, molecular rearrangements, reaction kinetics. Recent advancements in oxidation and reduction reactions reagents (Chromium, hyper-valent iodine, peroxides, molecular oxygen etc.) Named reactions in heterocyclic chemistry emphasizing aliphatic and aromatic heterocycles. Advances in metal catalysed carbon-carbon, Carbon-heteroatom bond formation reactions, and organo-catalytic reactions Medicinal chemistry of heterocycles: structure and ligand based approaches, Molecular modifications (prodrug approach, Molecular hybridization and bioisosterism approach). Overview of natural product chemistry. Pharmaceuticals: Recent developments and scope of bioactive drugs obtained from medicinal plants. Drug receptor interactions: Basic concepts of drug design (occupancy, rate and induced fit theory), Pharmacokinetics and molecular docking studies. Recent advancement in asymmetric synthesis.Total synthesis: Emphasis on retrosynthetic analysis of selected complex natural products. Synthetic carbohydrate chemistry-Glycosilation methods, synthesis and properties of glycoconjugates. Structural aspects of carbohydrates in cell-surface recognition and cell-biology. Polymorphism in organic chemistry. Molecular Modelling.

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AcSIR Academic Centre Code: 39

CSIR-National Institute for Interdisciplinary Science and Technology **CSIR-NIIST**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Advanced Photochemistry, Photophysics and Instrumentation	**AcSIR-39-CS-AD-002**	**3**

Introduction to photochemistry/photophysics, state energy diagrams, Schrödinger equation, Born-Oppenheimer approximation, electronic, vibrational & spin configurations of electronically excited states, Franck-Condon principle, radiative and non-radiative transitions, excited state processes, computational approaches to study ground and excited state properties, computation of HOMO-LUMO energies and various transition. Fluorescence and phosphorescence, quantum yields; quenching and sensitization, charge-transfer, solvatochromism, fluorescence polarization, excimers, exciplexes, delayed fluorescence. Excited state dynamics, transient absorption techniques, time-resolved emission techniques, two- and multi-photon processes. Photoinduced energy and electron transfer, FRET, applications of PET and FRET, photosynthesis. Photochemical reactions; photochemical reaction mechanisms and reaction intermediates, photochromism, photocatalysis. Photochemistry of organic chromophores, photochemistry in organized and confined media, photo-responsive materials and applications; vision, supramolecular photochemistry & photophysics. Advanced Spectroscopic techniques (UV, Fluorescence, FT-IR, Raman), photophysics and applications such as imaging, optical sensors, solar energy harvesting, OLED, photodynamic therapy, phtothermal therapy, photofabrication, optoelectronics, spectroelectrochemistry etc. Inorganic photochemistry, electronic spectra of transition metal complexes, photochemistry and photophysics of lanthanide compounds

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AcSIR Academic Centre Code: 39

CSIR-National Institute for Interdisciplinary Science and Technology CSIR-NIIST

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Advanced Materials Characterisation for Engineers	Course Code	Credits
		AcSIR-39-ES-AD-001	3

Microscopy: Optical microscopy (Bright field, Dark field, Phase contrast, differential interference contrast, polarized light, fluorescence and confocal imaging), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Tunneling Microscopy (STM), Atomic Force microscope (AFM), Energy Dispersive Spectrometry (EDS), Auger Electron Spectroscopy X-Ray Techniques: X-Ray Powder Diffraction (XRD), Single-Crystal X-Ray Structure Determination, X-Ray Fluorescence(XRF), and X-Ray Photoelectron Spectroscopy (XPS) Thermal Analysis: Introduction, Thermogravimetric Analysis (TG), Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC);

Spectroscopy: Basic principles, Instrumentation and Applications of Ultraviolet and Visible Absorption, Spectroscopy (UV-Vis), Fourier Transform Infrared Spectroscopy (FT-IR), NMR and Raman Spectroscopy, Physical and Mechanical Testing: Particle size analysis, BET analysis, porosimetry, pyconometry, density

measurements; Tension, Compression, Hardness, Impact toughness, fracture toughness, ,fatigue, creep, wear.

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CSIR-National Institute for Interdisciplinary Science and Technology	CSIR-NIIST

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Materials Processing for Engineers	AcSIR-39-ES-AD-002	3

Ceramic processing -Consolidation of ceramic powders, mechanical compaction, powder packing, uniaxial pressing, isostatic pressing, hot pressing, hot isostatic pressing, Slurry processing, slip casting, tape casting, pressure casting, gel casting, plastic forming, extrusion, injection moulding. Rapid prototyping, electrophoretic casting, electro-spinning. Green strength, drying, binder burnout, green machining, sintering. Sol-gel processing, Thermal and plasma spraying, Thick and thin film coatings PVD and CVD techniques,Vapor infiltration techniques.

Metals processing: Metal Casting - sand, permanent, pressure, centrifugal and investment processes, Deformation processing - stress during various metal working operations, friction and its role in bulkmetal forming operations, microstructural evolution during deformation processing, superplastic forming; Sheet metal forming, ehancement of sheet metal formability; Fundamentals of powder processing of metals, solid and liquid state sintering, driving force and mechanism of sintering, Polymer Processing: Compounding of plastics and rubbers, fabricating processes like compression,transfer, injection and blow moulding, extrusion, calendaring, thermoforming, roto molding, casting, sintering and compaction, dip coating, RTM, RIM, RRIM, post forming and finishing operations.

Composite Processing - Hand lay-up, Filament Winding, Pultrusion, Resin Transfer Molding, Processing, Science of Reactive Polymer composites - Process steps for production, Selection of processing, conditions Toolings, and equipments, Carbon- Carbon Composites -Processing, thermal and mechanical properties, Quality control

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Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Chemical and Food Process Engineering	AcSIR-39-ES-AD-003	3

Basic concepts of chemical engineering, Basic Process Calculations, Molality, Molarity and Normality Basics, Reaction Kinetics, Order and Molccularity, basic modes of heat transfer.
Thermal processing of foods: Principle, Classification- Cooking, blanching, pasteurization, sterilization, evaporation, extrusion, drying, Equipments and Applications; Separations and concentration methods in food processing: General Principle and application Evaporation, Membrane processing, Reverse osmosis, Nanofiltration, Ultrafiltration, pervaporation, freeze drying; Extraction- liquid-liquid & solid liquid, Super critical extraction, Osmotic dehydration, Sedimentation. Equipments and Applications; Non-thermal processing of food products - ozonation, UV radiation, Ultra-sonic treatment, Ohmic and pulsed electric field techniques and high pressure technology.
Size reduction operations in food processing: Introduction to Size Reduction Equipment, size measurement, Size separation, Energy and Power Requirement, Crushers, Dry and wet grinding, Slicers/dicers, Pulpers and granulators, Milling operations, Ball mills working principle and operations, Critical Speed calculations, Screening Equipment and problems. Food emulsions: Basics and examples, Homogenizers and colloid mills- Principles, types and applications; Mixing and kneading - Equipment and applications
Separation techniques in food processing: Filtration principles and problems, Evaporation and its problems, Membrane Separation Techniques, Sedimentation, Clarification Operations, Super-critical extraction, Separation Techniques pertaining to various Industries. Minimal processing, Hurdle technology, High pressure technology, Irradiation, Microwave, Cryogenics, Ohmic heating, Pulsed electric heating, Ultrasound processing, Applications; Basic packaging machinery, Can sealing, Bottle washing, Filing and sealing, Powder fillers Liquid fillers, Foam fill and seal systems; Sterilization techniques.
Numerical problems: Problems on drying kinetics, evaporation, mass and energy balances, microbial count, exponential relations, plant layouts, heat transfer problems.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 39

CSIR-National Institute for Interdisciplinary Science and Technology — CSIR-NIIST

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Advanced Materials Characterisation	AcSIR-39-PS-AD-001	3

Advanced microscopy: Optical microscopy - Fundamentals of optics, Optical aberrations, Telescopes, Microscopes and the Eye. Numerical aperture, Depth of focus, Contrast mechanisms, Bright field, Dark field, D1C, Phase contrast, Staining role of illumination, Variants in the optical microscopes and image formation.
SEM/FESEM: Basic theory of electron microscopy. Electron microscope, Imaging system, Scanning electron microscope. Field emission SEM, Principle, Components, Working procedure, Microstructural analysis, Energy dispersive X ray analysis, Principle, components, working procedure, Elemental compositional analysis .
Transmission electron microscopy: Basic electron scattering, Concepts of resolution, Aberration, electron sources, Beam-specimen interaction, Diffraction basics, Ewald sphere / reciprocal lattice, Multi-beam / kinematical scattering, TEM imaging modes, Bright field, Dark field, STEM, F1AADF, HRTEM, Interpretation of SAED patterns, Analysis of micrographs, Energy dispersive spectroscopy (EDX).
STM/AFM: Introduction to scanning tunneling microscopy, Theory of tunneling, Instrumentation of AFM, Imaging modes-contact, Non-contact, Intermittent contact, Lateral force imaging, Image processing and analysis, Recognition and avoidance of image artifacts, MFM and PFM, Applications. New developments in advanced microscopy techniques.
X-Ray Techniques, X-Ray diffraction, Generation of X-Rays, Continuous radiation, Characteristics radiation, Short wavelength limit (1SWL), Moseley's law, Mechanisms of X-Ray absorption (filtering), Filters for monochromatic X-rays, Bragg's law of X-ray diffraction, Peak broadening, Instrumental broadening, Particle size broadening, Nanoparticle size determination, Structure factor calculations (SC, BCC (or Orthorhombic), FCC, NaCl (AxBx), AuCu3 (AxBy) order-disorder transformation)
2D XRD: X-ray scattering from an atom and molecule, Debye formula for scattering profile, pherical harmonics, Guiniers law in SAXS, Porod's law in SAXS, SAXS intensity from scattered patterns.
X-Ray Photoelectron Spectroscopy: Importance of surface characterization techniques, physical principles of XPS, Photoelectric effects, XPS patterns, spin orbital splitting, quantitative analysis, chemical effect, chemical shift, XPS imaging, Auger electron generation, chemical effect, quantitative analysis, depth profiling, applications of XPS.
Thermal Characterization: Importance of thermal characterization, Thermogravimetric analysis (TO), Differential thermal analysis (DTA), Differential scanning calorimetry (DSC) and advanced elemental analysis, ICPMS.
Spectroscopy: Ultraviolet and visible spectroscopy, Electronic transitions, Radiative processes, Energy diagram, Iintersection, Frank Condon principle, Kasha's rule, Fexperiments, Quenching, Lifetime and quantum yield, Fluorescence anisotropy, Steady-state and time resolved Infrared spectroscopy, Raman spectroscopy vs resonance-enhanced Raman spectroscopy, Mass spectrometry, NMR spectroscopy, Application of spectroscopy in chemistry, materials science, physics and biology.

Physical testing: Particle size analysis, Absorption, molecular interactions in adsorption, Energetic and desorption, Physical and chemical adsorption, Adsorption isotherms (Freundlich, Langmuir, BET), Determination of surface area of adsorbent, Application of adsorption, Porosimetry, Pyconometry, Density measurements.
Dielectric characterization: Dielectric constant and polarizability, Internal electric field in a dielectric, Dielectric in an ac field, Types and models of ferroelectric transition, Microwave techniques, Piezoelectric and pyroelectric materials, Electrical measurements (2 probe and 4 probe), I-V analysis, Measurements, Microwave measurements, Solid state impedance spectroscopy, Ferroelectric and piezoelectric measurements, Impedance spectroscopy of soft materials (ferroelectric liquid crystals), Dielectric relaxation models, Electro-optical characterization techniques.
Mechanical characterization: Introduction to strength of materials, Generalized Hooke's law, Lame's constant, Elastic modulus, Bulk modulus, Bending of beams, Fiexural strength, Torsional moment, Applications to real world problems, Tension. Compression, Hardness, Impact toughness, Fracture toughness, Creep and Tribology.

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AcSIR Academic Centre Code: 39	
CSIR-National Institute for Interdisciplinary Science and Technology	CSIR-NIIST

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Advanced Materials Processing	Course Code	Credits
		AcSIR-39-PS-AD-002	3

Fundamental aspects of processing, testing, and phase transformations in materials, Introduction to thermodynamics and kinetics, Basic crystallography, Phase equilibria, Phase diagrams, Thermodynamics of transformations, Ellingham diagram, Free-energy vs composition curves in relation to phase diagrams, Theory of nucleation and growth kinetics, Diffusion in metals and materials, Precipitation hardening, Stress and size induced phase transformations, Shape memory effect, Linear-elastic fracture mechanics, Fatigue, Creep, Superplasticity.

Metal Processing (ferrous and non-ferrous metallurgy and surface engineering): Advanced mineral processing techniques, Extractive metallurgy, Titanium based materials and its applications, Rare earth metals and its applications, Waste recycling techniques, Basics of modelling and simulation for mineral beneficiation, Plasma metallurgy for special applications. Microstructural evolution, Solidification, Nucleation and growth kinetics, Induction melting, Zone refining, Czechrolski method, Solidification of metals and alloys, Gating and risering of castings, Metal filtration, Special casting techniques, Fettling and heat-treatment of castings, Casting defects, Joining methods, Development of functional and functionally gradient materials, Cellular structures, Metallic foams, Thin films and coatings.

Ceramics Processing: Concept of mono-dispersed submicron ceramic powder, Solid state reaction, Kinetic and thermodynamic considerations, Powders from chemical solutions, Co-precipitation, Flydrothermal and solvothermal synthesis, Sol-gel techniques, Advanced forming processes, Hot pressing, Isostatic pressing, Tape casting, Gel casting, Chemical vapour deposition, Coating processing, Plasma processing and plasma synthesis, Sintering, Driving force of sintering, Vitreous sintering, Mass transport mechanism during sintering, Sintering models, Homogeneous and heterogeneous nucleation and crystal growth.

Glass: Definition, ion-crystalline solids & glasses, Glass formation from solid, liquid and gaseous phases, Effects of different oxides on glass properties, Quenching synthesis, Refining of glass, Annealing, Thermal treatment, Chemical treatment, Optical fibre glass production & processes. Glass ceramics- fabrication, Advantages of glass ceramic formation, properties and applications.

Polymer processing: Plastic processing, Extrusion, Injection moulding, Blow moulding, Thermoforming,

Polymer synthesis: Condensation polymerization, Addition polymerization (radical polymerization, ionic and coordination polymerization), Copolymerization, Polymerization conditions and polymer reactions, Processing of engineering Thermoplastic and thermoset polymers, Structure-property relationship.

Composite materials processing: Constituents and types of composites, Metal matrix composite, Polymer matrix composites, Ceramic matrix composites, Fiber-reinforced polymers, Molding, Autoclave molding, Bag moulding, Resin transfer moulding, Compression moulding, Casting, Pultrusion, Filament Winding, Smart composites, Functionally graded composites and multimaterials.

Nanomaterials processing: Historical perspective of nanoparticle, Classification of nanomaterials, Nanorods and nanotubes, Synthesis of nanomaterial, Quantum Dots.

Thin films processing: Thin films and their importance, Essential fundamental aspects-thin-film nucleation, Growth process, Sticking coefficients, Surface bombardment rate, Thin film growth models- Adsorption, Thermal accommodation, Van der Waals forces, Lifetime of adsorbed species, Surface diffusion, Chemisorptions, Film growth modes: Capillary theory of nucleation and growth, Coalescence processes, Defects formation in thin films, Effect of stress, Epitaxy, Environment for film growth, Vacuum requirements for film growth, Relationships between deposition parameters and film properties. Thin film techniques: Thermal evaporation, Spin-coating, Sputtering, Chemical Vapour deposition, Electro vapour deposition, Ion beam sputtering, Pulsed laser ablation, Molecular beam epitaxy.

Advanced materials synthesis: Solid freeform fabrication, Thick films and thin films, Screen printing, Inkjet printing, Sputter coating DC and RF sputtering, Chemical vapour deposition of ceramics, Electro vapour deposition, Ceramic membrane processing, Templated synthesis of nanostructures, Nanofabrication, Lithography, Pattern transfer, Layer-by-layer self-assembly, Nano-contact printing and writing.

Soft material and device fabrication: Importance of soft materials, Structure and classification of mesophases, Symmetry and order parameter, Phase identification, Dielectric and electro-optical properties of liquid crystals (LC), Ferroelectric LC, LC based device fabrication, Testing of LC material properties, Elucidating dielectric and electro-optical parameters, Applications of FLC.

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41 CSIR-SERC | 3 *Advanced Course*

Faculty of Study	Course Code	Course Title
Engineering Sciences	AcSIR-41-ES-AD-001	Advanced Engineering Mathematics
Engineering Sciences	AcSIR-41-ES-AD-002	Advanced Fatigue & Fracture of Engineering Structures
Engineering Sciences	AcSIR-41-ES-AD-003	Computational Fluid Dynamics
Engineering Sciences	AcSIR-41-ES-AD-004	Finite Element Technology –II
Engineering Sciences	AcSIR-41-ES-AD-005	Mechanics of Wave Propagation
Engineering Sciences	AcSIR-41-ES-AD-006	Multi-Scale Modelling of Structures
Engineering Sciences	AcSIR-41-ES-AD-007	Stochastic Mechanics
Engineering Sciences	AcSIR-41-ES-AD-008	Uncertainty Handling in Engineering Decision Making

AcSIR Academic Centre Code: 41

CSIR-Structural Engineering Research Centre	**CSIR-SERC**

Course 3 : Advanced Course	**Engineering Sciences**	**Total Credits 6**

Title:	**Course Code**	**Credits**
Advanced Engineering Mathematics	**AcSIR-41-ES-AD-001**	**3**

Ordinary Differential Equations of the First Order , Ordinary Linear Differential Equation, Laplace Transformation, Line and Surface Integrals. Integral Theorems, Matrices and Determinants (Systems of Linear Equations), Fourier Series and Integrals, Partial Differential Equations, Sequences and Series, Taylor and Laurent Series, Special Functions. Asymptotic Expansions.

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AcSIR Academic Centre Code: 41

CSIR-Structural Engineering Research Centre CSIR-SERC

Course 3 : Advanced Course | Engineering Sciences | Total Credits 6

Title:	Course Code	Credits
Advanced Fatigue & Fracture of Engineering Structures	AcSIR-41-ES-AD-002	3

Introduction to deformation behavior: Concept of stresses and strains, engineering stresses and strains, Different types of loading and temperature encountered in applications, Tensile Test - stress - strain response for metal, ceramic and polymer, elastic region, yield point, plastic deformation, necking and fracture, Bonding and Material Behaviour, theoretical estimates of yield strength in metals and ceramics; Yielding and Plastic Deformation: Hydrostatic and Deviatoric stress, Octahedral stress, yield criteria and yield surface, texture and distortion of yield surface, Limitation of engineering strain at large deformation, true stress and true strain, effective stress, effective strain, flow rules, strain hardening, Ramberg-Osgood equation, stress - strain relation in plasticity, plastic deformation of metals and polymers; Deformation under cyclic load – Fatigue: S-N curves, Low and high cycle fatigue, Life cycle prediction, Fatigue in metals, Notch effects, residual stress effects, fatigue under variable amplitude loading; Crack-tip Stress and Displacement Field Equations:Airy's Stress Function for Mode-I, Westergaard Solution of Stress Field for Mode-I, Displacement Field for Mode-I, Relation between KI and GI, Stress Field in Mode-II, Generalised Westergaard Approach, William's Eigen Function Approach, Multi-parameter Stress Field Equations, Validation of Multi-parameter Field Equations; Experimental Techniques: Fractrographic studies, Using special gauges, Photo Elasticity, Acoustic Emission techniques, Compliance Measurements , ACPD technique, Digital Image correlation.

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AcSIR Academic Centre Code: 41		
CSIR-Structural Engineering Research Centre		CSIR-SERC
Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title: Computational Fluid Dynamics	Course Code	Credits
	AcSIR-41-ES-AD-003	3

Introduction: Conservation of mass, momentum and energy equations, Convective forms of the equations; Differential Equations: Parabolic, elliptic and hyperbolic equations, Boundary and initial conditions, Over view of numerical methods; Finite Difference Technique: Taylor series expansion, Integration over element, Local function method, Treatment of boundary conditions, Boundary layer treatment, Convergence criteria; Finite Volume Technique: Types of finite volume grids, Approximation of surface and volume integrals, Interpolation methods - central, upwind and hybrid formulations, Convection-diffusion problem; Methods of Solution: Iterative methods, Matrix inversion methods, ADI method; Time Integration Methods: Single and multilevel methods, Predictor corrector methods, Stability analysis, Applications to transient conduction and advection-diffusion problems; Numerical Grid Generation: Basics, Transformation and mapping; Navier-Stokes Equations: Explicit and implicit methods, SIMPLE based methods, Fractional step methods; Turbulence modeling: Direct Numerical Simulation (DNS), Large Eddy Simulation(LES) and Reynolds-Averaged Navier-Stokes equations (RANS).

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AcSIR Academic Centre Code: 41

CSIR-Structural Engineering Research Centre **CSIR-SERC**

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Finite Element Technology –II	**AcSIR-41-ES-AD-004**	**3**

Adaptive refinement techniques: Introduction, definition of errors, various basic error estimators for linear static and dynamic analysis, superconvergence and optimal sampling points, superconvergent patch recovery. Finite element procedures for fracture Mechanics problems, introduction, various implementation techniques.

Nonlinear finite element analysis: Introduction, Advantages of linear analysis,necessity of nolinear analysis, Consequences of nonlinear analysis, examples of nonlinear stress analysis, components of nonlinear computational model, classification of sources of nonlinearity, geometric and material nonlinear analysis, brief introduction to different types of formulations for geometric nonlinear analysis.

Geometrical nonlinear analysis: total Lagrangian and updated Lagrangian formulations for discrete elements and computer implementation, different strain measures, Brief review of continuum mechanics, geometrical nonlinear formulations and computer implementation for continuum elements.

Basic plasticity: Introduction, one-dimensional elastic-Plastic analysis, Small strain plasticity relations, Elastic-Plastic analysis procedures, computer implementation.

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AcSIR Academic Centre Code: 41

CSIR-Structural Engineering Research Centre | CSIR-SERC

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Mechanics of Wave Propagation	AcSIR-41-ES-AD-005	3

Spectral Analysis and Frequency domain dynamic analysis: Introduction to frequency domain dynamic analysis, Pros and cons over time domain analysis, DFT, FFT, spectral analysis of wave motions, propagation and re-construction of waves, Group velocity, phase velocity. Uniform and Dispersive waves, Geometric damping for infinite elastic continua;Spectral finite elements: Simple axial rod, Euler Bernoulli beam, Timoshenko beam, Approximations due to various mass formulations in combination of static stiffness;Longitudinal wave propagation through rods: Rod theory, De-Alembert's solution, Dissipation in rods, throw-off elements, reflections and transmissions, Pile integrity testing;Flexural wave propagation: Euler-Bernoulli beam theory, reflections of flexural waves from discrete masses and abrupt change in impedance, Impedance matching and mis-matching, non-destructive testing and inverse problems in wave propagation;Theory of Lamb waves: Lamb wave propagation, symmetric and un-symmetric modes and lamb wave propagation through composites; Acoustics: Introduction to wave propagation through fluid medium, Doppler effect, wave propagation under sonic, ultra-sonic ranges and EM waves;Seismic wave propagation: P and S waves, Surface waves, Rayleigh and Love waves, Hydrodynamic wave propagation, Tsunamis and Sieches (In-land water waves).

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AcSIR Academic Centre Code: 41

CSIR-Structural Engineering Research Centre CSIR-SERC

Course 3 : Advanced Course Engineering Sciences Total Credits 6

Title:	Course Code	Credits
Multi-Scale Modelling of Structures	AcSIR-41-ES-AD-006	3

Introduction to multiscale modelling and analysis:Computational modelling; Multiscale nature of materials; Importance of multiscale modelling; Identification of scales; Macro, meso, micro and nano scales - overview; Engineering Mechanics Principles; fundamentals of thermodynamics; Mechanics of materials; Micromechanics; Quantum mechanics; Essential continuum mechanics. Nano scale mechanics: Nanostructure; Mechanical Forces and Potential Energy, Nano computational Methods: Ab-initio simulations; Molecular Mechanics;

Energy minimization methods, Molecular Forces, Interatomic force and Potential function, Pseudo-potentials, Molecular Dynamics; Monte Carlo simulations; Nano structure of cementitious composites; CSH development; Nano experimentation. Micro and meso scale modelling and analysis: Microstructure features; particle based model; particle kinetics; hydration kinetics; phase reactions; particle expansion mechanism; Microstructural analysis; Lattice model principles and mechanics; implementation of heterogeneity; generation of uniform and random lattice structures; 2D and 3D lattice structure; generation of particle structure; fracture mechanics concepts; Concrete deterioration and fracture simulation; Hydration process of cement. Macro scale response: Features of macroscale; Mechanics of structures; Material models; FEM concepts; mechanical properties; cracking mechanism; prediction of cracks; modelling of concrete. Bridging techniques: Systematic upscaling: coarsening; Homogenization methods; Representative Volume Elements; Volume Averaging; Quasi-Continuum Method, Transport of parameters; Information exchange; Concurrent and sequential multiscale models; Application to response of brittle material to performance of structure; Bottom-up and top-down approaches

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AcSIR Academic Centre Code: 41

CSIR-Structural Engineering Research Centre	CSIR-SERC

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:		Course Code	Credits
	Stochastic Mechanics	AcSIR-41-ES-AD-007	3

Introduction. Basic probability theory. Brownian motion and white noise. Stochastic Integrals, Ito's formula. Stochastic differential equations (SDE). Diffusion Processes. Stochastic stability. Introduction to numerical solution of SDE. Applications.

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AcSIR Academic Centre Code: 41

CSIR-Structural Engineering Research Centre	CSIR-SERC

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title: Uncertainty Handling in Engineering Decision Making	Course Code	Credits
	AcSIR-41-ES-AD-008	3

Introduction: Basic Definitions; Examples; Different types of uncertainties; Exposure to formal frameworks for handling uncertainties; Application of Probability and Statistics in engineering decision making: Basic definitions of probability; random variables; Setting-up of framework for engineering decision making in the probabilistic/random environment; Statistical analysis of engineering data; Statistical decision making; Application of stochastic processes for engineering decision making : Basic definition of stochastic process; Some commonly used stochastic processes; Learning models for engineering decision making – learning in both stationary and non-stationary environment; Application of fuzzy sets in engineering decision making :Basic definition of fuzzy sets; Some commonly used fuzzy sets; Use of fuzzy stochastic models for engineering decision making; Handling of uncertainties using possibility and plausibility theories ; Introduction to application of game-theoretic approaches for engineering designs

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Faculty of Study	Course Code	Course Title
Mathematical & Information	AcSIR-42-MIS-AD-001	Science, Technology & Innovation Governance
Mathematical & Information	AcSIR-42-MIS-AD-002	Popular Science Writing
Mathematical & Information	AcSIR-42-MIS-AD-003	Science Communication
Mathematical & Information	AcSIR-42-MIS-AD-004	Communicating Science through Social Media
Mathematical & Information	AcSIR-42-MIS-AD-005	Science Journalism
Mathematical & Information	AcSIR-42-MIS-AD-006	Audio Visual Media and Science Film Production
Mathematical & Information	AcSIR-42-MIS-AD-007	Research Communication

CSIR-National Institute of Science Communication and Information	CSIR-NISCAIR

Course 3 : Advanced Course	Mathematical & Information Sciences	Total Credits 6

Title:	Course Code	Credits
Science, Technology & Innovation Governance	AcSIR-42-MIS-AD-001	2

Introduction, STI ecosystem, Governance of Knowledge, Research, Research Data, Technology, and Innovation, Indian STI/ R&D funding and financing mechanism, Indian S&T funding agencies/ schemes Institutional mechanism for S&T/R&D funding pattern and output- outcome analysis.

Introduction to Statistical Research Methods R&D Statistics & Indicators, Evaluation of research productivity, Ethics in STI. National S&T Policy, Regulatory frameworks, A global comparison of R&D intensity and output performance.

Science diplomacy, Industrial R&D system, S&T Entrepreneurships & Start-ups, Grassroots Innovation, High-tech innovation, STI and Sustainable Development Goals, State S & T Councils, Science academies

Science Policy Making and Policy Analysis, STI Policy: Perspectives, Methods and Skills for STI Studies; Public Perceptions of Science and Technology, Public Engagement in the Governance of Science

and Technology, Science and Technology for Socio -economic development

Managing Intellectual Property, Economics of Innovation, Strategies in STI management, Measurement of STI, Foresight and Strategic Planning, Infrastructure.

References:

1. Gustavo Crespi and Gabriela Dutrénit, Science, Technology and Innovation Policies for Development, Springer, 2014.
2. C.A. Tisdell, Science and Technology Policy: Priorities of Governments, Springer, 1981.
3. Pawan Sikka, Science Policy: New Strategies for India’s Modernization, Uppal Publishing House, 2008.
4. A FRAMEWORK for Science, Technology and Innovation Policy Reviews, United Nations Conference on Trade and Development, United Nations, 2019.
5. The Role of Science, technology and Innovation policies to Foster the implementation of the Sustainable Development Goals, Europian Commission, Editors: Enrico Giovannini, Ingeborg Niestory, Mans Nilsson, Francoise Roure and Michel Spanos, 2015.

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AcSIR Academic Centre Code: 42	
CSIR-National Institute of Science Communication and Information	**CSIR-NISCAIR**

Course 3 : Advanced Course	Mathematical & Information Sciences	Total Credits 6

Title:	**Popular Science Writing**	Course Code	Credits
		AcSIR-42-MIS-AD-002	**3**

Needs and objectives of popular science writing (PSW), Writing skill essentials: Grammar, Vocabulary, Structuring, Use of Tables and figures, Role of scientific and technical terminology in PSW, Characteristics of PSW, Making of a popular science write-up, Formats of PSW for various communication media (PRINT: Science News, feature, Article, Science Fiction, Science Poetry, interview etc.

Electronic/digital: Documentary, Short film, Phone-in, Radio feature, Radio/TV interview etc.

Social media: Blog/Facebook posts, Instagram stories, Podcast, AV programme, Storytel etc.)

Tips, limitations, challenges & precautions in PSW, Ethics in PSW, How to conduct an interview and its ground-work, Scope and career in PSW.

Famous popular science writers, Popular Science Magazines, channels, etc.

References:

1. D. Blum, M. Knudson and R. M. Henig, A Field Guide for Science Writers: The Official Guide of the National Association of Science Writers, OUP USA, 2005.
2. Richard Dawkins, The Oxford Book of Modern Science Writing, Oxford University Press, 2008.
3. N. P. Choubey & Sushma, Science Communication, Peoples Council of Education, 2009.
4. H. J. Khan, Gauhar Raza, Surjit Singh & S. Mahanti (Editors), Quest for Scientific temper, CSIR-NISCAIR, 2012
5. Manoj Patairiya, Vigyan Sanchar, Takshashila Prakashan, 2001.
6. R. D. Sharma, Vigyan aur Krishi Patrakarita, Vigyan Prasar, 2012.

AcSIR Academic Centre Code: 42

CSIR-National Institute of Science Communication and Information	CSIR-NISCAIR

Course 3 : Advanced Course	Mathematical & Information Sciences	Total Credits 6

Title:	Science Communication	Course Code	Credits
		AcSIR-42-MIS-AD-003	3

Science & History & development of Science, Science and History of Science in India, Modern Science and the Scientific Method, A discussion on hypothesis, experimentation, criteria for experimentation, theorizing, and the open-ended nature of the scientific quest, Science in other Cultures, Interdependence of Science and Technology, Science and the Public, Discussion on the need for an informed public in a democracy about S&T, Science policy and research funding, S&T and development, Technology Communication: Concept, history, need and objectives.

Science Communication: History of Science communication, Science communication in India: past and present scenario, Science Organizations, Fundamentals of Science communication, How to Communicate Science: Thumb rules (Framework as per medium and format, authentic science, science should not be diluted, balance between science and communication components, reference within the text, minimal use of technical jargon, interesting & easy to understand language, attractive title, analogy from daily life for explanation etc.)

Entrepreneurship in Science communication, Role of communication in science, Importance of IT in communication, Introduction to popular science communication in the broader contexts of (a) the role of communication in science, and (b) the cultural, practical and policy related role of science communication in wider society, Providing intellectual resources for constructive critical analysis of popular science communication in a variety of real-world settings, Cultivation of practical communication skills, with particular emphasis on effective speaking, writing and exhibiting on scientific and science-related topics to a variety of audiences, Providing students with a range of resources and skills for effective communication of complex

material, along with the opportunity to undertake a substantial practical project in either science writing or science exhibiting. Science outreach.

Introduction to Education and Public Outreach (EPO or E/PO), basic guidelines of EPO, importance of publication in EPO, connecting to the public via publications, seminars, discussions, lectures etc, organizing workshop for teachers and students.

Communicating science to differently abled (speech, sign language, writing (print or braille), picture communication systems, and tactile communication systems).

References:

1. J. V. Vilanilam, Science Communication and Development, SAGE Publications Pvt. Ltd., 1993.
2. Grant Allen and Sam Illingworth, Effective Science Communication: A Practical Guide to Surviving as a Scientist, IOP Publishing, 2016.
3. Craig Cormick, The Science of Communicating Science: The Ultimate Guide, CSIRO Publishing, Australia, 2019.
4. Sarah R. Davies and Maja Horst, Science Communication Culture, Identity and Citizenship, Palgrave Macmillan, 1st edition, 2016.
5. Anthony Wilson (Editor), Handbook of Science Communication, CRC Press, 1998.
6. Pallava, Bagla and V.V. Binoy (Editors), Bridging the Communication Gap in Science and Technology Lessons from India, Springer Singapore, 2017.
7. Richard Holliman, Investigating Science Communication in the Information Age: Implications for Public Engagement and Popular Media, Oxford University Press; 1st edition, 2008.
8. Martin W. Bauer, Journalism, Science and Society: Science Communication Between News and Public Relations, Taylor & Francis Group, 2008.
9. Richard Holliman, Practising Science Communication in the Information Age: Theorizing Professional Practices, Oxford University Press, 2009.
10. David J. Bennett and Richard C. Jennings, Successful Science Communication, Cambridge University Press, 2011.
11. Charles Pavitt, The Philosophy Of Science And Communication Theory, Nova Science Pub Inc., 2001.

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AcSIR Academic Centre Code: 42

CSIR-National Institute of Science Communication and Information CSIR-NISCAIR

Course 3 : Advanced Course	Mathematical & Information Sciences	Total Credits 6

Title:	Course Code	Credits
Communicating Science through Social Media	AcSIR-42-MIS-AD-004	2

Digital Communication Technology, Background & Historyof Social Media Literacy: Communicating appropriately and responsibly, Impact of Internet on Society, Stakeholders of Social Media, Identifying and Exploring Social Media, Online Tools for Social Media Communication, Social Media Policies and Management, Direct Communication with the audience, Search Engines and Mobile Media, Collaboration, Community and Communication, Long term sustenance of audience.

Social Media and Analytics: Measuring the Impact, Security and Privacy, Case studies of popular social media sites involved in Science Communication and Information Dissemination, Exposure on Social Media: Twitter, Facebook, Instagram, WhatsApp, Snapchat, Podcasts, Youtube etc.

References:

1. Jeremy Harris Lipschultz, Social Media Communication: Concepts, Practices, Data, Law and Ethics, Taylor & Francis, 2017
2. Connie M. White, Social Media, Crisis Communication, and Emergency Management: Leveraging Web 2.0 Technologies, Routledge, 2011
3. Graham Meikle, Social Media: Communication, Sharing and Visibility, Routledge, 2016

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 42

CSIR-National Institute of Science Communication and Information	CSIR-NISCAIR

Course 3 : Advanced Course	Mathematical & Information Sciences	Total Credits 6

Title:	Course Code	Credits
Science Journalism	AcSIR-42-MIS-AD-005	3

Science journalism: Historical and present perspective, understanding science, fundamentals of science journalism, analysis of work done by some notable science journalists, understanding your role of as science journalists, importance of science journalism, Science Journalism and Mass Media, Role of various forms of mass media in science journalism, Print Media, Audio/Visual Media, Folk Media, Interactive Media, Digital Media, Business writing, Brochures, Technical Brochures. Scientific Writing/Technical Writing: Trends in science writing/ reporting, reporting and researching techniques, finding expert sources, interviewing and working with archives, developing beats and conducting quantitative analyses, techniques of scientific writing, technology tools, multimedia and digital publications fo r science writers, contemporary science writing: creative and professional forms, science narratives writing. Thesis and Careers in Science Writing, Independent Study in Science Writing, Role of Social media in Science Journalism and Outreach, Ethics and neutrality in Science Journalism. Projects: Develop article ideas suitable for a range of science publications, Source information, conduct research and carry out effective interviews, Cover briefings, meetings, conferences, protests and other science events, Write articles and features on science topics for digital and print publications, Apply media law and ethics to the world of science journalism. Advanced Science Documentary Popularization of Science in India, Types of Science Writing, Research Paper Writing, Writing for Magazines, Newsletters & Newspapers, Sources of Science Reporting, What Makes a Good Article, Challenges in Science Writing, Editing, Publishing & Copyright. IT Tools in Science Writing, Assignments (Writing Research Paper, News report, Feature Article, Conference Report Interview, Letter to Editor and Editing).

References:

1. Martin W. Bauer and Massimiano Bucchi, Journalism, Science and Society: Science Communication Between News and Public Relations, Taylor & Francis, 2007
2. Nature, Special Issue on Science Journalism. Available online at: http://www.nature.com/news/specials/sciencejournalism/index.html
3. Filak Vincent F (ed), Convergent Journalism: an introduction, Focal Press, 2015
4. Boyd, Andrew, Broadcast Journalism (5th edition), Focal Press, 2003
5. Bradshaw P & Rohumaa L, The Online Journalism Handbook, Pearson, 2011
6. Bull A, Multimedia Journalism - a practical guide, Routledge, 2010

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 42

CSIR-National Institute of Science Communication and Information | CSIR-NISCAIR

Course 3 : Advanced Course | Mathematical & Information Sciences | Total Credits 6

Title:	Course Code	Credits
Audio Visual Media and Science Film Production	AcSIR-42-MIS-AD-006	2

Audio science documentary film production and its significance in communicating science. Introduction to the methods developed for studying the fiction, documentary and experimental audio-visual film over the past 100 years. A close analysis and interpretation of the social function and cultural value of science and natural history films, with a particular emphasis for broadcast nationally and internationally. Introduction to the critical methodologies necessary for intelligently interrogating the representations of science and technology in print and media.

Basic field production techniques in audio, video, sound, and editing. Training in digital video, 16mm cinematography, analogue and hard -disk sound recording, and digital nonlinear editing.

Advanced audio and video cinematography techniques. The course will include advanced lighting, camera movement, narrative uses of the camera.

Unique post-production requirements for contemporary documentary film and video.

References:

1. Eve Light Honthaner, The Complete Film Production Handbook, Focal Press (Fourth Edition), 2010.
2. Bastian Cleve, Film Production Management, Focal Press (Third Edition), 2005.
3. Alka Agrawal, Making Movies: Scientists as Filmmakers, Science, AAAS, 2001.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 42

CSIR-National Institute of Science Communication and Information **CSIR-NISCAIR**

Course 3 : Advanced Course	**Mathematical & Information Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Research Communication	**AcSIR-42-MIS-AD-007**	**2**

Principles of academic communication, Structure of a postgraduate dissertation or thesis, and 'signposting' in writing.
Introductions and signposting: Investigating the introductions to theses and proposals, thinking about titles, and more on signposting.
Literature review: Key strategies in writing literature reviews, using references appropriately, and scaffolding arguments and ideas through the use of key words.
Research proposals and citation systems: Structure of a research proposal, citation systems, and work on your own research proposal.
Analysis of research findings and interpretation
Finishing touches: Writing conclusions, summarizing findings, discussing limitations and significance
How to prepare/write a research paper, review article etc.
Presenting research work: Power point presentation and making formal presentations on research topics in seminars and conferences.

References:

1. David H Jonassen, Handbook of Research on Educational Communications and Technology, Lawrence Erlbaum, 2004.
2. Philip Gaunt, Beyond Agendas: New Directions in Communication Research (Contributions to the Study of Mass Media & Communications), 1993.
3. Laura J. Gurak and Mary M. Lay. Research in Technical Communication, 2002.
4. Dan O'Hair and Gary L. Kreps, Applied Communication Theory and Research, 2013.
5. Mark L. Knapp and John A. Daly, A Guide to Publishing in Scholarly Communication Journals, 3rd Edition, 2014.
6. Robert A. Day and Barbara Gastel, How to write & publish a scientific paper, 7th edition, 2011.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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Faculty of Study	Course Code	Course Title
Chemical Sciences	AcSIR-43-CS-AD-001	Coal Geology and Organic Petrology
Chemical Sciences	AcSIR-43-CS-AD-002	Analytical Techniques for Coal and Derivatives
Chemical Sciences	AcSIR-43-CS-AD-003	Coal Beneficiation
Chemical Sciences	AcSIR-43-CS-AD-004	Combustion Science and Technology
Chemical Sciences	AcSIR-43-CS-AD-005	Coal Gasification
Chemical Sciences	AcSIR-43-CS-AD-006	Coal to Liquid (CTL) Technology
Chemical Sciences	AcSIR-43-CS-AD-007	Coal Carbonization
Chemical Sciences	AcSIR-43-CS-AD-008	Coal,Energy and Environmental Biotechnology
Chemical Sciences	AcSIR-43-CS-AD-009	Environmental Management in Coal Industry
Chemical Sciences	AcSIR-43-CS-AD-010	Management of Soil, Water & Air Pollution in Coal Industry
Chemical Sciences	AcSIR-43-CS-AD-011	GHG Emission and Clean Development Strategies
Engineering Sciences	AcSIR-43-ES-AD-001	Advanced Numerical Simulation for Design of Underground Mining Structures
Engineering Sciences	AcSIR-43-ES-AD-002	Environmental Monitoring and Instrumentation
Engineering Sciences	AcSIR-43-ES-AD-003	Mine Air Emissions Monitoring and Control Engineering
Engineering Sciences	AcSIR-43-ES-AD-004	Mine Closure

43	CSIR-CIMFR	3	*Advanced Course*

Faculty of Study	Course Code	Course Title
Engineering Sciences	AcSIR-43-ES-AD-005	Mine Fire and Mitigations
Engineering Sciences	AcSIR-43-ES-AD-006	Open Pit Slope Design Engineering
Engineering Sciences	AcSIR-43-ES-AD-007	Water Resource Management in Mining Areas

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 43

CSIR-Central Institute of Mining and Fuel Research	**CSIR-CIMFR**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:		**Course Code**	**Credits**
	Coal Geology and Organic Petrology	**AcSIR-43-CS-AD-001**	**2**

Methods in treating water and wastewater; water disinfection. Thermodynamics and kinetics of air pollutants; chemical and photochemical reactions in atmosphere. Soil chemistry: nature and importance; acid-base and ion-exchange reactions in soils; colloidal chemistry of inorganic constituents, clays, organic matter and soil humus; adsorption desorption reactions, ion exchange, degradation of pesticides and hazardous substances in soil.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 43

CSIR-Central Institute of Mining and Fuel Research **CSIR-CIMFR**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Analytical Techniques for Coal and Derivatives	**AcSIR-43-CS-AD-002**	**2**

Analytical techniques for analysis of coal, fly ash, minerals, tar. Instrumental analysis: GC; XRD, XRF, DSC/ DTA-TG, STA, TPR/ TPO/ TPD/ Pulse chemisorptions, particle size analysis, BET surface area, flame photometry AAS, ICP, CHNS, INAA, MS hyphenated techniques, FTIR, NMR, SEM-EDX, TEM, TMA, CSR/CRI.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 43

CSIR-Central Institute of Mining and Fuel Research CSIR-CIMFR

Course 3 : Advanced Course Chemical Sciences Total Credits 6

Title:	Course Code	Credits
Coal Beneficiation	AcSIR-43-CS-AD-003	3

Introduction, sampling and sample preparation, size reduction; screening and classification; Fundamentals of coal washability, development of washabiilty curves, interpretation of washability data, Separation process: dry coal beneficiation, coarse coal beneficiation, fine coal beneficiation, efficiency testing of gravity concentrators, solid- liquid/dewatering separation and types, flocculation, thermal drying; chemicals in coal preparation, process control and instrumentation, materials handling and transportation; blending and homogenization, testing of coal for end users, economics of coal preparation, waste disposal and environmental factors, computer applications-modelling & simulation, development of flow sheet, plant design and layout, process equipment selection, plant performance testing, coal washing practices in India.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 43

CSIR-Central Institute of Mining and Fuel Research **CSIR-CIMFR**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	**Combustion Science and Technology**	**Course Code**	**Credits**
		AcSIR-43-CS-AD-004	**3**

Principle of coal combustion, oxidation and combustion, combustion process, kinetics of combustion, thermodynamics of combustion process, flame, flame temperature and velocity. Coal combustion technology – conventional and advanced, combustion behaviour of coal – laboratory, bench and pilot scale. Impact of coal quality parameters including petrography on combustion, spontaneous combustion of coal. Oxy fuel combustion, co-combustion, chemical looping combustion, super critical and ultra super critical boiler technology. Combustion products- solids and gases, pollution from coal combustion. Ash deposition characteristics, utilization of fly ash, trace and heavy metals pollution from coal combustion.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 43

CSIR-Central Institute of Mining and Fuel Research	CSIR-CIMFR

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Coal Gasification	AcSIR-43-CS-AD-005	3

Introduction: chemistry of gasification; pyrolysis; char gasification; factors affecting gasification and kinetics; gasification processes; coal properties on gasification; fluidization; fluidized bed gasifier design; types of gasifiers; major gasification technologies; gasification of high ash Indian coals; gasification applications; syn gas cleaning; present status of international and national gasification scenario.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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CSIR-Central Institute of Mining and Fuel Research	CSIR-CIMFR

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Coal to Liquid (CTL) Technology	AcSIR-43-CS-AD-006	3

Basics of catalysis, different types of Fischer-Tropsch (FT) catalysts, design, development and synthesis of FT catalysts, historical development of CTL Technology, direct liquefaction (Bergius Process); syngas conversions; Indirect Liquefaction (FT Synthesis); FT reactor design and development, modified FT processes, case studies of CTL plants, bench & pilot scale investigations.

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CSIR-Central Institute of Mining and Fuel Research	CSIR-CIMFR

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Coal Carbonization	Course Code	Credits
		AcSIR-43-CS-AD-007	3

Caking and coking coals; characteristics; significance of proximate analysis and thermal rheological properties; role of macerals; coal blending for coke making; carbonization at various temperature; thermal characteristics of coal and mechanism of coke formation; design and types of coke oven; cooling / quenching of coke; coke oven by-products; pollution in coke industries and its abetment, operation and troubleshooting in coke oven industries; characterization and evaluation of coke; carbonization technology for future generation and utilization of low grade coal for coke making: stamp charging, partial briquette charging, selective crushing.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 43

CSIR-Central Institute of Mining and Fuel Research CSIR-CIMFR

Course 3 : Advanced Course Chemical Sciences Total Credits 6

Title: Coal,Energy and Environmental Biotechnology	Course Code	Credits
	AcSIR-43-CS-AD-008	2

Introduction; structure of low rank coal and biomass (lignin & cellulose, hemicellulose etc), microbial techniques; microbial diversity and characteristic features; microbial classification; extremophiles; bioinstrumentation; fermentation technology; microbial physiology; microbial metabolism; microbial genetics; enzyme technology; bioreactors and application; bio-cleaning, bio-desulphurization of coal, bio-methanation and bio-liquefaction of coal, environmental microbial technology; biostatistics.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 43

CSIR-Central Institute of Mining and Fuel Research	**CSIR-CIMFR**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:		Course Code	Credits
	Environmental Management in Coal Industry	**AcSIR-43-CS-AD-009**	**2**

Microbial diversity and characteristic features; microbial classification; extremophiles; bioinstrumentation; fermentation technology; microbial physiology; microbial metabolism; microbial genetics; enzyme technology; bioreactors and application; bio-cleaning, bio-desulphurization of coal, bio-methanation and bio-liquefaction of coal, environmental microbial technology; biostatistics.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 43

CSIR-Central Institute of Mining and Fuel Research **CSIR-CIMFR**

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Management of Soil, Water & Air Pollution in Coal Industry	**AcSIR-43-CS-AD-010**	**2**

Soil: concept, properties, classification. Soil pollution; soil erosion and conservation; soil quality assessment, reclamation of coal mine spoil. Source and characteristics of wastewater, sampling and analysis, fundamentals of water treatment, physical, chemical and biological processes and design parameters, sludge stabilization, effluent disposal and reuse, Recycling of water in coal washery, recovery of coal fines. Air pollution; sources; abiotic, biotic and gaseous pollutants; air sampling and monitoring techniques; ambient air and stack monitoring; qualitative and quantitative analyses; environmental health hazards; abatement strategies.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 43

CSIR-Central Institute of Mining and Fuel Research	CSIR-CIMFR

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
GHG Emission and Clean Development Strategies	AcSIR-43-CS-AD-011	2

Kyoto protocol, national and international protocols and guidelines. Climate change issues. Tire-I, Tire-II and Tier -III, approach for GHG emission estimates. Estimation of GHGs in mining and industrial sectors; flue gas cleaning. Carbon footprints and carbon market, CO2-capture & storage. Uncertainties in emission estimates, development of country specific NCV and CEF for different types of coal and lignite. Clean development mechanism (CDM); sectors eligible for CDM; national CDM authority and guidelines.

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AcSIR Academic Centre Code: 43

CSIR-CIMFR

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title: Advanced Numerical Simulation for Design of Underground Mining Structures	Course Code	Credits
	AcSIR-43-ES-AD-001	4

General principles of design of underground mining structure; Design process for excavation in rocks; Influence of geological structures on design; Collections, preparation, and evaluation of in situ and laboratory data for underground excavation design; Use of rock mass rating systems for site characterization and excavation design; Design of support and reinforcement systems; Design methods of different openings in massive, stratified and jointed rock; Analysis of stress and rock mass deformations around excavations using numeri¬cal method; Application of different numerical modelling methods and software for design of underground mining structures; Demonstration of concepts using various case studies.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Environmental Monitoring and Instrumentation	AcSIR-43-ES-AD-002	4

Environmental sampling, need, scope and approaches; concentration units, precision, accuracy and recovery, detection and quantization limits, standard calibration curves. Fundamentals, purpose and types of sample preparation for trace elements and organics; principles of gravimetry, titrimetry, colorimetry, spectroscopy, electrophoresis, XRF, XRD, flame photometry, TLC, GC, ICP-OES, GC-MS; AAF/ICP-MS and Chromatograph; Analysis and interpretation of environmentakl, case studies.

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Mine Air Emissions Monitoring and Control Engineering	AcSIR-43-ES-AD-003	4

Mining and fugitive emission and control system: Techniques of identification and assessment of Quantum of emissions in mining operations and suitable control devices like condensers, spray systems, scrubbers, cyclones, ESP(s) bag filters etc.; Design techniques of air pollution control systems, International treaties related to air emissions and preparation of cost estimates; Air Quality Modelling in prediction of dispersion of pollutants in mining operations and related techniques for point, area and line sources.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 43

CSIR-CIMFR

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Mine Closure	AcSIR-43-ES-AD-004	4

Purpose of mine closure; Designing, planning and financing closure; Stakeholder engagement and community development; Mine site reclamation and rehabilitation; Phytostabilisation and phytoremediation; Soil ecology and biodiversity; Cover design; Construction and monitoring; Tailings deposit closure; Mining legacies and relinquishment; Mining for Closure: Policies, practises and guidelines for sustainable mining and closure of mines; Mine closure case studies.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 43

CSIR-CIMFR

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Mine Fire and Mitigations	AcSIR-43-ES-AD-005	4

Types of Fire; Spontaneous combustion; Mechanism of spontaneous heating of coal; Categorisation of Coal in respect of susceptibility of spontaneous combustion; Role of moisture and V.M.; Fire risk assessment; Detection and assessment of spontaneous heating/fire; Gas hazards; Methods of sampling of gases from fire area; Mine gas Analysis; Thermo-compositional Investigation; Environmental affects due to fire; Fire prevention and combating in underground coal mines; Fire combat methods; Dealing with long standing fires. Surface Fire: Fire in virgin coal bench, developed pillars worked by opencast method, Coal Stock, Overburden dump fire, Causes and techniques for prevention and control; Fire fighting equipment.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title: Open Pit Slope Design Engineering	Course Code	Credits
	AcSIR-43-ES-AD-006	4

Physical Characterization of discontinuities; Geomechanical Properties of slope mass; Groundwater condition and its measurement; Basic Mechanics of slope stability; Slope stability in rock slopes: Plane, wedge and toppling failures; Slope stability in soil and weathered slopes: Circular failure; Influence of blasting and damage control; Slope monitoring; Remedial measures: Influence of shape of slope face, slope water depressurization, Surface protection of slopes, control of rock falls.

AcSIR Academic Centre Code: 43

CSIR-CIMFR

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Water Resource Management in Mining Areas	AcSIR-43-ES-AD-007	4

Source and occurrence of waters in mines; water problems, mine inundation and preventive measures; mine water chemistry, source of mine water contaminants and their natural attenuation; acid mine drainage its cause and effects; mine water treatment processes; water makeup, mine dewatering processes and environmental impacts of dewatering and their mitigation; water problems and legislation in mines; Water use and demand in coal industries. Water pollution monitoring and management. Techniques of analysis and description of hydrological data related to mining, aquifer characteristics like permeability, transmissivity estimation of ground water potential and impact of withdrawal of ground water in mining.

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Faculty of Study	Course Code	Course Title
Mathematical & Information	AcSIR-44-MIS-AD-001	Patentability Criteria – United States
Mathematical & Information	AcSIR-44-MIS-AD-002	Patentability Criteria – Europe and India
Mathematical & Information	AcSIR-44-MIS-AD-003	Priority right – US, Europe and India Perspective
Mathematical & Information	AcSIR-44-MIS-AD-004	Advanced Patent Searching
Mathematical & Information	AcSIR-44-MIS-AD-005	Patent Infringement
Mathematical & Information	AcSIR-44-MIS-AD-006	Patent Valuation
Mathematical & Information	AcSIR-44-MIS-AD-007	IP Management
Mathematical & Information	AcSIR-44-MIS-AD-008	R&D Management
Mathematical & Information	AcSIR-44-MIS-AD-009	Technology Management

AcSIR Academic Centre Code: 44

CSIR-Unit for Research and Development of Information Products **CSIR-URDIP**

Course 3 : Advanced Course	**Mathematical & Information Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Patentability Criteria – United States	**AcSIR-44-MIS-AD-001**	**3**

USC 101, 102, 103, 112 Patentable Subject Matter (§101) Novelty (§102)- Prior art-Anticipation 35 USC 102, Verdegaal Bros. v. Union Oil Co. of California, 814 F.2d 628, 631 (Fed. Cir. 1987) Obviousness (103); person of "ordinary skill"; TSM; Differences with prior art, Graham v. John Deere Co Specification (§112) Written description requirement, Enablement requirement, Best mode US - Enablement, Written Antecedent basis in claims, Definite and Indefinite claims.

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AcSIR Academic Centre Code: 44			
CSIR-Unit for Research and Development of Information Products			CSIR-URDIP
Course 3 : Advanced Course	Mathematical & Information Sciences		Total Credits 6

Title:	Patentability Criteria – Europe and India	Course Code	Credits
		AcSIR-44-MIS-AD-002	3

India Section 2, Non-patentable inventions Sec 3,and Sec 4, Non obviousness criteria under Indian Patent Act.2(1)(ja), Inventive step as ground of opposition section 25 (1)(e) and 25 (2)(e) and for revocation under section 64 (1)(f) of the Act Case Law Interpretation on Inventive step: Bishwanath Prasad Radhey Shyam v. Hindustan Metal Industries; Asian Electronics Ltd. Vs. Havells India Limited
Case law interpretation on Obviousness: Novartis v. Union of India (Pharma Patent Policy Sec 3d)
MPPP Chap 3
Enablement requirement: India- Sec 10(4).
Patentability Criteria (Europe)
Novelty- Non obviousness Requirement - Europe perspectives
Europe - Article 52 EPC with Article 56 EPC, Technical effect
Enablement requirement Europe - Article 83 EPC.

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AcSIR Academic Centre Code: 44

CSIR-Unit for Research and Development of Information Products	CSIR-URDIP

Course 3 : Advanced Course	Mathematical & Information Sciences	Total Credits 6

Title: Priority right – US, Europe and India Perspective	Course Code	Credits
	AcSIR-44-MIS-AD-003	2

Introduction to patent priority system, What is right of priority for patents, Origin of the Patent priority system, Paris Convention [United States], Types of applications based on Priorities, Continuation, Divisional (35 USC 121), Continuation-In-Part (CIP)s
[Europe] - Divisional Applications, Right to claim priority
[India] - Divisional Applications (Sec 16), Patent of Addition (Sec 54,55,56) Priority Dates of claims of complete specification (Sec 11) , MPPP (Chap 7).
PCT National Phase Application Sec 39 (118) Rule 4, International Search Authority (ISA) and International Preliminary Examining Authority (IPEA) under PCT filing.

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AcSIR Academic Centre Code: 44

CSIR-Unit for Research and Development of Information Products	**CSIR-URDIP**

Course 3 : Advanced Course	**Mathematical & Information Sciences**	**Total Credits 6**

Title:	**Advanced Patent Searching**	**Course Code**	**Credits**
		AcSIR-44-MIS-AD-004	**3**

Searching on Patent Databases, Introduction & scope of databases on Scifinder platform, Classic STN: STN, Basic search, Caplus database: Introduction to CAPLUS (Chemical Abstracts), Content & coverage of caplus database, Different search fields and commands used to analyse data, Introduction to Derwent file: DWPI/WPIX., Derwent manual codes, PACO codes for assignees, Introduction to New STN/STNext platform, Different search fields and commands used to analyse data, Live Demonstration on database for practice,One patentability report to be prepared using advanced searching technique/databases.

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AcSIR Academic Centre Code: 44

CSIR-Unit for Research and Development of Information Products	CSIR-URDIP

Course 3 : Advanced Course	Mathematical & Information Sciences	Total Credits 6

Title:	Course Code	Credits
Patent Infringement	AcSIR-44-MIS-AD-005	2

Statutes: Types of Infringement, Infringement Analysis in different jurisdiction and countries, Prosecution History Estoppel II, Markman Hearing, Europe India - IPAB (Sec116), FER, Defense available for Infringement (35 USC Chap 29), Damages/Remedies (35 SC 284)
India (Sec 107, 108).
Grounds of Opposition, Inter partes review/Post grant review (USC Chap 31, 32)
Indian Patent Act, Opposition Proceedings (MPPP ch10, 11)
Pre and Post grant oppositions: section 25(1) and 25(2)
Analysis of a patent litigation case in US or India to be done as an assignment/practice

References:

1. Comparative Patent Remedies: A Legal and Economic Analysis 1st Edition - Prof. Thomas F. Cotte Oxford University Press (SBN-13: 978-0199840656)

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AcSIR Academic Centre Code: 44

CSIR-Unit for Research and Development of Information Products | CSIR-URDIP

Course 3 : Advanced Course | Mathematical & Information Sciences | Total Credits 6

Title:	Course Code	Credits
Patent Valuation	AcSIR-44-MIS-AD-006	2

Introduction to patent valuation, Why IP valuation, What is IP valuation, Definition, Examples of commercialization and exploitation of patents

Valuation techniques (Qualitative and Quantitative), Qualitative indicators/Quality of a patent, Quantitative preparing for the valuation, Approaches for valuation, Income method, Cost based, market based method, Strategies for filing a patent.

Valuation during licensing, Early stage valuation by investors.

One techno-commercial evaluation report to be prepared for a technology/patented invention before comprehensive examination by considering the qualitative indicators.

References:

1. Patent Valuation: Improving Decision Making through Analysis by William J. Murphy, John L. Orcutt, Paul C. Remus

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AcSIR Academic Centre Code: 44

CSIR-Unit for Research and Development of Information Products CSIR-URDIP

Course 3 : Advanced Course	Mathematical & Information Sciences	Total Credits 6

Title: IP Management	Course Code	Credits
	AcSIR-44-MIS-AD-007	2

Overview of IP systems: Patent power, What is a patent, Types of patents, Why patent, How does the patent system work?, Types of applications, Common myths about patents (duration, ownership, freedom to practice, secrecy, global patent, geographical boundaries), Infringement, Damage awards, Industry structure and importance of patent, Leveraging patents as financial assets, Perils of ignoring patents, IP savvy organizations.
Requirement of a patent, Criteria for patenting, Subject matter, Novelty, non obviousness, Utility, Enablement, Best mode, Definiteness, Unity of inventions, Inventorship, Statutes, Interpretation, Infringement , Case studies.
Abstract, Specification, Written description, Claims, Independent and dependent claims, Swiss claims, Length of a document, Claim drafting with file Estoppel in mind, Capturing invention.
Should a patent be filed?, Where to file, Criteria, When to file?, Timing and filing, Foreign filings, PCT route, Drafting the application, USPTO procedures, Manipulating patent filing and prosecution process, Maintaining secrecy for longer, Fighting competition, Importance of record keeping.
Goals of patent strategy, Types of strategies, Shield and sword patents, Protecting markets, Company and future, Protecting single invention, Multiple inventions, Bracketing, clustering and fencing, Strategy for existing products, Patent investment strategies for commercializing technology, Aligning patent strategy with business strategy, Business driven patenting strategy extending the life of invention, Transferring IP assets to business assets, Invention, product and market considerations, Market economies and technology density considerations, Organizing patent portfolio, Enhancing patent quality, Patent cost management – Benchmarking patent strategy against competition, Patent strategy for long term growth, Patent strategy for building corporate assets and exploiting the same, Case studies.
Conventional flow path for product development, Gaps analysis for R&D planning, New model, From pure research to commercial development, Market pull vs. research push.
Role of IP in M&A decisions, IP due diligence for M&A, Negotiating value – Case studies
Approaches to exploiting IP, When licensing is the preferred option, Rationale for licensing, Objectives of licensing, Carrot and stick licensing, Licensing decision, Factors governing licensing and financial compensation, Approaches to IP valuations, Sharing profits, Cost based valuations, Market based valuations, Industry standards, Researching the markets and targets, Scope of licensing, Exclusive/ non exclusive, territories, duration, non competitive clauses Sublicensing, Improvements, Cross licensing, Preparing for negotiations, Steps and processes for negotiation, Responsibilities of the licensor and licensee, Draft agreements, Typical drafts, Licensing as a business strategy in chemical industry, Licensing practices at leading companies, Trends in IP and licensing management, Case studies.
Levels of IP exploitation in organization, Moving up the value chain, Organization, From filing to transacting, Transformation at Xerox, Dow Chemicals, P&G.

References:

1. Rivette, K.G. - Rembrandts in the attic: unlocking the hidden value of Patents —-Boston: Harvard Business School Press, 2000
2. Knight,H.J. - Patent strategy: for researchers and research managers -Chichester: John Wiley and Sons, 2001
3. Goldstein, A.N. Ed. - Patent law for scientists and engineers - Boca Raton: Taylor and Francis, 2005
4. Junghans, C. - Intellectual property management: a guide for scientists, engineers, financers and managers - Weinheim: Wiley Vch, 2006
5. Miller, C.P. - Chemist's companion guide to patent law - Hoboken: John Wiley & Sons, 2010
6. Alexander I. Poltorak, Paul J. Lerner - Essentials of Intellectual Property - John Wiley & Sons Inc, 2002. ISBN: 9780471209423
7. Ganguli, Prabuddha - Gearing up for patents: The Indian scenario - Universities Press (India) Limited, 1998. ISBN: 8173711054
8. Junghans, C.; Levy, Adam - Intellectual property management: A Guide for Scientists, Engineers, Financiers and Managers - Wiley-VCH Verlag GmbH & Co. KGaA, 2006. ISBN: 9783527312863

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AcSIR Academic Centre Code: 44

CSIR-Unit for Research and Development of Information Products	CSIR-URDIP

Course 3 : Advanced Course	Mathematical & Information Sciences	Total Credits 6

Title:	Course Code	Credits
R&D Management	AcSIR-44-MIS-AD-008	2

Conceptual framework of R&D management, Origins of industrial R&D, The industrial R&D process, Changing role of R&D in industry, Role of R&D in technological innovation, Implications for R&D strategy, Formulating R&D strategy, Evolution of corporate R&D, Centralized vs decentralized R&D, Organizational structure for R&D, Input and output oriented structures, Critical activities of R&D function, Role of leadership, Components of R&D organization, Make vs buy decision, R&D project management, R&D project portfolio, Resource allocation for R&D, Managing value and risk in R&D portfolio Aligning R&D portfolio with business strategy, Planning directed basic research, Globalization of R&D, Implications for corporate R&D, Coordinating multi locational R&D Location strategies, Global R&D centres in India From first to fourth generation R&D, Project selection and evaluation, Evaluation of R&D performance, R&D performance metrics, R&D performance effectiveness and impact, Decision support systems for R&D project management, Terminating R&D projects, Post project evaluation and learning, Trends in R&D management, Open Innovation, Working with national innovation systems, Directed basic research with universities, Managing R&D collaborations, Issues in value based R&D Case studies in R&D management, 3M, DuPont, GE, P&G , Merck.

References:

1 Saunders, J.H. - Careers in industrial research and development - 1974
2 White, P.A.F. - Effective management of research and development - 1975
3 Rawat, A. - Management of corporate R & D and innovation - Global Business Press, Delhi, 1995
4 Bamfield, P. - Research and development management in the chemical industry – Vch Verlagsgesellschaft Mbh, Weinheim, 1996
5 Cohan,P.S. - Technology leaders: How America's most profitable high tech companies innovate their way to success - Jossey Bass Inc., San Francisco, 1997
6 Chiesa,V. - R and D strategy and organization: managing technical change in dynamic contexts - London: Imperial College Press, 2001
7 Martin, M.J.C. - Managing innovation and entreneurship in technology based firms - Wiley Interscience, New York, 1994
8 Miller, W.L. - Fourth generation R and D: managing knowledge, technology and innovation

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AcSIR Academic Centre Code: 44

CSIR-Unit for Research and Development of Information Products **CSIR-URDIP**

Course 3 : Advanced Course **Mathematical & Information Sciences** **Total Credits 6**

Title:	Technology Management	Course Code	Credits
		AcSIR-44-MIS-AD-009	2

Concept and framework of technology management, Strategic role and scope of technology management, Technology life cycles and flow processes, S curves in technological progress, Technology push vs. market pull, Product life cycles, Technology diffusion, Technology environment, Industry structure, Organizational structure, Resources, Competitive advantage at firm and national level.

Product, technology and business strategy, Aligning strategies Positioning approach, Resource based approach, Rationalist and incrementalist approach, Technology selection, Timing, Acquisition or development, Make vs. buy decision, Types of technology strategies.

Models of technology growth and diffusion, Forecasting techniques and tools, Managing forecasting process, Case studies from industries, Technology monitoring, Trend analysis techniques and tools, Simulation and scenario building, Economic forecasting and analysis, Forecasting directions and changes, Forecasting technological discontinuities and change.

Mapping technological environment, Competitor activities, Assessing technological positions, Technology analysis, Technology base of the firm, Technology planning and business strategy, Planning process, Case studies from chemical industries.

Profit sharing, Cost basis, Market basis, Economic assessment, DCF analysis to estimate present value.

Modalities of acquisition, Joint ventures, Outsourcing, Licensing, Discipline of acquisition, Role of management, Factors influencing managerial decision, Selecting partners, Case studies.

Licensing decision, Licensing strategies, Due diligence prior to licensing, Licensing agreements, Negotiating and drafting, Model agreement, Post licensing activities, Licensing from universities, Case studies.

Technology transfer, Technology management case studies, Developing technology managers.

References:

1. Gaynor,G.H._Ed. - Handbook of technology management - Mc-Graw Hill, New York,1996
2. Betz, F - Strategic technology management - Mc-Graw Hill, Inc., New York, 1993
3. Boer, F.P. - Valuation of technology: business and financial issues in R and D - John Wiley and Sons, New York, 1999
4. Megantz, R.C. - Technology management: developing and implementing effective licensing programs - John Wiley and Sons, New York , 2002
5. Khalil, T.M. - Management of technology - Mc Graw Hill Book Co., Singapore, 2000
6. Narayanan, V.K. - Managing technology and innovation for competitive advantage - Pearson Education Inc., Delhi, 2001
7. Szakonyi, R. Ed - Technology management, Auerbach, 1999
8. Porter, A.L. - Forecasting and management of technology - Wiley Interscience, New York, 1991
9. Martin, M.J.C - Managing innovation and entreneurship in technology based firms - Wiley Interscience, New York, 1994
10. Phaal, R. - T plan: the fast start to technology road mapping planning your route to success - Institute of Manufacturing, University of Cambridge, Cambridge, 2001

Faculty of Study	Course Code	Course Title
Engineering Sciences	AcSIR-45-ES-AD-001	Applied Computational Methods
Mathematical & Information	AcSIR-45-MIS-AD-001	Advanced Information Security and Privacy
Mathematical & Information	AcSIR-45-MIS-AD-002	Weather and Climate Informatics
Mathematical & Information	AcSIR-45-MIS-AD-003	Navigation Satellite System (GNSS) theory and its applications to Geosciences
Mathematical & Information	AcSIR-45-MIS-AD-004	Advanced Scientific Computing
Mathematical & Information	AcSIR-45-MIS-AD-005	Analysis of Meteorology and Climate Data
Mathematical & Information	AcSIR-45-MIS-AD-006	Advanced Machine Learning
Physical Sciences	AcSIR-45-PS-AD-001	Earthquake and Volcano Deformation
Physical Sciences	AcSIR-45-PS-AD-002	GNSS (Global Navigation Satellite Systems) Remote sensing and Geodesy
Physical Sciences	AcSIR-45-PS-AD-003	Climate Dynamics and Modeling
Physical Sciences	AcSIR-45-PS-AD-004	Tropical Meteorology and Monsoon
Physical Sciences	AcSIR-45-PS-AD-005	Applied Seismology and Seismic Hazard

AcSIR Academic Centre Code: 45	
CSIR-Fourth Paradigm Institute	**CSIR-4PI**

Course 3 : Advanced Course	Engineering Sciences	Total Credits 6

Title:	Course Code	Credits
Applied Computational Methods	**AcSIR-45-ES-AD-001**	**3**

Ordinary Differential Equations, Initial Value Problems: Single step methods, Multi step methods, Boundary Value Problems: Shooting Method, Finite Difference Methods, Finite Element Method, Partial Differential Equations, Finite Difference Discretization, Finite difference treatment of 2nd order nonlinear PDE of parabolic, elliptic types, Hyperbolic problems, Higher Order Methods: Spectral Method, Pesudospectral Method.

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AcSIR Academic Centre Code: 45

CSIR-Fourth Paradigm Institute	**CSIR-4PI**

Course 3 : Advanced Course	**Mathematical & Information Sciences**	**Total Credits 6**

Title:		Course Code	Credits
	Advanced Information Security and Privacy	**AcSIR-45-MIS-AD-001**	**3**

One-way and trapdoor functions; encryption; authentication; symmetric cryptography, pseudo-random number generators, asymmetric cryptography: RSA cryptosystem, Message authentication and hash functions, Digital signatures, RSA digital signature scheme, Key distribution, Diffie-Hellman secret key exchange, Two-party and multi-party protocols, simultaneous secret exchange protocol, Neural and quantum cryptography, public key infrastructure, privacy aware security.

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CSIR-Fourth Paradigm Institute	CSIR-4PI

Course 3 : Advanced Course	Mathematical & Information Sciences	Total Credits 6

Title:	Course Code	Credits
Weather and Climate Informatics	AcSIR-45-MIS-AD-002	3

Earth system overview: Introduction to geography and natural resources, Overview of fundamentals of Earth's climate, including greenhouse effect, water and chemical cycles, outstanding features of atmospheric and ocean circulation, and feedback between different system components. Exciting and contentious scientific puzzles of climate system, like causes of ice ages, greenhouse warming, IOD, El niño etc.

Observation, analysis, modelling, forecasting and validation: Statistical analysis in climate research: probability theory, Distribution of climate variables, concepts of statistical interference, statistical test of hypothesis, analysis of atmospheric circulation problems, Forecast quality evaluation.

Application of weather informatics: Real time flood forecasting, landslide prediction, forest fire, precision agriculture: planting and fertilizer application, demand for electricity and gas, aviation etc.

Climate Change and Climate Modeling: Global environmental issues in climate change due to human activities or natural climate variations. Climate and environmental change, understand how physical geography techniques can help quantify and understand these changes, learn how to work with climate data and simple models, analyze the potential impacts of environmental change on a range of sectors including agriculture, food, forestry, water resources, energy usage, rapid change caused by natural hazard processes and human health, and discuss potential mitigation and adaptation options.

Software Lab: Introduction to basic data analysis tools. Survey of numerical methods employed in atmospheric and related sciences: theory, application, and programming.

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AcSIR Academic Centre Code: 45

CSIR-Fourth Paradigm Institute	**CSIR-4PI**

Course 3 : Advanced Course	**Mathematical & Information Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Navigation Satellite System (GNSS) theory and its applications to Geosciences	**AcSIR-45-MIS-AD-003**	**3**

Introduction to GNSS geodesy, GNSS theory, GNSS reference frames, sources of errors and correction, positioning using GNSS observables, GNSS data collection, data processing and analysis, GNSS applications for Geoscience, Modelling of GNSS derived surface deformation.

Introduction to GNSS geodesy covers the state of art on Global Navigation Satellite systems, its components, geodesy, Military and Civil applications. GNSS reference frames: Introduction to celestial and terrestrial reference frames, Earth Centered Earth fixed reference frame and earths pole of rotation. Sources of errors and corrections: Introduction of positioning using GNSS satellites, errors involved covering orbit, clock errors, troposphere and ionosphere errors, miscellaneous errors. Positioning using GNSS observables: To determine the precise position and time, error correction, different types of positioning. GNSS data and processing theory: Models involved in data processing and analysis. GNSS applications to Geoscience: Surveying, continental deformation studies, landslide hazard mapping, Glacier dynamics, Volcano deformation, troposphere and ionosphere modeling, InSAR (Interferometric Synthetic Aperture Radar), GIS (Geographical Information System) etc. Modelling of GNSS deformation: brief introduction of different kind of modeling techniques that are currently being used

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AcSIR Academic Centre Code: 45

CSIR-Fourth Paradigm Institute	**CSIR-4PI**

Course 3 : Advanced Course	**Mathematical & Information Sciences**	**Total Credits**	**6**

Title:		Course Code	Credits
	Advanced Scientific Computing	**AcSIR-45-MIS-AD-004**	**3**

High-performance sequential computing: Elementary concepts of modern computer architectures, Pipelining, Instruction level parallelism, cache performance, memory hierarchy, compiler optimization issues.
High Performance Computing: Motivating applications, parallel architectures, shared-memory parallel computing, distributed-memory parallel computing
Cloud computing: Introduction to Cloud Computing, Infrastructure as a service, Platform as a service, Software as a service, Cloud applications

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AcSIR Academic Centre Code: 45

CSIR-Fourth Paradigm Institute	CSIR-4PI

Course 3 : Advanced Course	Mathematical & Information Sciences	Total Credits 6

Title:	Analysis of Meteorology and Climate Data	Course Code	Credits
		AcSIR-45-MIS-AD-005	3

Weather and climate data storage formats (includes various regular and non regular ASCII formats for observational data and a range of self-describing gridded binary formats, including HDF, GRIB, netCDF), Data structure of meteorological and climate data. Algorithms for reading/writing in data format. Elementary statistics (Correlation, Regression, Epoch, Statistical Significance, etc.), Eigen mode analysis methods (EOFs, SVDs), Time series analysis (Autocorrelation, spectral analysis, filtering), Error and uncertainty analysis, Parametric vs. non-parametric methods, Extreme value analysis, Dynamical analysis (e.g. cyclone track statistics, EP fluxes), forecast verification, Diagnostic verification methods, Introduction to uses of GIS for Meteorological and climate analysis

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AcSIR Academic Centre Code: 45

CSIR-Fourth Paradigm Institute	CSIR-4PI

Course 3 : Advanced Course	Mathematical & Information Sciences	Total Credits 6

Title:	Advanced Machine Learning	Course Code	Credits
		AcSIR-45-MIS-AD-006	3

Machine Learning Basics and Statistical Modelling, Data Preprocessing, Supervised vs. Unsupervised Learning, Machine Learning and Deep Learning Algorithms, Time series Modelling, Ensemble Learning, Practical Examples.

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AcSIR Academic Centre Code: 45

CSIR-Fourth Paradigm Institute	CSIR-4PI

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Earthquake and Volcano Deformation	AcSIR-45-PS-AD-001	3

Theoretical concepts of earthquake faulting, Stress in crust, Mechanics of earthquakes, Rupture propagation, Earthquake clustering and migration, Coulomb stress loading, Crustal deformation cycle, Models of strain accumulation, Earthquake cycle and recurrence times, Observational techniques for strain and recurrence quantification, Qualitative and quantitative seismo-tectonic analysis, Mechanisms of various tectonic regime earthquakes, Slow and tsunamigenic earthquakes, Aseismic slip, Seismic coupling, Episodic tremor and slip, Induced seismicity, Mechanisms.
Volcanism: Basics, Structure and evolution of spherical magma chamber.

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Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title: GNSS (Global Navigation Satellite Systems) Remote sensing and Geodesy	Course Code	Credits
	AcSIR-45-PS-AD-002	3

Global Navigation Satellite Systems (GNSS) as a remote sensing and geodetic tool, Use of signals from GNSS navigation satellites including US global positioning system(GPS) for remote sensing, Quantification of causative atmospheric parameters like Tropospheric Precipitable Water Vapour (TPWV), Ionospheric Total Electron Content (TEC), Use of reflection of the GNSS signals for measuring soil moisture, ocean altimetry etc. Possibility of use of GNSS as a tool to sense seismic signals and Tsunami waves in open ocean, GNSS for geodetic studies.

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AcSIR Academic Centre Code: 45

CSIR-Fourth Paradigm Institute	CSIR-4PI

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title: Climate Dynamics and Modeling	Course Code	Credits
	AcSIR-45-PS-AD-003	3

Basic equations in atmospheric sciences, Overview of hierarchy of models. Numerical methods: Filtering problem, Finite difference techniques, Stability analysis, Spectral and semi-Lagrangian techniques. Overview of spectral and finite element models. Model physics: Parameterization of subgrid-scale processes. Coupled ocean-atmosphermodels.

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AcSIR Academic Centre Code: 45		

CSIR-Fourth Paradigm Institute	CSIR-4PI

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Tropical Meteorology and Monsoon	AcSIR-45-PS-AD-004	3

Basics of tropical meteorology, Multiscale tropical weather systems, Trade winds, Hadley cell, Jet streams, Atmosphere and rotating systems.

Tropical convection: Tropical precipitation and spatio-temporal variation, Equatorial trough, ITCZ, Easterly waves, Convective systems, Conditional instability of first and second kind.

Monsoon: Monsoon over Asia, Australia and Africa, Monsoons over India, Heat lows, TCZs and monsoon trough, Onset and advance of monsoon, Active and break monsoon, Withdrawal of monsoon, Tibetan anti-cyclone, Mascarene high, Low level jet, Tropical Easterly jetstream, Monsoon Hadley circulation, Monsoon depression, Mid tropospheric cyclone, Monsoon and typhoons, Monsoon and orography.

Variability of monsoon: Intra-seasonal variation, ISOs and Madden-Julian oscillation (MJO), El-Nino and Southern oscillation (ENSO), Indian ocean dipole and EQUINOO, Inter annual variation (IAV), Monsoon and the ocean.

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AcSIR Academic Centre Code: 45	
CSIR-Fourth Paradigm Institute	**CSIR-4PI**

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Applied Seismology and Seismic Hazard	**AcSIR-45-PS-AD-005**	**3**

Basic concepts of seismology, seismicity, wave propagation, seismic hazard assessment through ground motion modeling and microtremors. Seismotectonics: Earth and its interiors, Plate tectonics, Causes of earthquakes, Seismic waves, Earthquake magnitudes, Earthquake intensities, Seismicity patterns and tectonic settings, Seismogenic source zones in India. Earthquake sources and wave propagation: Introduction to fourier transform and its use in seismology, Double-couple force systems, Omega-square and Haskell source models, Directivity, Wave propagation and waveform modeling, Source parameters and teleseismic modeling, Source time function and fault slip, Wave propagation at regional distances, Empirical study of regional wave propagation.

Earthquake recurrence statistics: Earthquake magnitude and magnitude scales, Seismometry, Gutenberg-Richter relation, Maximum magnitude, Characteristic earthquake models, Maximum earthquake magnitudes, Relationship of seismological parameters to field geology parameters, Poisson vs. other models of earthquake recurrence

Seismic hazard analysis: Concept of earthquake hazard analysis, Ground motion modelling for hazard analyses, Role of attenuation law, Probabilistic and deterministic seismic hazard analysis, Uncertainties in hazard evaluation, Role of random scatter, Role of modeling uncertainty, Hazard deaggregation, site effects and ground motion modeling.

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64	DST-BSIP	3	Advanced Course

Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-64-BS-AD-001	Biostratigraphy and Sequence stratigraphy
Biological Sciences	AcSIR-64-BS-AD-002	Palynology, phytoliths and palynofacies analysis
Biological Sciences	AcSIR-64-BS-AD-003	Palaeobiology and Biogeography, Megafloral Study and Coastal Ecology Mangroves
Biological Sciences	AcSIR-64-BS-AD-004	Vertebrate and Invertebrate Palaeontology, Micropaleontology
Biological Sciences	AcSIR-64-BS-AD-005	Archaeobotany and Dendrochronology
Biological Sciences	AcSIR-64-BS-AD-006	Phylogenetic Systematics/Cladistic Analysis and Palaeogenomics
Physical Sciences	AcSIR-64-PS-AD-001	Inorganic Geochemistry
Physical Sciences	AcSIR-64-PS-AD-002	Organic Geochemistry and Coal Petrology
Physical Sciences	AcSIR-64-PS-AD-003	Geochronology and Dating Techniques
Physical Sciences	AcSIR-64-PS-AD-004	Paleoclimatology and Palaeoceanography
Physical Sciences	AcSIR-64-PS-AD-005	Paleomagnetism and Environmental magnetism, Remote Sensing and GIS methodologies and Applications
Physical Sciences	AcSIR-64-PS-AD-006	Sedimentology and Stratigraphy

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AcSIR Academic Centre Code: 64

DST-Birbal Sahni Institute of Palaeosciences DST-BSIP

Course 3 : Advanced Course Biological Sciences Total Credits 6

Title: Biostratigraphy and Sequence stratigraphy	Course Code	Credits
	AcSIR-64-BS-AD-001	

Introduction, Purpose of Biostratigraphic Classification, Kinds of Biostratigraphic units, Significance of Fossils in Biostratigraphy, Biostratigraphic zones, Biomakers: Index and facies fossils, Age interpretation based on fossils, Key biostratigraphic Events on Earth History. Definition of sequence stratigraphy, Rationale: the need for formalization, Basic concepts, Sequence stratigraphic units: Sequence, Sequence stratigraphic units: Systems tracts, Parasequences, Sequence stratigraphic surfaces: Subaerial unconformity, Correlative conformities, Maximum flooding surface, Maximum regressive surface, Transgressive / Regressive surfaces.

References:

B.U. Haq. 1995. Sequence Stratigraphy And Depositional Response To Eustatic Tectonic And Climatic Forcing. Coastal Systems and Continental Margins book series (CSCM, volume 1)

Octavian Catuneanu. 2006. Principles Of Sequence Stratigraphy. pp 386.

Dominic Emery Keith Myers. 1996. Sequence Stratigraphy. pp 297.

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AcSIR Academic Centre Code: 64	
DST-Birbal Sahni Institute of Palaeosciences	DST-BSIP

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Palynology, phytoliths and palynofacies analysis	Course Code	Credits
		AcSIR-64-BS-AD-002	

Introduction to Palynology; Natural history of palynomorphs; Spores/Pollen basic biology; Spores/Pollen basic morphology; Stratigraphic Palynology-Precambrian, Cambrian, Ordovician; Cambrian to Silurian Non-Marine Palynology; Devonian Palynology; Carboniferous/Permian Palynology; Permo-Triassic Palynofloras; Triassic-Jurassic Palynology; Jurassic-Cretaceous Palynology; Advent and diversification of Angiosperms; Evolution of dinoflagellates; Paleogene palynology; Neogene Palynology; Holocene Palynology; Production, dispersal, sedimentation and taphonomy of spores/pollen.
Introduction to Palynofacies, Nature of organic matter in sediments, Biological degradation and consumption of palynofacies matter, Preservation of Palynofacies, Origin and nature of: - Phytoclasts, Palynomorphs, Zoomorphs, Amorphous OM. Distribution of - Phytoclasts, Palynomorphs, Zoomorph, Amorphous OM. Classification of Kerogen, Perspective on palynofacies in depositional environment and sequence stratigraphic framework.
Basics of phytoliths: origin, formation and utility for plants; phytoliths in plant groups; broad significance of phytolith research; classification of phytoliths; application of phytoliths in taxonomy, archaeology, palaeoecology, and palaeoclimatology; phytoliths in understanding past climate variability: qualitative and quantitative approaches.

References:

Erdtman, G. 1943. An Introduction to Pollen Analysis. Chronica Botanica, Mass. USA.
Ertdman, G. 1953. Pollen Morphology and Plant Taxonomy: Angiosperms.
Faegri K., Iversen, J. 1964. Text book of pollen analysis. Waltham Mass, USA: Chronica Botanica Co; 239 pp. 4.
Pearsall, D.M . 2000. Palaeoethnobotany: Handbook of procedures. Left Coast Press, California.
Piperno, D.R . 2006. Phytoliths, pollen: a comprehensive guide for archaeologists and palaeoecologists. Rowman and Littlefield Publishers, INC. New York.
Traverse, A., 1994. Sedimentation of organic particles. Cambridge University Press. pp. 557.
Tyson, R., V., 1995. Sedimentary Organic Matter. Organic facies and palynofacies. Chapman and Hall, London.
Hesse, M., Halbritter, H., Zetter, R., Weber, Buchner, M.R., Frosch-Radivo, A. Ulrich, S. 2009. Pollen Terminology An illustrated handbook. Springer Wien New York. pp. 266

AcSIR Academic Centre Code: 64

DST-Birbal Sahni Institute of Palaeosciences	DST-BSIP

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title: Palaeobiology and Biogeography, Megafloral Study and Coastal Ecology Mangroves	Course Code	Credits
	AcSIR-64-BS-AD-003	

Introduction to Palaeobiology; Paleontology as a science; Fossils in time and space; Taphonomy and the quality of fossil record; Paleoecology and paleoclimates; macroevolution and the tree of life; Mass extinctions and biodiversity loss; fossil plants; Trace fossils; Diversification of life; Biogeography- Development and history; Maps, ranges and geological changes; Evolution- Descent with modification; Ecology, Biomes and biodiversity; Islands and Oceans; Historical biogeography; Human evolution and biogeography.

Introduction to Cenozoic megafossils. Types of megafossils. Evolution of angiosperms and their biogeography. Cenozoic paleoclimate reconstructions (qualitative and quantitative). Evolution and intensification of monsoon during the Cenozoic.

Functions of coastal ecosystem; Habitat sustainability, stability and restoration; Life in sediments; Brackish-water environments; marshes and mangroves; Coastal zone management; History and evolution of mangroves; biology of mangroves; Responses of mangroves to environmental stress; ecological role of mangrove ecosystem.

References:

Allmon, WD and Yacobucci, MM. 2016. Species and Speciation in the fossil record. University of Chicago Press.

Harper, D and Benton, MJ 2020.. Introduction to Paleobiology and the fossil record. Wiley Blackwell.

Tomlinson, PB.1994. The Botany of Mangroves. Cambridge University Press.

Hutchings, PA and Saenger, P. 1987. Ecology of mangroves. University of Queensland Press. 388 pp.

DST-Birbal Sahni Institute of Palaeosciences | DST-BSIP

Course 3 : Advanced Course | Biological Sciences | Total Credits 6

Title:	Course Code	Credits
Vertebrate and Invertebrate Palaeontology, Micropaleontology	AcSIR-64-BS-AD-004	

Principles of Palaeontology; Evolution and fossil record; classification scheme of vertebrates and invertebrates; some aspects on vertebrate groups: fishes, Mesozoic marine reptiles, turtles, crocodiles, dinosaurs; Origin of Mammals and Radiation of Placental mammals, Human Evolution. Some aspects on invertebrate groups: earliest Metazoans, Ediacara fauna, Arthropods, Sponges, Molluscs, Echinoderms.

Introduction, Micropalaeontology- evolution and biodiversity, Microfossils in stratigraphy, Types of microfossils (calcareous, siliceous, organic walled, phosphatic) - basic concepts, outline of morphology and modern biogeography; Sample processing for microfossil study; Properties of microfossils used as techniques in palaeoclimatology; Microfossils and past sea level changes and monsoon variability; Role of microfossils in environmental monitoring and petroleum exploration. Microfossils, stable isotopes and ocean-atmosphere history.

References:

Ungar, P.S. (2017). Evolution’s Bite. A story of teeth, diet and human evolution. Princeton University Press.

Benton, M.J. (2005). Vertebrate Palaeontology. 3rd Edition, Blackwell Publishing.

Carroll, R.L. (1988). Vertebrate Paleontology and Evolution. Freeman Publishing.

Clarkson, E.N.K. (1998). Invertebrate Palaeontology and Evolution. 4th Edition, Blackwell Publishing.

Brasier, M., Armstrong, H. (2013). Microfossils. Germany: Wiley.

Saraswati, P. K., Srinivasan, M. (2015). Micropaleontology: Principles and Applications. Germany: Springer International Publishing.

De Wever, P. (2020). Marvelous Microfossils: Creators, Timekeepers, Architects. United States: Johns Hopkins University Press

Traverse, A. (2007). Paleopalynology. Germany: Springer Netherlands.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 64

DST-Birbal Sahni Institute of Palaeosciences DST-BSIP

Course 3 : Advanced Course Biological Sciences Total Credits 6

Title:	Course Code	Credits
Archaeobotany and Dendrochronology	AcSIR-64-BS-AD-005	

Introduction, Archaeological plant remains, Botanical issues, Problems of nomenclature, Definition and application of terms - Archaeobotany, Palaeoethnobotany, Palaeobotany, Archaeoethnobotany, Archaeological Botany. Fossil, Macrofossil and Microfossil. Methods of collection and analysis of samples. The utility of Archaeobotany in Palaeosciences. Applications of ethnographic and ethnobotanical data.

Introduction of Dendrochronology/ tree-ring analysis - Historical development, Application, Biological background and how tree rings are formed; Principles of dendrochronology; Field sampling protocols; Laboratory processing of the tree-ring samples; Basics of cross-dating and skeleton plot; Dating and measuring the tree rings; Development of tree-ring chronologies and chronology statistics; Climate data-concept, source and analysis; ; Climate signal Identification-Response Function; Transfer function-information towards climate reconstruction; Case studies on Dendrochronology

References:

Fritts HC. 1976. Tree Rings and Climate. Academic Press: New York, NY

Speer JH. 2010. Fundamentals of Tree-ring Research. The University of Arizona Press: Tucson.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 64

DST-Birbal Sahni Institute of Palaeosciences **DST-BSIP**

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Phylogenetic Systematics/Cladistic Analysis and Palaeogenomics	**AcSIR-64-BS-AD-006**	

Concept of the evolutionary history of life; the field of Systematics; Some important terminologies in Phylogenetic Systematics or Cladistics: Character, Homology, Homoplasy, Synapomorphy; the Parsimony rule; Determination of plesiomorphic and apomorphic characters; Outgroup and Ingroup taxa; Cladograms (important terminologies, construction, descriptive statistics).

Introduction to Palaeogenomics; DNA structure and Function; DNA technology and fossils; Major advances in ancient genomics; Sources of Ancient DNA; Preservation of a-DNA; DNA decay; Mitochondrial, nuclear and chloroplast a-DNA; Human a-DNA; Precautions for sample collection; Ancient Plant DNA; Diverse application of Ancient DNA in the reconstruction of our past.

References:

Ungar, P.S. (2017). Evolution’s Bite. A story of teeth, diet and human evolution. Princeton University Press.

Wiley, E.O. and Lieberman, B.S. (2011). Phylogenetics. Theory and Practice of Phylogenetic Systematics. Wiley-Blackwell Publications.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 64

DST-Birbal Sahni Institute of Palaeosciences | DST-BSIP

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Inorganic Geochemistry	AcSIR-64-PS-AD-001	

Physical and Chemical weathering, Mineralogy, Element distribution in the Earth and other planetary bodies, Composition of rocks, ores, minerals, water and soils, Fundamentals of hydro-geochemistry, Composition of earth crust, ocean water, volcanic emissions, pH scale, Alkalinity, Salinity, Electrical conductivity of Liquids, Geochemistry of Shale sediments , Rare earth element Geochemistry, Chemical alteration indices, Investigation of redox processes, Geochemical proxy indicators for environmental reconstruction

References:

Henderson, P., 1982. Inorganic geochemistry. opp.
McSween, H.Y., Richardson, S.M. and Uhle, M.E., 2003. Geochemistry: pathways and processes. Columbia University Press.
Gunter Faure: Isotopes Principles and Applications
WM White: Isotope Geochemistry
Hoefs: Stable isotope Geochemistry
Ian D. Clark and Peter Fritz: Environmental Isotopes in Hydrology
Tipple, B. J., & Pagani, M. (2007). The early origins of terrestrial C4 photosynthesis. Annu. Rev. Earth Planet. Sci., 35, 435-461.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 64

DST-Birbal Sahni Institute of Palaeosciences DST-BSIP

Course 3 : Advanced Course Physical Sciences Total Credits 6

Title:	Organic Geochemistry and Coal Petrology	Course Code	Credits
		AcSIR-64-PS-AD-002	

Composition and structure of Organic matter, Nomenclature, Stereochemistry, Organic matter accumulation and burial. Lipid biochemistry. Dominant factors controlling preservation of organic matter in sediments, Different stages of organic matter degradation, digenetic alterations of carbon skeletons, fossil fuel and natural biogas production, Biomarkers for ancient life. Advance techniques used in Organic geochemistry.

and Coal PetrologyFormation of coal, its classification and Macerals; Methodology of coal analysis; Palaeo-environment analysis & Utilization aspects; Distribution of coal and lignite resources in India.

References:

Stephen Killops and Vanessa Killops: Introduction to Organic Geochemistry.

Eglinton, Geoffrey, Murphy, Mary Teresa Joseph Organic Geochemistry.

Engel, Michael, Macko, Stephen A: Organic Geochemistry Principles and Applications.

Hatcher P G, Clifford D J. 1997. The organic geochemistry of coal: from plant materials to coal, Organic Geochemistry 27(5–6), 251-274.

Peters_K.E.,_Walters_C.C.,_Moldowan_J.M.The Biomarker Guide Second Edition- Vol. 2-Biomarkers and Isotopes in Petroleum Systems and Earth History

Douglas_Waples,_Tsutomu_Machihara_Biomarkers for Geologists—A Practical Guide to the Application of Steranes and Triterpanes in Petroleum Geology

Volkman. 2006-Marine Organic Matter - Biomarkers, Isotopes and DNA

AcSIR Academic Centre Code: 64			
DST-Birbal Sahni Institute of Palaeosciences			DST-BSIP
Course 3 : Advanced Course	Physical Sciences		Total Credits 6
Title: Geochronology and Dating Techniques		Course Code	Credits
		AcSIR-64-PS-AD-003	

Radioactivity – Mathematical relations for radioactive decay and radiogenic daughter's growth – Secular equilibrium – Radioactive disequilibrium – Radiometric dating techniques – U/Th series dating – Radiocarbon dating – Luminescence dating - 210Pb dating, Relative isotopic anomaly based dating, Palaeomagnetic dating .

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 64

DST-Birbal Sahni Institute of Palaeosciences DST-BSIP

Course 3 : Advanced Course Physical Sciences Total Credits 6

Title: Paleoclimatology and Palaeoceanography	Course Code	Credits
	AcSIR-64-PS-AD-004	

Introduction to PalaeoclimatologyPalaeoclimate proxies, Archives and proxies of past climate changes; Applications of palaeoclimatic studies; Earth's climate system and components; Feedback mechanism and response; Energy Balance of the Earth and its Atmosphere; Timescales of climatic variation; Variation in Orbital cycle and Milankovitch theory; Solar and Volcanic forcing; Geochronology application in palaeoclimatic studies; Abrupt climate change – Natural and Human fingerprint; Internal modes of climate variability – Oscillations and tele-connections; Atmospheric circulation patterns; Deep thermohaline circulation dynamics; Ekman transport and ocean currents; Biological productivity and energy transfer; Northern Indian Ocean-Monsoon dynamics and biogeochemistry; Ocean drilling programmes and expedition; Reconstructing and modeling past climates; Concept of climate modelling.

References:

Cline, R. M., and Hays, J. D. (eds.), 1976. Investigations of Late Quaternary Paleoceanography and Paleoclimatology. Boulder, CO: Geological Society of America. Geological Society of America memoirs, 145, 464 pp.

Fischer, G., and Wefer, G. (eds.), 1999. Use of Proxies in Paleoceanography. Examples from the South Atlantic. Heidelberg: Springer, 735 pp

Gornitz, V., 2009. Encyclopedia of Paleoclimatology and Ancient Environments. Springer Heidelberg.

Kennett, J., 1982. Marine Geology. Englewood Cliffs: Prentice-Hall, 813 pp

Schopf, T. J. M., 1980. Paleoceanography. Cambridge, MA: Harvard University Press, 341 pp.

Michael McElhinny, Phillip McFadden. 1999. Paleomagnetism, Continents and Oceans, Vol. 73, 2nd Edition. pp 904.

AcSIR Academic Centre Code: 64

DST-Birbal Sahni Institute of Palaeosciences DST-BSIP

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Paleomagnetism and Environmental magnetism, Remote Sensing and GIS methodologies and Applications	AcSIR-64-PS-AD-005	

Geomagnetism and Palaeomagnetism: Basics of Rock Magnetism: Principles, methods and applications; Magnetic elements and description of the Earth's magnetic field; Origin of Earth's magnetic field, magnetic reversals; Environmental magnetic minerals:-sources, transport and depositional processes in soils and sediments; Sediment sampling surveys, measurements, techniques. Magnetic mineral characterization using magnetic proxies: in soils & sediments and its implications. Data analysis and interpretations of environmental magnetic parameters. Palaeomagnetism, continental drift and polar wander. Applications of environmental and paleomagnetic studies- source, transport & deposition. Shelf & deep seas:-paleoclimate, paleoceanography and case studies. Magnetostratigraphy in lavas and sediments- Geomagnetic polarity time scales - Frequency of polarity reversals. Recent developments in Paleo-, rock and environmental magnetism.
Definition - Remote Sensing (RS) and GIS, Resolution in RS, Electromagnetic Energy (EMR), Types of sensors, Elements of Image interpretation, Digital Image Processing (DIP), Concept of Image classification - Supervised/ Unsupervised, GIS – Introduction and Applications, Remote Sensing and GIS applications in Geology, Vegetation, Land use/ land cover, soil, ecosystem modeling, ArcGIS, PaleoGIS, OPeNDAP.

References:

Nurgaliev, D., Shcherbakov, V., Kosterov, A., Spassov, S. (Eds.). 2019. Recent Advances in Rock Magnetism, Environmental Magnetism and Paleomagnetism. pp. 354.

Hirokuni Oda, Yuhji Yamamoto, Xixi Zhao, Satria Bijaksana, Qingsong Liu. 2016. Recent Advances in Environmental Magnetism and Paleomagnetism.

Michael McElhinny Phillip McFadden, 1999. Paleomagnetism, Vol. 73. 2nd Edition Continents and Oceans. pp. 386.

Basudeb Bhatta. 2020. Remote Sensing and GIS (3rd edition). Oxford University Press. pp 752.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Sedimentology and Stratigraphy	AcSIR-64-PS-AD-006	

Introduction to basic concepts, concept of flow regimes and bedforms, Sedimentary texture and Grain size analysis, Sedimentary structures, Paleocurrent analysis. Introduction to siliciclastic (Sandstone, Conglomerate and mudrocks), non-siliciclastic rocks (Carbonate and other biochemical rocks), diagenetic processes and histories, Sedimentary environments, Sedimentary basins and their classification, basin analysis (maps, cross sections, petrofacies, geological history, applications), Sedimentation in orogenic belts and cratons, plate tectonics and sedimentation, divergent margins, convergent margins, transform margins, secular changes in sedimentary record

Principles of stratigraphy, Facies Concept in Stratigraphy, Basic concepts of Litho-, Bio-, Sequence-, magneto-, seismic and chemo- stratigraphy. Methods of measurements of Geological time. Recent advances in Geological time Scale. Stratigraphic Correlation. Paleogeographic reconstructions and its application in oil exploration, Precambrian/ Cambrian boundary, Permian-Triassic boundary, Cretaceous-Tertiary boundary with special reference to India, Sequence of major Precambrian events in terms of rock record in Indian Stratigraphy, Precambrian biota and their application in stratigraphy, potential petroliferous basins of India and their brief stratigraphic framework, Continental Quaternary deposits and their significance.

References:

Pettijohn, F.J., 1975. Sedimentary Rocks, Harper and Row Publication, New Delhi.

Reineck, H.E. and Singh, I.B., 1980. Depositional Sedimentary Environments: with reference to terrigenous clastics. Springer-Verlag, Berlin Heidelberg.

Miall, A.D., 1999. Principles of Sedimentary Basin Analysis (3rd Edition) Springer Verlag, New York.

Nichols, G., 1999. Sedimentology and Stratigraphy, Blackwell publishing.

Tucker, M.E., 2006. Sedimentary Petrology. Blackwell Publishing.

Boggs Jr, S., 2017. Principles of Sedimentology and Stratigraphy (fifth edition). Pearson India Education Pvt. Ltd.

Ramakrishnan M. and Vaidyanadhan R., 2008. Geology of India (Vol. 1 & 2). GSI Publications, Bangalore, India.

Faculty of Study	Course Code	Course Title
Biological Sciences	AcSIR-66-BS-AD-001	Advanced Biotechnology
Biological Sciences	AcSIR-66-BS-AD-002	Biology of Macromolecules
Biological Sciences	AcSIR-66-BS-AD-003	Biotechniques and Instrumentation
Biological Sciences	AcSIR-66-BS-AD-004	Exploration of Microbes for Production of Bioactive Metabolites
Biological Sciences	AcSIR-66-BS-AD-005	Human Microbiome
Biological Sciences	AcSIR-66-BS-AD-006	Plant-Microbe Interaction
Chemical Sciences	AcSIR-66-CS-AD-001	Introduction to Nanoscience and Nanotechnology
Chemical Sciences	AcSIR-66-CS-AD-002	Analytical Techniques in Material Characterization
Chemical Sciences	AcSIR-66-CS-AD-003	Polymer, Polyelectrolytes & Polymer Based Sensors
Chemical Sciences	AcSIR-66-CS-AD-004	Introduction to Environmental Chemistry
Chemical Sciences	AcSIR-66-CS-AD-005	Techniques in Environmental Chemistry
Chemical Sciences	AcSIR-66-CS-AD-006	Advanced Nanoscience and Nanotechnology
Chemical Sciences	AcSIR-66-CS-AD-007	Natural Medicinal Chemistry
Mathematical & Information	AcSIR-66-MIS-AD-001	Differential Equations and Application
Mathematical & Information	AcSIR-66-MIS-AD-002	Epidemiology

Faculty of Study	Course Code	Course Title
Mathematical & Information	AcSIR-66-MIS-AD-003	Mathematical Theory of Hydrodynamics and Applications
Mathematical & Information	AcSIR-66-MIS-AD-004	Theory of Complex Analysis
Mathematical & Information	AcSIR-66-MIS-AD-005	Wave-structure Interaction and Solution Methods
Mathematical & Information	AcSIR-66-MIS-AD-006	Advanced Skills in AI
Mathematical & Information	AcSIR-66-MIS-AD-007	Biostatistics
Mathematical & Information	AcSIR-66-MIS-AD-008	Introduction to Computer Vision and Pattern recognition (CVPR)
Mathematical & Information	AcSIR-66-MIS-AD-009	Machine Learning
Mathematical & Information	AcSIR-66-MIS-AD-010	Statistical Analysis, Data driven modelling and Digital Image Processing
Physical Sciences	AcSIR-66-PS-AD-001	Plasma Physics
Physical Sciences	AcSIR-66-PS-AD-002	Applications of Plasma
Physical Sciences	AcSIR-66-PS-AD-003	Theory & Simulation of Plasma Physics
Physical Sciences	AcSIR-66-PS-AD-004	Advanced Condensed Matter Physics
Physical Sciences	AcSIR-66-PS-AD-005	Soft Matter Physics
Physical Sciences	AcSIR-66-PS-AD-006	Nano Physics
Physical Sciences	AcSIR-66-PS-AD-007	Techniques of Characterisation of Materials

66	DST-IASST	3	*Advanced Course*

Faculty of Study	Course Code	Course Title
Physical Sciences	AcSIR-66-PS-AD-008	Computational Techniques in Materials Science

AcSIR Academic Centre Code: 66

DST-Institute of Advanced Study in Science and Technology DST-IASST

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Advanced Biotechnology	Course Code	Credits
		AcSIR-66-BS-AD-001	2

Basic principles and techniques of electrophoresis;2D electrophoresis; ELISA (Enzyme Linked Immunosorbent Assay);High Speed Centrifugation;FTIR (Fourier Transformed Infra-Red Spectrophotometry); AAS (Atomic Absorption Spectrophotometry). Use of marker and selector genes for scoring; microinjection, bolistic transformation; principle, types and optimization of PCR; Real Time PCR; microsatellites; repetitive sequences; DNA and protein sequencing.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 66

DST-Institute of Advanced Study in Science and Technology	DST-IASST

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Biology of Macromolecules	AcSIR-66-BS-AD-002	1

Cell Biology Basic concept: life forms from prokaryotes to eukaryotes, Structure and function of Cell and Cell organelles, Nucleic acids and proteins; Molecular aspects of cell division and cell cycle, Chromatin structure; Organization of nucleosome and chromosomes, Mitochondrial Genome Organization. Basic macromolecular structure and function: DNA, RNA, protein, lipids and carbohydrates.

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AcSIR Academic Centre Code: 66

DST-Institute of Advanced Study in Science and Technology **DST-IASST**

Course 3 : Advanced Course	**Biological Sciences**	**Total Credits 6**

Title: Biotechniques and Instrumentation	**Course Code**	**Credits**
	AcSIR-66-BS-AD-003	**2**

Electrophoresis, Microscopy, Immunotechniques, Techniques in cell culture.

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AcSIR Academic Centre Code: 66

DST-Institute of Advanced Study in Science and Technology	DST-IASST

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Exploration of Microbes for Production of Bioactive Metabolites	Course Code	Credits
		AcSIR-66-BS-AD-004	1

Isolation, screening of microbes for industrial and agriculture application, production of bioactive metabolites for pharmaceutical and industrial lead/hits, DNA fingerprinting, DNA sequencing, Molecular characterization of genes and traits responsible for biological activity, enzyme production, isolation, purification, characterization and applications. Molecular characterization and genetic diversity for database preparation and preservation of biologically active secondary metabolite/s producing organisms.

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AcSIR Academic Centre Code: 66

DST-Institute of Advanced Study in Science and Technology DST-IASST

Course 3 : Advanced Course Biological Sciences Total Credits 6

Title:		Course Code	Credits
	Human Microbiome	AcSIR-66-BS-AD-005	2

Introduction to human microbiome, advanced study on human microbiome, microbiome and human health.

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Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

DST-Institute of Advanced Study in Science and Technology **DST-IASST**

Course 3 : Advanced Course	Biological Sciences	Total Credits 6

Title:	Course Code	Credits
Plant-Microbe Interaction	**AcSIR-66-BS-AD-006**	**1**

Introduction to plant-microbe interaction; Plant associated rhizobacteria, edophytic microorganisms and microbial diversity;Isolation, identification, characterization and molecular genetic diversity of plant growth promoting microbes; Microbial bio-inoculants; current advances in microbial bio-inoculants; bioprospecting from endophytes; plant metabolites from endophytes; host specificity, characterization of bioactive secondary metabolite biosynthetic pathways in endophytes, production of biologically active microbial metabolites in response to biotic stress, actinobacteria as source of bioactive metabolites; Concept, definitions, importance, principles of plant disease management with bioagents; Plant diseases and management, Biological control of pathogens; Role of microbial technology in agriculture.

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AcSIR Academic Centre Code: 66

DST-Institute of Advanced Study in Science and Technology DST-IASST

Course 3 : Advanced Course Chemical Sciences Total Credits 6

Title:	Introduction to Nanoscience and Nanotechnology	Course Code	Credits
		AcSIR-66-CS-AD-001	3

History of Nanoscience, Definition of nanometer, Nanomaterials, Classification of nanomaterials, Nanomaterials in nature. Shapes and structure of nanomaterials, Quantum dots, semiconductor nanoparticle, Carbon nanomaterials. Optical properties of nanoparticles.
Application of Nanotechnology: Application in Material Science, Application in Biology and Medicine, application in Energy and Environment.

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Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 66

DST-Institute of Advanced Study in Science and Technology — DST-IASST

Course 3 : Advanced Course — Chemical Sciences — Total Credits 6

Title:	Course Code	Credits
Analytical Techniques in Material Characterization	AcSIR-66-CS-AD-002	2

Spectroscopic methods (EPR, IR, UV, Fluorescence), Optical Microscopy, Electron Microscopy (SEM, TEM), Electron Probe Micro Analysis (EDS, WDS), Quantitative Analysis (AAS, ICP, CHN) Scanning probe microscopy: AFM, STM, MFM, confocal, etc, Raman spectroscopy/microscopy, Thermal analysis techniques, Spectroscopic ellipsometry. X-ray methods (XRD, XRF, SAXS), Chromatographic methods (TLC, GC, LC),

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Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

DST-Institute of Advanced Study in Science and Technology **DST-IASST**

Course 3 : Advanced Course **Chemical Sciences** **Total Credits 6**

Title:	Course Code	Credits
Polymer, Polyelectrolytes & Polymer Based Sensors	**AcSIR-66-CS-AD-003**	**2**

Solid-state chemistry and physics of various polymeric materials ranging from crystalline polymers to liquid crystalline polymers, colloids, gels and block copolymers. Classification of polymers in the structure point of view; hierarchical structure in semicrystalline polymers, synthesis of liquid crystalline (LC) polymers; thermotropic and lyotropic LC behavior, phase structure and transitions in LC polymers. Liquid crystal phases, classification, Chiral liquid crystalline phases, Ferroelectric liquid crystalline phases, discotic liquid crystalline phases, Characterization techniques, Characterization techniques to assess polymer behavior in thin films.

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Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 66

DST-Institute of Advanced Study in Science and Technology	DST-IASST

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Introduction to Environmental Chemistry	Course Code	Credits
		AcSIR-66-CS-AD-004	2

Course Description : Introduction to Water and Soil Chemistry,Risk Assesment on Polluted Water, Soil and Sediment system. Metal Speciation in Soil and Sediment matrix.Chemo-Bio techniques for remediation and reclamation of polluted water and soil system. Air Pollution monitoring and analysis,Air pollution effetes and control,Air pollution Metereology.

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Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 66

DST-Institute of Advanced Study in Science and Technology | DST-IASST

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Techniques in Environmental Chemistry	Course Code	Credits
		AcSIR-66-CS-AD-005	2

Analytical Tools and Techniques for Assessing Water, Soil and Air pollution.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 66

DST-Institute of Advanced Study in Science and Technology **DST-IASST**

Course 3 : Advanced Course	**Chemical Sciences**	**Total Credits 6**

Title:	Course Code	Credits
Advanced Nanoscience and Nanotechnology	**AcSIR-66-CS-AD-006**	**3**

Introduction to Nanoscience and Nanotechnology, Nanomaterials, Classification of nanomaterials, Nanomaterials in nature. Shapes and structure of nanomaterials, Quantum dots, semiconductor nanoparticle, Carbon nanomaterials. Optical properties of nanoparticles.
Quantum Mechanics of low dimensional system: Energy consideration, Bound state, density of states, Quantum confinement, Quantum transport in Nanoclusters/ quantum dots.
Synthesis of nanomaterial and device fabrication: Top down and bottom up approach, Synthesis techniques, Specialized growth technique for nanostructure.
Thin film fabrication technique, Optical, electrical and magnetic properties of nanostructured material, Nanocomposites.
Application of Nanotechnology: Application in Material Science, Application in Biology and Medicine, application in Energy and Environment. Recent advances in Nanotechnology.

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Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 66	
DST-Institute of Advanced Study in Science and Technology	DST-IASST

Course 3 : Advanced Course	Chemical Sciences	Total Credits 6

Title:	Course Code	Credits
Natural Medicinal Chemistry	AcSIR-66-CS-AD-007	2

Introduction to Natural Product and Medicinal Chemistry.Natural product extraction, bioactivity-guided fractionation, preparation of standardized active fraction, isolation and characterization of marker / active compounds. Chromatographic separation techniques, Structure elucidation of natural products, FT-IR, LCMS,1H and 13C NMR Spectroscopy, 2D NMR: H-H COSY, HSQC, HMBC and NOESY.

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Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 66

DST-Institute of Advanced Study in Science and Technology — DST-IASST

Course 3 : Advanced Course | Mathematical & Information Sciences | Total Credits 6

Title:	Course Code	Credits
Differential Equations and Application	AcSIR-66-MIS-AD-001	3

Existence and uniqueness of initial value problems: Picard's and Peano's Theorems, Gronwall's inequality, continuous dependence, maximal interval of existence.
Second and higher order linear equations: Fundamental solutions, Wronskian, variation of constants, behaviour of solutions.
Power series method, solution for the Legendre polynomials and Bessel functions.
Linear Systems: Autonomous systems and phase space analysis, matrix exponential solution, critical points, proper and improper nodes, spiral points and saddle points.
First order partial differential equations: Classification, method of characteristics for quasi-linear equations, Cauchy's problem, Cauchy-Kowalewski's theorem.
Second-order partial differential equations: Classification, normal forms and characteristics, Well-posed problem, Stability theory, energy conservation, and dispersion, Adjoint differential operators.
Laplace Equation: Maximum and minimum principle, Green's identity and uniqueness by energy methods, Fundamental solution, Poisson's integral formula, Mean value property, Green's function.
Heat equation: Maximum and minimum principle, Duhamel's principle.
Wave equation: D'Alembert solution, method of spherical means and Duhamel's principle.
Method of separation of variables for heat, Laplace and wave equations.

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Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 66

DST-Institute of Advanced Study in Science and Technology DST-IASST

Course 3 : Advanced Course Mathematical & Information Sciences Total Credits 6

Title: Epidemiology	Course Code	Credits
	AcSIR-66-MIS-AD-002	2

Scope of epidemiology, Measures of disease frequency, Measures of association, Measures of population impact, Measures of dynamics of infectiousness, Ecological/geographical studies, Case control studies, Cohort studies, Intervention studies and Randomised Controlled Trials, Routine data sources: registries and record linkage, mortality, sociodemographic information, Disease trends and standardization, Random error/chance, Bias, Confounding, Interaction and effect modification, Association and causation, Validity and reliability, Screening, Research synthesis.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
Approved at the 27th meeting of Senate, AcSIR on Sep 10, 2020

AcSIR Academic Centre Code: 66

DST-Institute of Advanced Study in Science and Technology DST-IASST

Course 3 : Advanced Course	Mathematical & Information Sciences	Total Credits 6

Title:	Course Code	Credits
Mathematical Theory of Hydrodynamics and Applications	AcSIR-66-MIS-AD-003	3

Eqaution of motion , Two dimensional flow, Navier-Stokes equation of motion, Velocity potential and Laplace equation, Simple irrotational flows, Separation of variables for an axisymmetric flow, Bernoulli equation for unsteady irrotational flow, Deep water wave, Shallow water wave, Theory of surface wave, Finite amplitude wave, Water wave interaction with very large floating structure, Solitary waves, Schrodinger equation.

Reommended at the 4th meeting of Board of Studies, AcSIR on Sep 7, 2020.
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AcSIR Academic Centre Code: 66

DST-Institute of Advanced Study in Science and Technology DST-IASST

Course 3 : Advanced Course | Mathematical & Information Sciences | Total Credits 6

Title: Theory of Complex Analysis	Course Code	Credits
	AcSIR-66-MIS-AD-004	3

Analytic functions, properties of elementary analytic functions. Complex integration, Cauchy's theorem, Liouville's theorem, power series representation, open mapping theorem, calculus of residues. Harmonic functions, Poisson integral, Harnack's theorem, Schwarz reflection principle. Maximum modulus principle, Schwarz lemma, Phragmen-Lindelof method. Runge's theorem, Mittag-Leffler theorem, Weierstrass theorem, Jensen's formula, Hadamard's theorem.

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DST-Institute of Advanced Study in Science and Technology	DST-IASST

Course 3 : Advanced Course	Mathematical & Information Sciences	Total Credits 6

Title:	Course Code	Credits
Wave-structure Interaction and Solution Methods	AcSIR-66-MIS-AD-005	3

Wave forces on structures, Morison equation, Froude-Krylov theory, Diffraction Theory, Perturbation method of solutions Radiation, Dynamics of floating structures, damping and added-mass, Intraction of water waves with spherical and cylindrical objects, Hydrodynamic coefficients, Nonlinear long waves in shallow water, KdV equation, Inverse scattering transforms and the theory of solitons, Scrodinger equation, Soliton solution of the KdV equation

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DST-Institute of Advanced Study in Science and Technology **DST-IASST**

Course 3 : Advanced Course **Mathematical & Information Sciences** **Total Credits 6**

Title:	Course Code	Credits
Advanced Skills in AI	**AcSIR-66-MIS-AD-006**	**3**

Advanced Computer Vision: Bilinear models, symmetricmodel, asymmetric model, classification, extrapolation, translation of the data set.

Structure from motion & image motion: Domain dependent & domain independent motion understanding, optical flow adjacency, depth and collision, surface orientation and edge detection, egomotion, understanding of image sequences and probability theory for clustering. Review of Bayes theorem. Maximum likelihood estimation, Bayesian estimation. Object recognition pose Estimation using analytical or geometrical methods and learning based methods. Object tracking with adaptive background

generation & shadow removal using single & multi camera tracking techniques with common algorithms for filtering and data association.

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DST-Institute of Advanced Study in Science and Technology	DST-IASST

Course 3 : Advanced Course	Mathematical & Information Sciences	Total Credits 6

Title:	Course Code	Credits
Biostatistics	AcSIR-66-MIS-AD-007	2

Introduction to biostatistics and computing using SPSS / R, Descriptive statistics, Normal distribution and confidence intervals, Comparison of continuous variables between two groups, Hypothesis tests and p-values, Comparison of categorical variables between two groups, Comparison of variables between two groups using distribution free methods, Correlation and simple linear regression, Multiple linear regression with several continuous exposures, Multiple linear regression with binary and categorical exposures, Multiple linear regression in practice, Logistic regression, Survival analysis.

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DST-Institute of Advanced Study in Science and Technology **DST-IASST**

Course 3 : Advanced Course **Mathematical & Information Sciences** **Total Credits 6**

Title:	Course Code	Credits
Introduction to Computer Vision and Pattern recognition (CVPR)	**AcSIR-66-MIS-AD-008**	**3**

Introduction to Computer vision- Fundamentals of Computer Vision, Computer Vision Research and Application on image formation, camera model and camera calibration, properties of projection, interaction of light and its modeling, perspective modeling, homogeneous coordinate, lens equation, types of image digitizers and image digitizing components. Feature Extraction, filtering and edge detection, fourier transform, texture primitives and texture as a pattern recognition problem, wavelets and multiresolution processing including image pyramids, subband coding, Harr Transform; multiresolution expansions and colour processing. Tutorial on Matlab platform & Project. Python data structure, Loops, Classes, Linear Algebra; Google Colab, GPU service, Useful Python libraries, GitHub.

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DST-Institute of Advanced Study in Science and Technology **DST-IASST**

Course 3 : Advanced Course **Mathematical & Information Sciences** **Total Credits 6**

Title:	Course Code	Credits
Machine Learning	**AcSIR-66-MIS-AD-009**	**3**

Decision Trees: Definition of a decision tree, metrics of impurity, greedy algorithm to split a node, tree depth and pruning, ensemble of trees (random forest)
Bayesian decision theory: Maximum likelihood estimation, conditional probability, linear algebra regression Bayes rule: Prior, likelihood, posterior, evidence, Gaussian density, sufficient statistics, maximum likelihood derivation for mean and covariance.
Linear models: linear regression and its analytical solution, loss function, gradient descent and learning rate, logistic regression and its cost, SVM: hinge loss with L2 penalty
Kernelization: Support vector machine, Kernel trick, Dual form of an SVM, kernels for a dual form, examples of kernels and their typical uses, SVR in primal form, SVR in dual form.
Feature selection and engineering: T-test, forward selection, features for images, features for audio, features for images, features for NLP, PCA, ZCA, K-PCA
Dense and shallow neural networks: Logistic regression as a sigmoid, single hidden layer using sigmoid and ReLU, approximation of any function using a single hidden layer, overfitting, advantage of multiple hidden layers, neural networks for regression, multiregression, multi-classification using softmax, back propagation.
Advanced topics in neural networks: Weight initialization, momentum, weight decay, early stopping, batch SGD, advanced optimizers such as RMSprop and ADAM
Clustering: Introduction to clustering, K-means clustering, Cluster analysis, K-means, DBSCAN, agglomerative clustering, scaling of dimensions, goodness of clustering.
CNNs for Image classification: Digital image processing filters, Dense Neural. Applications of computer vision, implementation of convolution, building a convolutional neural network, image Classification using CNNs.
Semantic segmentation: Basics of CNN, Digital image processing filters, Dense Neural Networks. Using CNNs for semantic image segmentation, labelling specific regions of an image, Detecting instances of semantic objects, tasks of computer vision, Unsupervised Learning, Representation Learning, Density.

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DST-Institute of Advanced Study in Science and Technology DST-IASST

Course 3 : Advanced Course Mathematical & Information Sciences Total Credits 6

Title:	Statistical Analysis, Data driven modelling and Digital Image Processing	Course Code	Credits
		AcSIR-66-MIS-AD-010	2

Statistics In research, Common terms in statistics, Constraints in research, population and sample, Choosing appropriate sample size, Sampling, Errors in sampling, Data collection, Bias in statistics, Data representation, Types of data, data analysis, Measures of central tendency, Standard deviation, Variance, Standard error of means, Gaussian distribution, Normal distribution curve, Skewness, Tests of significance – t/z/ANOVA, chi square test, correlation and regression analysis.
Applied Machine Learning: Linear algebra revisited, ML Tools, Supervised learning, Unsupervised learning, Artificial intelligence based methods, Model validation, Practical applications in data reduction, feature selection, classification.
Elements of visual perceptions : digital Image sensing, sampling and quantization, digital image representation, basic relationship between pixels, elements of digital image processing system.
Image transforms: Discrete Fourier transform and properties, separable image transforms, image enhancement.
Wavelet transforms.
Restoration and Reconstruction: Image restoration, image segmentation, image reconstruction from projections.
Statistical pattern recognition: Cluster analysis, feature selection & extraction, syntactic pattern recognition: stochastic languages, problem solving methods for pattern recognition.

Case studies: Medical image processing, colour image processing, thermal image processing.

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DST-Institute of Advanced Study in Science and Technology DST-IASST

Course 3 : Advanced Course Physical Sciences Total Credits 6

Title:	Course Code	Credits
Plasma Physics	AcSIR-66-PS-AD-001	2

Plasmas: Definition, Criterion for plasma, Debye shielding, Natural occurrence of plasmas
Single particle motion: Gyromotion in magnetic field, Motion in E-B field, Particle drift motion
Plasma as fluids: Two fluids model of plasma, Plasma fluid equation
Waves in plasma: Linearization procedure, Plasma oscillation, Electromagnetic waves in plasmas, Cut-off and resonances, Hydromagnetic waves, Magnetosonic wave
Diffusion and resistivity: Diffusion and mobility in weakly ionize plasma, Diiffusion across the magnetic field, Collision in fully ionized plasma, Single fluid MHD equation, Diffusion in fully ionize plasma, Bohm diffusion and Neoclassical diffusion
Introduction of Kinetic theory of Plasma: Meaning of distribution function, Equations in kinetic theory, Plasma Oscillation and Landau damping
Plasma diagnostics: Langmuir probe design, construction and plasma parameter measurement, Optical Emission Spectroscopy for plasma diagnostics

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DST-Institute of Advanced Study in Science and Technology DST-IASST

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Applications of Plasma	AcSIR-66-PS-AD-002	2

Plasma chemistry: Molecular collisions, Chemical reactions, Surface processes, Plasma enhanced chemical vapour deposition (PECVD), Plasma polymerization, Thin film deposition. Plasma etching: Ion etching, Reactive ion etching, Plasma ashing, Plasma based pattern transfer. Magnetron sputtering: Introduction to sputtering, Planar magnetron, Cylindrical magnetron, Film deposition and nanoparticle synthesis by magnetron sputtering. Atmospheric plasma applications: Dielectric barrier discharge, Atmospheric pressure plasma jet, Fused hollow cathode cold atmospheric plasma, Atmospheric plasma for decontamination, Plasma medicine, Atmospheric plasma for material synthesis. Liquid plasma: Basics of liquid plasma discharge, Liquid plasma for nanoparticle synthesis and decontamination.

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DST-Institute of Advanced Study in Science and Technology	DST-IASST

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Theory & Simulation of Plasma Physics	AcSIR-66-PS-AD-003	2

Nonlinear waves in plasma, Kinetic description, Partial differential equations, Navier–stokes equation, Vlasov equation, Plasma as fluid and derivation of fluid equations.
Transport phenomena, Classical transport equations and collisional relaxation processes.
Electrostatic waves in plasma, Nonlinearity and dispersion, Electron & Ion plasma waves, Ion acoustic wave, Solitary and shock wave propagation, K-dV equation, K-dV-Burgers (K-dVB) equation and stationary solutions.
Reductive perturbation method, Sagdeev potential approach, Linear electrostatic waves in plasmas.
Simulation of plasma wave equations, Approximation of differential equations, Numerical solution of K-dV and K-dVB equations. Graphical representation of waves in plasma, Introduction to Matlab, Mathematica and OriginLab etc.

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DST-Institute of Advanced Study in Science and Technology | DST-IASST

Course 3 : Advanced Course | Physical Sciences | Total Credits 6

Title:	Course Code	Credits
Advanced Condensed Matter Physics	AcSIR-66-PS-AD-004	2

Crystal systems: Lattices and space groups, Reciprocal lattices, Defects in solids, Bonding in solids, Band theory: Metals, Insulators, Semiconductors, Properties of solids: Dielectric and ferroelectric properties, Magnetic properties, Electrical properties, Optical properties, Tight binding method, Augmented plane wave method, Pseudopotentials, Lattice dynamics, Phonons.

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DST-Institute of Advanced Study in Science and Technology	DST-IASST

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Course Code	Credits
Soft Matter Physics	**AcSIR-66-PS-AD-005**	**2**

Soft matters, Self-assembly, Structures, Ordering and organization, Intermolecular forces in soft matters, Phases and phase transitions, Properties in 2D dimensions, Organic monolayers and multilayers, Polymers, Colloids, Liquid crystals, Surfactants, Biomolecules, Metal-organic systems, Nanoclusters, Scattering techniques (X-ray, neutron and light scattering) in soft matters, Microscopic techniques (optical, electron and atomic force microscopy) in soft matters, Soft matters: Its broadness and applications.

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DST-Institute of Advanced Study in Science and Technology	DST-IASST

Course 3 : Advanced Course	Physical Sciences	Total Credits 6

Title:	Nano Physics	Course Code	Credits
		AcSIR-66-PS-AD-006	2

Low-dimensional structures (quantum well, quantum wire, quantum dot), Surface properties and functionalization, Nano clusters & nano crystals, Strong and weak confinement of excitons, Optical absorption and emission, Transport properties of nanostructures, Nanoscale magnetism, Light-matter interaction at nanoscale, Evanescent wave, Light at a metal-dielectric interface, Near-field optics, Theory of surface plasmon nanophotonics.

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DST-Institute of Advanced Study in Science and Technology	**DST-IASST**

Course 3 : Advanced Course	**Physical Sciences**	**Total Credits 6**

Title:		Course Code	Credits
	Techniques of Characterisation of Materials	**AcSIR-66-PS-AD-007**	**2**

Principles and applications of the instruments and their techniques: X-ray diffraction, Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Scanning tunnelling microscopy (STM), Electron energy loss spectroscopy (EELS), Atomic force microscopy (AFM), Magnetic force microscopy, X-ray photoelectron spectroscopy, Auger electron spectroscopy, energy dispersive X-ray spectroscopy, X-Ray absorption spectroscopy, UV-visible spectroscopy, Steady state and time resolved spectroscopy, Fourier transform infrared spectroscopy (FTIR), Raman spectroscopy, Thermo-gravimetric analysis, Differential thermal analysis, BET analysis, magnetic study of materials with VSM, SQUID, Deep level transient spectroscopy, Positron annihilation spectroscopy, Attosecond spectroscopy.

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DST-Institute of Advanced Study in Science and Technology			**DST-IASST**
Course 3 : Advanced Course	**Physical Sciences**		**Total Credits 6**
Title: Computational Techniques in Materials Science		**Course Code**	**Credits**
		AcSIR-66-PS-AD-008	**2**

Linux operating system, Basics of shell scripting, Graphics through Gnuplot, VESTA, Errors and fitting of data: Concepts of errors in data, Fitting experimental data with parametrized models, Least square method, Convergence criteria, Fit quality tests, Classical molecular dynamics (MD) simulation: Force calculation, Verlet algorithm, Periodic boundary conditions, Finite-difference time-domain (FDTD) method: Yee algorithm, Inhomogeneities, Lossy material, Introduction to density functional theory (DFT): Quantum many-body problem, Hohenberg-Kohn theorem, Kohn-Sham ansatz, Self consistent field (SCF) cycle, Exchange-correlation functionals in DFT, Local density approximation (LDA), Generalized gradient approximation (GGA), Beyond LDA and GGA.

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