BHARATHIAR UNIVERSITY
COIMBATORE

A three-year Under-Graduate Programme in

B. Sc. (Blended) Chemistry

Offered By
Centre for International Affairs (CIA), Bharathiar University

in collaboration with The University of Melbourne
(For the students admitted during the academic year 2023 – 24 onwards)

Syllabus for SEM I – VI

(To Be Implemented from Academic Year 2023 – 2024)

For detailed understanding of the principles and structure of the curriculum please refer the

"Annexure 1"

Overview of the B. Sc. (Blended) Course

Bharathiar University is offering an innovative Bachelor's Degree known as B.Sc. (Blended) in collaboration with the University of Melbourne (UoM), Australia, to strengthen science education at the undergraduate level.

Bharathiar University is among the top universities in the country and has been at the forefront of initiating innovative programs. The UoM is ranked #1 in Australia and has been among the top 50 universities in the world.

The B.Sc. (Blended) course is a joint initiative of BU-UoM, offering a transparent and internationally recognized bachelor's degree that clearly outlines the teaching objectives and learning outcomes. In the first two years of the degree program, students will study all four basic sciences (Biology, Chemistry, Mathematics, and Physics), and in the third year, they will specialize in either Physics or Chemistry. The UoM will provide support in terms of special lectures, workshops, and quality assurance.

The B.Sc. (Blended) course aims to achieve the following objectives:

- Introduce students to the fundamental concepts of science education.
- Enrich students' knowledge in all basic sciences, including Biology, Chemistry, Mathematics, and Physics.
- Help students develop an interdisciplinary approach to learning that integrates various scientific fields.
- Inculcate a sense of scientific responsibility, social awareness, and environmental consciousness in students.
- Assist students in building a successful and progressive career in academia and industry by providing them with the necessary skills and knowledge.

The B.Sc. (Blended) course will be jointly conducted by Bharathiar University and the University of Melbourne (UoM). **The following features are included in the course:**

- Special lectures will be delivered by expert faculty from UoM and other renowned institutes.
- UoM will provide online teaching of certain topics from the syllabus to supplement students' learning.
- The course will be quality assured by UoM, ensuring that it meets the highest standards of education.
- Upon completion, the degree will be considered equivalent to a degree from UoM, enabling students to pursue higher studies at UoM or any other Australian university.

- The collaboration with UoM ensures that students receive an internationally recognized education of the highest quality, opening up opportunities for further academic pursuits and careers in various fields. The students will be imparted solid training to enable them to pursue Masters and Integrated Ph. D. degrees in reputed institutes such as IITs, IISERs and Central Universities

Eligibility

Higher Secondary School Certificate (10+2) or its equivalent Examination in Science stream with either PCM group (Physics, Chemistry & Mathematics) or PCMB group (Physics Chemistry, Mathematics & Biology)

Course Structure

- The B.Sc. (Blended) course follows a semester and credit system that spans over six semesters of 14 weeks each. The course curriculum is divided into two phases: the first two years and the third year.
- During the first two years, students will receive instruction in the four basic sciences, namely Biology, Chemistry, Mathematics, and Physics. In the third year, students will specialize in either Physics or Chemistry.
- The course's credit-based system provides students with the flexibility to choose their course load and study at their own pace while meeting the course's requirements. The curriculum is designed to provide students with a well-rounded education in the sciences, preparing them for further academic pursuits or careers in various scientific fields.

Examination and Grading

- The B.Sc. (Blended) course follows a credit-based system, and its examination process comprises two parts: continuous assessment (internal 50%) and end-semester examination (50%).
- The internal assessment will be based on various parameters, including classroom examinations (subjective/objective), fieldwork, viva-voce, assignments, lab work, tutorials, and group discussions. The grading will be carried out in accordance with the university norms applicable to the credit system.
- This examination process ensures that students are regularly assessed and evaluated based on their academic performance, facilitating a more comprehensive understanding of the subjects and enhancing the overall learning experience. The grading will be as per the university norms applicable to credit system.

University Terms

- The commencement and conclusion dates for the odd and even semesters of the B.Sc. (Blended) course will adhere to the university regulations applicable to other departments.

- To be eligible for the term-end examination, students must fulfill the minimum attendance requirement of 75 percent for both theory and practical courses. Additionally, students must demonstrate satisfactory performance during the term.

- Adherence to these guidelines ensures that students attend classes regularly and maintain consistent academic performance throughout the term. This, in turn, promotes a positive and conducive learning environment for all students.

Intake capacity of student: B. Sc. Blended course: 40 (20 for Physics and 20 for Chemistry)

Duration: The duration of **B. Sc. (Blended)** Degree Program shall be of three years.

Medium of Instruction: The medium of instruction for the course shall be English.

Scheme of Examinations (CBCS Pattern)

Number of weeks in a semester: 15 (excluding holidays and one week mid semester examination)

Nomenclature: BIO: Biology. CHM: Chemistry. MTH: Mathematics PHY: Physics ENG: English; COMP –Computing; IDC: Interdisciplinary Course; FLX: Flexible timetabling

1 Credit =1 Contact hour per week both for theory and lab courses

Course Code	Title of the Course	Credits	Hours		Maximum Marks		
			Theory	Practical	CIA	ESE	Total
FIRST SEMESTER							
MTH101	**Maths 1: Calculus**	**4**	**4**	**-**	**50**	**50**	**100**
PHY101	**Physics 1: Introductory Classical Physics**	**4**	**4**	**-**	**50**	**50**	**100**
CHM101	**Chemistry 1: Introductory and Organic Chemistry**	**4**	**4**	**-**	**50**	**50**	**100**
BIO101	**Biology 1: The Diversity of Life**	**4**	**4**	**-**	**50**	**50**	**100**
PHY102	**Physics Practical**	**2**	**-**	**2**	**25**	**25**	**50**
CHM102	**Chemistry Practical**	**2**	**-**	**2**	**25**	**25**	**50**
BIO102	**Biology Practical**	**2**	**-**	**2**	**25**	**25**	**50**
11T/11H/11M (FLX101*)	Part I: Language Paper I- Tamil/Malayalam/French/ Hindi##	4	4	-	50	50	100
12E (FLX102**)	Part II: English I ##	4	4	-	50	50	100
1FA#	Foundation Course: Environmental Studies	2	2	-		50	50
	Total	32	26	6	375	425	800
** **and** ** indicates the mandatory language papers for all UG students as per the TN state government. # indicates the UGC mandatory course that all students must opt for. This course will be taught either in online mode or offline mode.*							
SECOND SEMESTER							
MTH201	**Maths 2: Algebra**	**4**	**4**	**-**	**50**	**50**	**100**
PHY201	**Physics 2: Modern Physics**	**4**	**4**	**-**	**50**	**50**	**100**
CHM201	**Chemistry 2: Inorganic and Physical Chemistry**	**4**	**4**	**-**	**50**	**50**	**100**
BIO201	**Biology 2: Biology of Cells**	**4**	**4**		**50**	**50**	**100**
PHY202	**Physics Practical**	**2**	**-**	**2**	**25**	**25**	**50**

CHM202	**Chemistry Practical**	**2**	**-**	**2**	**25**	**25**	**50**
BIO202	**Biology Practical**	**2**	**-**	**2**	**25**	**25**	**50**
IDC201	**Scientific Computation and Modeling: Introduction to simple models and programming**	**4**	**4**	**-**	**50**	**50**	**100**
21T/21H/21M (FLX201*)	Part I: Language Paper II- Tamil/Malayalam/French/Hindi##	4	4	-	50	50	100
22E (FLX202**)	Part II: English II ##	4	4	-	50	50	100
2FB#	Foundation Course: Human Rights	2	2	-		50	50
	Total	36	30	6	425	475	900
** and ** indicates the mandatory language papers for all UG students as per the TN state government. # indicates the UGC mandatory course that all students must opt for. This course will be taught either in online mode or offline mode.*							

THIRD SEMESTER							
MTH301	Maths 3: Vector Calculus, and Differential Equations	4	4	-	**50**	**50**	100
PHY301	Physics 3: Quantum mechanics and Thermodynamics	4	4	-	**50**	**50**	100
CHM301	Chemistry 3: Reactions and Synthesis	4	4	-	**50**	**50**	100
BIO301	Biology 3: Functional Biology of Organisms	4	4	-	**50**	**50**	100
PHY302	Physics Practical	2	-	2	25	25	50
CHM302	Chemistry Practical	2	-	2	25	25	50
BIO302	Biology Practical	2	-	2	25	25	50
IDC301	Scientific Computation and Modeling: Projects*	4	-	4	50	50	100
31T/31H/31M	Part I: Language Paper III- Tamil/Malayalam/French/Hindi##	4	4	-	50	50	100
32E	Part II: English III ##	4	4	-	50	50	100
3FC#	Yoga for Human Excellence	2	2	-		50	50
	Total	36	26	10	425	475	900
** and ** indicates the mandatory language papers for all UG students as per the TN state government.*							

# indicates the UGC mandatory course that all students must opt for. This course will be taught either in online mode or offline mode.							
FOURTH SEMESTER							
MTH401	Maths 4: Probability and Statistics	4	4	-	50	50	100
PHY401	Physics 4: Electricity, magnetism, Special Relativity and Optics	4	4	-	50	50	100
CHM401	Chemistry 4: Structure and properties	4	4	-	50	50	100
BIO401	Biology 4: Genetics Evolution and Ecology	4	4	-	50	50	100
PHY402	Physics Practical	2	-	2	25	25	50
CHM 402	Chemistry Practical	2	-	2	25	25	50
BIO402	Biology Practical	2	-	2	25	25	50
41T/41H/41 M	Part I: Language Paper IV- Tamil/Malayalam/French/ Hindi##	4	4	-	50	50	100
42E	Flexible timetabling Part II: English IV ##	4	4		50	50	100
4FC#	General Awareness	2	2	-	-	50	50
	Total	32	26	6	375	425	800
**** and ***** *indicates the mandatory language papers for all UG students as per the TN state government.* *# indicates the UGC mandatory course that all students must opt for. This course will be taught either in online mode or offline mode.*							
FIFTH SEMESTER							
CHM 501	Chemical Kinetics, Thermodynamics & Quantum Chemistry	4	4	-	50	50	100
CHM 502	Catalysis and Industrial Processes	4	4	-	50	50	100
CHM503	Design & Synthesis of Organic Molecules	4	4	-	50	50	100
CHM 504	Introduction to Analytical Chemistry	4	4		50	50	100
CHM 505	Elective - 1	2	2	-	25	25	50
CHM 506	Elective - 2	2	2	-	25	25	50

CHM 507	Physical/Analytical Chemistry Lab	2	-	2	25	25	50
CHM 508	Inorganic/Organic Chemistry Lab	2	-	2	25	25	50
CHM 509	Graduate Level Thesis	2	-	2	25	25	50
	Total	26	20	6	325	325	650
	SIXTH SEMESTER						
CHM 601	Solid State Chemistry and its applications	4	4	-	50	50	100
CHM 602	Bioinorganic and Coordination Chemistry	4	4	-	50	50	100
CHM 603	Natural Product & Heterocyclic Chemistry	4	4	-	50	50	100
CHM 604	Separation Techniques and advanced analytical techniques	4	4	-	50	50	100
CHM 605	Elective - 3	2	2	-	25	25	50
CHM 606	Elective - 4	2	2	-	25	25	50
CHM 607	Physical/Analytical Chemistry Lab	2	-	2	25	25	50
CHM 608	Inorganic/Organic Chemistry Practical	2	-	2	25	25	50
CHM 609	Graduate Level Thesis	2	-	2	25	25	50
	Total	26	20	6	325	325	650
	Grand Total	**188**			2200	2500	**4700**

List of Elective papers

(Students can choose any one of the paper as electives among A or B)

Elective – I	**A**	Molecular Modeling in Chemistry
	B	Pharmaceutical Chemistry
Elective – II	**A**	Introduction to forensic Science and technology
	B	Introduction of Industry 4.0
Elective – III	**A**	Material Chemistry
	B	Dye Chemistry
Elective – IV	**A**	Supramolecular Chemistry
	B	Internet of Things (IoT)

SEMESTER I

Course code	MAT101	Maths-1	4 Credits	
Core/Elective/SBS		CORE PAPER		
			Syllabus Version	2023-24

Unit-1:Logic and Proof

Basic set theory(review)
Logical connectives (conjunction, disjunction, negation, conditional, bi-conditional)and truth tables
Propositional logic, logical equivalence, logical laws
Quantifiers, predicate calculus
Relations, equivalence relations, ordering
Functions including injective, surjective, bijective, inverse, composition

Unit-2:

Number systems: Natural numbers, integers, rational numbers and their
Properties(eg. closure under addition/multiplication/division; existence of additive/multiplicative identity/inverses)
Real numbers and their properties; completeness property
Proof methods: direct proof, Contrapositive
Proof methods: contradiction, proof by cases
Proof methods: induction
Natural numbers, integers, rational numbers
Real numbers

Unit-3: Sequences and series

Sequences, limits, convergence and divergence
Proving limits using definition
Methods for evaluating limits: standard limits, limit theorems, continuity rule, sandwich theorem
Series, convergence and divergence of series, geometric series, harmoni cp-series
Series convergence tests: divergence test, comparison test
Series convergence tests: ratio test, integral test, alternating series test
Power series, Taylor polynomials
Taylor series
Taylor's theorem, error in Taylor polynomial estimates

Unit-4: Differential calculus& Integral Calculus

Review of differential calculus: limits, derivative, differentiation rules incl. polynomials, trigonometric, exponential, log functions; product, quotient, chain rules
Review of inverse trigonometric functions and their derivatives, implicit differentiation
Integral calculus
Riemann integration
Fundamental Theorem of Calculus; review of standard anti-derivatives
Techniques of integration(review): derivative present substitution, linear substitution

Unit-5

Techniques of integration (review): integration of trigonometric functions
Using identities

Techniques of integration (review): integration of rational functions Including partial fractions, integration yielding inverse trig functions Techniques of integration (review): trigono metric substitutions; Integration by parts Improper integrals Applications of integration: areas between curves Applications of integration: volumes of surfaces of revolution Ordinarydifferentialequations:definitionofODE,order,generalsolution,initialconditions;separable ODEs Solving linear ODE using integrating factor Particular solutions of in homogeneous constant coefficient linear ODEs Using method of undetermined coefficients; principle of superposition
Reference Books
Discrete Mathematics and Its Applications with Combinatorics and Graph Theory (SIE) (7th Edition) by Kenneth Rosen. Publisher: McGraw Hill Education; Year: 2017; ISBN-13: 978-0070681880, 998 pp. Mathematical Proofs: A Transition to Advanced Mathematics (Featured Titles for Transition to Advanced Mathematics) by Gary Chartr and, Albert D. Polimeni, Ping Zhang. Publisher: Pearson; Year: 2012; ISBN-13: 978-0321797094; 424 pp. Calculus by James Stewart. Publisher: Cengage Learning; Year: 2015; ISBN-13: 978-1285740621; 1392 pages Calculus: Concepts and Contexts, by James Stewart. Publisher : Brooks/Cole; Year: 2015; ISBN-13 : 978-1337687669; 1152 pages. Calculus: A Complete Course by Robert Adams, Christopher Essex. Publisher : Pearson; 9th edition; Year: 2015; ISBN-13 : 978-0134154367; 1168 pages.

Course code	PHY101	Physics 1: Introductory Physics	4 Credits	
Core/Elective/SBS		CORE PAPER		
			Syllabus Version	2023-24

Unit:1	Classical Mechanics	

Straight line motion – Vectors – Two and three dimensional motion – Force and Motion : Newton's Laws – Force and Motion : Drag and Friction – Kinetic energy, work, power – Potential energy, conservation of energy – Collisions and momentum – Rotational motion – Angular momentum-I – Angular momentum-II

Unit:2	Gravitation	

Newton's law of gravity – superposition – Gravity at the earth's surface – far above the earth and within the earth – Work and gravitational potential energy - Kepler's laws : the planets and satellites – Orbital motion and energy – Einstein, the equivalence principle, gravity, gravitational lenses, gravitational waves

Unit:3	Thermal physics	

Zeroth Law of Thermodynamics – Thermal expansion and absorption of heat – Heat transfer, conduction, emission, absorption

Unit:4	Elasticity, fluids and gases	

Equilibrium and elasticity – Density and Pressure, Pascal's and Archimedes' Principles – Continuity and Bernoulli's Equation – Ideal gases (Kinetic theory of gases) – Mean free path, molecular speed distribution – Specific heat, adiabatic expansion – Real world examples – examples: wind power, hydro, blood circulation, water in plants, materials, osmosis, wind and atmosphere

Unit:5	ODEs	

Applications of 2^{nd} order ODEs: Springs – Applications of 2^{nd} order ODEs: LRC series electrical circuits – Real world contextual examples in physics and application of ODEs

TextBook(s)

1	Properties of Matter, Brijlal and N.Subrahmanyam,3rdEdition, S.Chand & Co.(2005).
2	Heat & Thermodynamics, Brijlal & N.Subramaniam, S.Chand & Co(2007)

Reference Books

1	Elements of Properties of Matter, D.S.Mathur, 11thEdition, S.Chand &Co.,(2010).
2	Heat and Thermodynamics–Zemansky and R.H.Dcltanann,TMH (2017)

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.,]

1	https://www.physicstutoronline.co.uk/alevelphysicsnotes/
2	https://latestcontents.com/bsc-physics-mechanics-notes/
3	https://www.askiitians.com/revision-notes/physics/thermodynamics/
4	www.khanacademy.org/science/physics/elasticity/surfacetension

Course Code	CHM101	GENERAL CHEMISTRY – CHEMISTRY OF LIFE	4 Credits
CORE		Chemistry 1	
			Syllabus Version 2023-2024

UNIT I	General Chemistry	

The Periodic Table - The Basis of the Periodic System, Classifications of Elements and Groups - Molecular Structure and Bonding - Chemical Bonding, Types of Chemical Bonds, Bond Characteristics - Acids and Bases - Theories of Acids and Bases, pH of Acids and Bases, Properties of Acids and Bases - Stoichiometry - Stoichiometric Coefficient, Balanced Reactions and Mole Ratios

UNIT II	Organic Chemistry	

Carbon - The Basis of Life - Structure and Bonding Alkanes - Alkanes Formula and its Condensed Structures, Branched Chain Alkane Formula, sp^3Hybridisation - Structure and Bonding Alkenes - sp^2Hybridisation - Benzene and its derivatives - Structure and Bonding of Alkynes - sp hybridization

UNIT III	Organic Chemistry	

Functional Groups - Nomenclature of Common Functional Groups -Electrophiles and Nucleophiles - Nucleophilic Substitution Reactions - Elimination Reactions - Addition Reactions - Electrophilic Aromatic Substitution Reactions - Nucleophilic Addition Reactions - Organic Redox Reactions

UNIT IV	Physical Chemistry	

First Law of Thermodynamics-Adiabatic processes, Constant Volume Processes, Enthalpy, Cyclical Processes, Free Expansions - Second Law of Thermodynamics - Irreversible Processes, Entropy, Free Energy, Real world Examples - Solar Energy, Geothermal, Wind Power

UNIT V	Applications of ODEs	

Applications of 1st Order ODEs: Ecology Models - Applications of 1st Order ODEs: Chemical Reaction Rates, Newton's Law of Cooling - Second-Order ODEs: Definitions of Homogeneous/Inhomogeneous, Linear/Non-linear ODEs -Solution of Homogeneous Constant-Coefficient Linear ODEs.

Text Book(s)

1	Principles of Physical Chemistry, B.R. Puri, L.R. Sharma, S.Chand& Co.
2	Inorganic Chemistry, P. L. Soni, Sultan Chand & Sons.

3	A Textbook of Organic Chemistry, Arun Bahl, B.S. Bahl, S.Chand& Co.
4	Organic Chemistry, Vol. 1, 2 & 3, S. M. Mughergee, S.P. Singh, R.P. Kapoor, Wiley Eastern.
Reference Books	
1	Advanced Organic Chemistry, B.S. Bahl, Arunbahl, S.Chand & Co.
2	Essentials of Physical Chemistry, B.S. Bahl and G.D. Tuli, S.Chand & Co.
3	Text book of Physical Chemistry, P.L.Soni, D.B. Dharmarke, S.Chand & Co.
4	Ordinary Differential Equations with Applications, Sze-Bi Hsu, World Scientific Publishing Co. Pte. Ltd
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://chem.libretexts.org/
2	https://byjus.com/chemistry/
3	https://openstax.org/details/books/chemistry-2e

Course code	BIO101	Biology 1: Diversity of Biology	4 Credits	
Core/Elective/SBS		CORE PAPER		
			Syllabus Version	2023-24

Unit:1	Origin of life	
Theory of Evolution: Understanding Life's diversity – Evolutionary relationships (phylogenies) classifications – Chemical evolution of life – Molecules to cells– Cell theory and the origin of life		

Unit:2	Prokaryotes and Eukaryotic Origin	
Prokaryotic Cells: Bacteria and Archaea –Evolution of the eukaryotic cell – Endosymbiosis – Protists 1 – Red and Green algae- Protists 2 – Chromists –Protists 3 – Dinoflagellates and apicomplexans, flagellates, ciliates, amoebae		

Unit:3	Multicellularity and Kingdom Fungi	
Evolution of sex, life cycles – Origins of multicellularity –Slime moulds and fungi –Fungi 2		

Unit:4	Kingdom Plantae	
Introduction to Land Plants –Bryophytes – Evolution of vascular tissue, Lycophytes, fern allies, early fossil land plants –Seed plants, the seed and secondary growth, Cycads and Ginkgo – Conifer diversity and biology –Angiosperm structure, biology and diversity, the flower, double fertilization –Angiosperm phylogeny and evolution		

Unit:5	Metazoa	
Introduction to animals (Metazoa)- Simple animals – Protostomes Flatworms and annelids, - Molluscs, Arthropods, Deuterostomes, Echinoderms-Chordates, Fishes–sharks/rays, teleosts, coelacanth, lungfish–Amphibians, Reptiles, Birds, Mammals, The Primate story		

TextBook(s)

1	Evolution, Strickberger. Fifth Edition, Jones and Bartlett Publishers, Inc (2013).
2	Biology,P.H. Raven, G.B. Johnson, K.A. Mason, L. Jonathan, T. Duncan, Twelfth Edition, McGraw Hill (2019)

ReferenceBooks

1	Campbell Biology, L. Urry, M. Cain, S. Wasserman , P. Minorsky, J. Reece11thEdition,Pearson,(2017).
2	Evolution, Douglas Futuyma, Mark Kirkpatrick, 4th edition, Sinauer, 2017

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.,]

1	https://www.easybiologyclass.com/chemical-evolution-theory-biochemical-origin-of-life-short-lecture-notes/
2	https://bio.libretexts.org/Introductory_and_General_Biology/Diversity_of_Microbes_Fungi_and_Protists
3	https://bio.libretexts.org/Bookshelves/Introductory_and_General_Biology/_Diversity_

	of_Plants
4	https://www.khanacademy.org/science/biology-india/ animal-kingdom

Course code	**105**	**PHYSICS PRACTICAL 1**	**2 Credits**	
Core/Elective/SBS		**CORE PRACTICAL**		
			Syllabus Version	**2023-24**

LIST OF EXPERIMENTS

1. Simple Pendulum: To plot a L-T^2 graph using a simple pendulum and find the effective length of the simple pendulum for a given time period using the graph.
2. To calculate the acceleration due to gravity at a place.
3. Torsional Pendulum**:** To find the moment of inertia of the disc and the rigidity modulus of the material of the suspension wire subjected to torsional oscillations.
4. Young's Modulus: To determine the Young's modulus of elasticity of the material of a given wire using Searle's apparatus.
5. Spring: To determine the restoring force per unit extension of a spiral spring by statistical and dynamical methods and also to determine the mass of the spring.
6. Euler's Method: To determine the coefficient of friction by Euler's Method.
7. Viscosity: To determine Coefficient of Viscosity by Stoke's Method.

Reference Books

1	AtextbookofpracticalPhysics,M.N.Srinivasan,S.Balasubramanian,R.Ranganathan,Sultan Chand & Sons (2017)
2	PracticalPhysicsandElectronics,C.C.Ouseph,U.J.Rao,V.Vijayendran,S.Viswanathan Publishers (2007)

Related Online Contents[MOOC, SWAYAM, NPTEL, Websites etc.]

https://nptel.ac.in/course.html/physics/experimentalphysicsI,IIandIII
https://nptel.ac.in/courses/115/105/115105110/
https://www.youtube.com/playlist?list=PLuiPz6iU5SQ8-rZn_LgLofRX7n8z4tHYK

Course Code	**CHMLAB106**	**CHEMISTRY PRACTICAL 1**	**2 Credits**	
Core/Elective/SBS		**CORE PRACTICAL**		
			Syllabus Version	**2023-24**

List of Experiments

List of Physical chemistry experiments (Any 2)

1. To determine the rate constant of the hydrolysis of Ethyl acetate using an acid catalyst.
2. Molar mass determination of some base metals, gases.
3. Determination of dissociation constant of a weak acid.
4. Determination of heat capacity of a calorimeter for different volumes using change of

enthalpy data of a known substance.

5. Calculation of the enthalpy of ionization of ethanoic acid.

List of Inorganic chemistry experiments (Any 2)

Basic Analytical Terms: Volumetric and Gravimetric analysis, Titration, Types of titration viz. acid base, redox, iodometric, iodometric and complexometric titrations, Types of indicators, Selection of indicator, Aquametry (Karl-Fisher titration)

1. Oxalate Complexes of Aluminum and Chromium.
2. Estimation of Fe (II) with $K_2Cr_2O_7$ using internal external (diphenylamine, anthranilic acid) and external indicator.
3. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
4. Estimation of Fe (II) and oxalic acid using standardized $KMnO_4$ solution.

List of Organic chemistry experiments (Any 3 in Each Group)

1. Techniques:

Crystallization, Sublimation, Distillation, Steam Distillation, Vacuum Distillation, Column Chromatography, Thin Layer Chromatography. Record Melting Point & Boiling Point.

2. Functional group tests following functional groups

Alcohols, Alkenes, Aldehydes and Ketones, Acids, Phenols, Amines, Amides, Esters, Aromatic compounds.

3. Preparations:

Preparation of 4, 4'-Dimethoxy-dibenzylideneacetone
Preparation of 4-tert-Butylphenol
Reduction of p-nitro benzaldehyde by sodium borohydride
Nitration of Salicylic acid by green approach (using ceric ammonium nitrate).
Bromination of cinnamic acid.

TextBook(s)

1	Basic Principles of Practical Chemistry, Kulandaivelu A.R., Veeraswamy R., Venkateswaran, Sultan Chand & Sons, 2017
2	Practical Chemistry for B.Sc Chemistry, A.O. Thomas
3	Practical Chemistry, Pandey D.N., Sultan Chand Publishers, 2018
4	https://www.freebookcentre.net/chemistry-books-download/Chemistry-Laboratory-Manual-by-CSOS.html

Reference

1	Vogel's Text book of Practical Organic Chemistry, Brian S. Furniss, Antony J.Hannaford, Peter W. G. Smith, Fifth Edition, Bath Press, Great Britan, 1989
2	Vogel's Textbook of Quantitative Chemical Analysis, G H Jeffery, J Bassett, JMendham, R C Denney, Fifth Edition, Bath Press, Great Britan, 1989

Course code	BIOLAB107	BIOLOGY PRACTICAL	2 Credits
Core/Elective/SBS		CORE PRACTICAL	
			Syllabus Version 2023-24

List of Experiments

1. Basic instrumentation techniques – Principles and Operation
2. Laboratory Sterilization Methods - Principles and Operation
3. Estimation of proteins: Bradford Assay
4. Estimation of DNA: DPA(diphenylamine)method
5. Identification of sugars/carbohydrates.
6. Observation of zooplankton from pond samples under microscope.
7. Determination of dissolved oxygen in water sample.

Text Book(s)

1	Laboratory manual in biochemistry by J. Jayaraman, Wiley Eastern Publishers
2	Biochemical Methods- Sadasivam and Manickam, 3rd Edition, New Age International Publishers
3	Zooplankton Methodology, Collection & Identification – - a field manual, S.C Goswami,

Reference

1	Roy, K. Gupta, S., Nandi, S. K. (2016) Int. J. Res. Biol. Sci. 6 (1):1-6 2.
2	Aneesh E. M., Fathibi, K. and Ambalaparambil, V. S. (2017) Int. J. Recent Sci. Res. 8 (10) : 20999-21015; available athttps://www.researchgate.net/publication/321025466_Indian_Fresh_Water_Zooplankton_A_Review_Int_J_Recent_Sci_Res_810_pp_209 99-21015

VALUE ADDED 1: ENVIRONMENTAL STUDIES

Course code	1FA	Environmental Studies	L	T	P	C
Value Added		Value Added 1	2	-	-	2
Pre-requisite		Understanding in Environment	**Syllabus Version**			**2023-24**

Course Objectives:

The main objectives of this course are to:

1. Evolve into ecologically informed and socially responsible citizens who are empowered to protect the natural resources while ensuring sustainable lifestyle and developmental mode

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Gaining in-depth knowledge on natural processes that sustain life	K1, K2

2	Predicting the consequences of human actions on the web of life, global economy, and quality of human life.	K1, K2
3	Develop critical thinking for environmental protection and conservation	K1, K2
4	Acquiring values and attitudes towards understanding environmental-economic-social challenges.	K1, K2
5	Adopting sustainability as a practice in life, society, and industry.	K1, K2
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyse; **K5** - Evaluate; **K6** - Create		
Unit:1	Multidisciplinary nature of environmental studies	**3 Hours**
Unit:2	Natural Resources	**4 Hours**
Unit:3	Ecosystems	**3 Hours**
Unit:4	Biodiversity and its conservation	**3 Hours**
Unit:5	Environmental Pollution	**3 Hours**
Unit:6	**Contemporary Issues**	**2 Hours**
Case Study, Expert Lectures, Online Seminars –Webinars		
	Total Lecture Hours	**18 Hours**
Textbook(s)		
1	Erach Barucha, Textbook for Environmental Studies, UGC	
2	Dr. Radha (2019), Environmental Studies, Revised Edition Prasanna Publishers	
Reference Books		
1	Dharmendra S. Sengar, (2007) 'Environmental law', Prentice hall of India	
2	G. Tyler Miller and Scott E. Spoolman, (2014) "Environmental Science", Cengage Learning India	
3	Rajagopalan, R, (2005) 'Environmental Studies-From Crisis to Cure', Oxford University Press,	
4	Benny Joseph, (2006) 'Environmental Science and Engineering', Tata McGraw-Hill, New Delhi,	
5	Gilbert M. Masters, (2004) 'Introduction to Environmental Engineering and Science', 2nd edition, Pearson Education,	
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]		
1	Environmental Studies - By Dr. Tushar Banerjee | Devi Ahilya Viswavidyalaya, Indore - SWAYAM	
Course Designed By: **Bharathiar University**		

SEMESTER II

Course code	Mat201	Maths-2	4 Credits	
Core/Elective/SBS		CORE PAPER		
			Syllabus Version	2023-24

Unit-1: Analysis

Limits of real-valued functions
Proving limits using the definition
Continuity & differentiability
Examples of differentiable and non-differentiable functions; continuity and differentiability of standard functions including polynomials, trigonometric, exponential, log functions and their inverses
Techniques for evaluating limits including L'Hopital'srule, sandwich theorem
Mean Value Theorem and applications
Applications of differential calculus eg. related rates

Unit-2: Complex Numbers

Complex numbers
Review of complex numbers including algebra, Arg and plane, cartesian And polar form
Complex exponential
Fundamental Theorem of Algebra
deMoivre's theorem; roots of complex numbers

Unit-3: Vectors

Vector arithmetic, dot product, vector projections (review)
Vector cross product; scalar triple product; para metric curves specified by vector equations
Lines and planes in R^3
Lines and planes in R^3

Unit-4:LinearAlgebra1

Solving systems of linear equations with Gaussian elimination
Solutions of systems of linear equations - consistency, uniqueness
Geometric interpretation of solutions
Matrices,matrixaddition,multiplication,transposeandproperties(review)
Matrix inverse
Determinant
R^n as a vector space, linear independence of vectors in R^n
Span of a set of vectors, sub spaces of R^n

Unit-5:Linear Algebra 1A

Basis and dimension in R^n
Abstract vector space axioms; examples and non-examples of vector spaces
Bases, dimension and co-ordinatesin (finite dimensonal) abstract vector spaces
Definition of linear transformation and examples/non-examples

Linear transformations of the plane Matrix representation of a linear transformation Image and kernel of a linear transformation Rank and nullity
Reference Books
Calculus: Early Transcendentals, Seventh edition by James Stewart. Publisher: Brooks/Cole Year: 2010; ISBN: 9780538497909 (Hardcover), 1170 pp
Complex Variables and Applications by James Brown, Ruel Churchill. Publisher: McGraw Hill Higher Education; Year: 2013; ISBN-13: 978-0073383170, 480 pp.
Vector Calculus by Susan Colley. Publisher: Pearson; Year: 2011; ISBN-13: 978-0321780652, 624 pp.
Linear Algebra And Its Applications by Gilbert Strang. Publisher: Cengage India Private Limited; Year: 2005; ISBN-13:978-8131501726; 544 pp.

Course code	**PHY201**	**Physics 2: Modern Physics**	**4 Credits**	
Core/Elective/SBS		**CORE PAPER**		
			Syllabus Version	**2023-24**
Unit:1		**Electricity**		
Electric charge, conductors and insulators – Coulomb's Law, superposition principle – Electric field, superposition principle – Electric flux – Gauss's law, applications – Energy and electric field; electric potential – Calculating potential from the field, electric potential, potential energy surfaces – Electric dipoles – Capacitance; parallel plate capacitors – Energy storage in capacitors, dielectrics, series and parallel circuits – Conductors, electric current, electric power, Ohm's law – Kirchoff's rules, resistors in series and parallel circuits.				
Unit:2		**Magnetism**		
Magnetic field, magnetic force, Lorentz force, cyclotrons – ion velocity filter, Hall effect, - Bio-Savart Law, Ampere's Law, solenoids, earth's magnetic field - Magnetic field due to a current, forces on current – carrying wires, Electromagnetic induction, magnetic flux – Lenz' Law, Faraday's law, Maxwell's equations, applications – Magnetic materials.				
Unit:3		**Oscillations and Waves**		
Damped harmonic motion, resonance – electronic circuits, evolution of populations – One dimensional waves, Interference and standing waves, Sound waves and the speed of sound, Intensity, sound level and the physics of music – Doppler effect and supersonic motion, shock waves.				
Unit:4		**Optics**		
Images and mirrors – Thin lenses and optical instruments – Young's experiment, interference – Thin films and the Michaelson interferometer – Diffraction by slits and apertures – Diffraction by grating sand X-ray diffraction – Optical Microscopy – Spectroscopy.				
Unit:5		**Modern Physics**		
Challenges to classical physics; special relativity – Lorentz transformation, transformation of velocities, Doppler effect – Relativistic momentum and energy – Photons and the photoelectric				

effect – Quantum physics, black body radiator, matter waves – Trapped particles and the tunneling particles – Nuclear physics, nuclear properties, nuclear decay – Quarks, Leptons, The Big Bang.	
Textbook(s)	
1	A Text book of Optics, Brijlal & Subramaniam,S. Chand Limited (2001)
2	Modern Physics, R. Murugesan, S. Chand Publishing, 18thEdition (2017)
3	Solid State Physics Gupta and Kumar,K. Nath & Co.(2018)
4	Electricity and Magnetism, R. Murugesan, S.Chand & Co(2017)
Reference Books	
1	Optics and Spectroscopy,RMurugesan,S.ChandPublishing,5thEdition(2013)
2	Heat and Thermodynamics–Zemansky and R.H.Dcltanann,TMH(2017)
3	Modern Physics, Sehgal D.L. ChopraK.L.andSehgalN.K.SultanChand&Sons,9thedition, (2004)
4	Introduction to Solid State Physics Charles Kittel, Wiley(2019)
5	Electricity and Magnetism, D.N.Vasudeva, S.Chand & Co, twelfth edition(2007)
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.,]	
1	**https://www.askiitians.com/revision-notes/physics/current-electricity.html**
2	**https://www.askiitians.com/revision-notes/physics/electromagnetic-induction-and-alternating-current/**
3	**https://www.khanacademy.org/science/physics/light-waves/introduction-to-light-waves/v/polarization-of-light-linear-and-circular**
4	**https://nptel.ac.in/courses/115/105/115105099/**

Course Code	**CHM201**	**PHYSICAL AND INORGANIC CHEMISTRY**	**4 Credits**	
CORE		**Chemistry 2**		
			Syllabus Version	**2023-2024**
UNIT I	**Chemistry of Life**			
The Chemical Basis of Life - Bioenergetics - Examples of Major Bioenergetic Processes - Enzymes and Catalysed Reactions - The Chemistry Behind Enzyme Catalysis - Metabolism: Catabolism and Anabolism - Concatenation and Biopolymers - Stereochemistry and Biomolecular Chirality				
UNIT II	**Biochemistry & Inorganic Chemistry**			
Biochemistry and Biomolecular Structure - Types of Biomolecules, Structure and Functions of Biomolecules - Small Inorganic Molecules of Biological Importance Ionic Compounds and their Solutions - Formation, Bonding, Structure and Properties - Ionic Solutions - Structures of Solids - Classification of Solids - Types of Crystalline Solids				
UNIT III	**Inorganic Chemistry & Electrochemistry**			
Main Group Chemistry - General Trends in Main Group Chemistry - Chemistry of s- and p-block Elements, Structure, Chemical Reactivity and Bonding Concepts				

Redox Reactions and Electrochemistry - the Basics of Redox Reactions - Electrochemical Cell - Electrochemical Series - Electrode and Cell potentials - Nernst equation		
UNIT IV	**Inorganic Chemistry**	
The Transition Metals : A Survey - Coordination Chemistry - Important Terms Involving Coordination Compounds - Bonding in Complex Ions - Types of Coordination Complexes - Transition Metals in Biological Systems - Simple Harmonic Motion, Pendulum, Diatomic Molecules		
UNIT V	**Quantum Chemistry**	
Schrödinger's Equation and Heisenberg's Uncertainty Principle - Bohr and Schrodinger Models of the Hydrogen Atom - Complex Atoms; Pauli Exclusion Principle, Periodic Table of Elements, Selection Rules and Spectra - Nuclear Fission and Fusion		

Text Book(s)	
1	Textbook of Biochemistry, Seema P. Upadhye, I.K. International Publishing House Pvt. Ltd.
2	Inorganic Chemistry, P. L. Soni, Sultan Chand & Sons.
3	Principles of Physical Chemistry, B.R. Puri, L.R. Sharma, S.Chand& Co.
4	Main Group Chemistry, 2nd Edition, A. G. Massey, Wiley Publication
Reference Books	
1	Bioenergetics: Molecular Biology, Biochemistry, and Pathology, Chong H. Kim, Takayuki Ozawa, Springer Publication
2	Essentials of Physical Chemistry, B.S. Bahl and G.D. Tuli, S.Chand & Co.
3	Principles of Inorganic Chemistry, B.R. Puri L.R. Sharma, S.Chand& Co.
4	Fundamentals of Biochemistry, J L Jain, Nitin Jain, Sunjay Jain, S.Chand & Co.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://chem.libretexts.org/
2	https://byjus.com/chemistry/
3	https://openstax.org/details/books/chemistry-2e

Course code	**BIO201**	**Biology 2: The Biology of Cells**	**4 Credits**	
Core/Elective/SBS		**CORE PAPER**		
			Syllabus Version	**2023-24**
Unit:1	**The Cell**			

Introduction to Cell Biology – The plasma membrane – Cell walls, extracellular matrix, cellulose synthesis, other cell wall components – Cytoplasm: content, chemistry and properties – Cytoskeleton, actin filaments, microtubules		
Unit:2	**Information Flow in the Cell**	
Nucleus, chromosomes, DNA – Genes and the genetic code – Control of gene expression		
Unit:3	**Endomembrane system and Intracellular Trafficking**	
ER and ribosome, proteins and enzymes – Golgi apparatus –Vesicles, transport and secretion, Lysosomes		
Unit:4	**Harvesting Energy**	
Mitochondria, ATP, energetic reactions, electron transport pathways, cellular respiration – Chloroplasts, photosynthesis, historical experiments, pigments, photo systems		
Unit:5	**Multicellularity and the Dividing Cell**	
Cell division, cell cycle, mitosis, cytokinesis, division and distribution of organelles – Meiosis, formation of haploid cells – Communication and signaling, recognizing and responding – Cell differentiation and multicellularity.		

Text Book(s)	
1	Molecular cell biology, Harvey Lodish, 8th edition, W.H. Freeman, (2016).
2	Cell and Molecular Biology concepts and Experiments, Gerald Karp, Janet Iwasa, Wallace Marshall,9thEdition, Wiley(2019)
3	Molecular Biology of the cell, Bruce Alberts, 6th edition, Garland Science(2014)
Reference Books	
1	The Cell : A molecular approach, Geoffrey M. Cooper, Robert E. Hausman, Sixth edition, Sinauer (2013)
2	Essential Cell Biology, Bruce Alberts, 5th edition, Garland Science (2019).
3	Lewin' s Genes XII, 2017, Jocelyn E Krebs, Elliott S. Goldstein, and Stephen T. Kilpatrick Jones, Bartlett Publishers, 12th revised edition
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.,]	
1	**https://microbenotes.com/category/cell-biology/**
2	**https://www.larberthigh.com/_documents/%5B1405%5DUnit_1-_Cell_biology_summary_notes.pdf**
3	https://nptel.ac.in/courses/102/103/102103012/
4	**https://www.khanacademy.org/science/ap-biology/cell-structure-and-function**

Course code	**PHYLAB205**	**PHYSICS PRACTICAL 2**	**2 Credits**	
Core/Elective/SBS		CORE PRACTICAL		
			Syllabus Version	**2023-24**

LIST OF EXPERIMENTS:
1. Young's Modulus – Non-uniform pending methods
2. Determination of the radius of a current carrying coil 2-Determination of magnetic field with the variation of distance along the axis of current carrying coil.
3. To determine the Wavelength of main spectral line of mercury light using plane transmission grating.
4. To determine the Refracting Angle, Refractive Index and Dispersive power of prism using spectrometer.
5. To determine the coefficient of thermal Conductivity of bad conductor by Lee's Disc.
6. Charging and Discharging of Capacitor.
7. Verification of Kirchhoff's law.
Reference Books
1 A text book of practical Physics, M.N.Srinivasan, S.Balasubramanian, R.Ranganathan, Sultan Chand & Sons(2017). 2 Practical Physics and Electronics, C.C. Ouseph, U.J.Rao, V.Vijayendran, S.Viswanathan Publishers(2007)
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]
https://nptel.ac.in/course.html/physics/experimentalphysicsI,IIandIII https://nptel.ac.in/courses/115/105/115105110/ https://www.youtube.com/playlist?list=PLuiPz6iU5SQ8-rZn_LgLofRX7n8z4tHYK

Course Code	**CHMLAB206**	**CHEMISTRY PRACTICAL 2**	**2 Credits**	
Core/Elective/SBS		**CORE PRACTICAL**		
			Syllabus Version	**2023-24**

List of Experiments

List of Physical chemistry experiments (Any 2)

1. To determine the rate of chemical reaction by using hydrolysis of tert-Butyl chloride.
2. Effects of catalase enzyme obtained from potato in cleaving H_2O_2 into H_2O and O_2.
3. To measure the vapour pressure of n-Pantane by using high vacuum line.
4. Heat of solution of KNO_3/ NH_4Cl.
5. Glass electrode- Buffer solutions: To titrate a weak base (Na_2CO_3) with a strong acid a) an acid-base indicator,(b) a glass electrode

List of Inorganic chemistry experiments (Any 2)

1. Synthesis of hexamine nickel (II) $[Ni(NH_3)_6]I_2$
2. Cuprous Chloride, Cu_2Cl_2

3. The transition metals: a survey (Transition metals in biological systems and Bonding in complex ions).
4. Estimation of Cu (II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodometrically).
5. Estimation of available chlorine in bleaching powder iodometrically.

List of Organic chemistry experiments (Any 3 in Each Group)

1. Preparation of Derivatives:

Oxime, 2, 4-DNP, Acetyl, Benzoyl, Semicarbazone, Anilide, Amide, Aryloxyacetic acid.

2. Organic single stage preparation:

The preparation of paracetamol.

The synthesis of meso-1,2-Dihydroxy-1,2-Diphenylethane.

Preparation of α-phenyl Cinnamic acid from Benzaldehyde.

Preparation of benzyl alcohol from Benzaldehyde

Preparation glucose pentaacetate from Glucose.

Preparation of 2-iodobenzoic acid from Anthranilic acid.

Use of Computer (Chemistry Software)

Chem Draw-Sketch, ISI – Draw, Draw the structure of simple aliphatic, aromatic, heterocyclic organic compounds with substituents. Get the correct IUPAC name.

Text Book(s)

1	Basic Principles of Practical Chemistry, Kulandaivelu A.R., Veeraswamy R., Venkateswaran, Sultan Chand & Sons, 2017
2	Practical Chemistry for B.Sc Chemistry, A.O. Thomas
3	Practical Chemistry, Pandey D.N., Sultan Chand Publishers, 2018
4	https://www.freebookcentre.net/chemistry-books-download/Chemistry-Laboratory-Manual-by-CSOS.html

Reference

1	Vogel's Text book of Practical Organic Chemistry, Brian S. Furniss, Antony J.Hannaford, Peter W. G. Smith, Fifth Edition, Bath Press, Great Britan, 1989
2	Vogel's Textbook of Quantitative Chemical Analysis, G H Jeffery, J Bassett, JMendham, R C Denney, Fifth Edition, Bath Press, Great Britan, 1989
3	ChemDraw 17.0 User Guide, PerkinElmer Informatics Inc, 1998-2017

Course code	BIOLAB207	BIOLOGY PRACTICAL 2	2 Credits
Core/Elective/SBS		CORE PRACTICAL	
			Syllabus Version 2023-24

List of Experiments

1. Microscopy and observation recording of representative organelle readymade specimens.
2. Staining of cell for observations of-Flagella, cell wall, endospores, etc.
   a. Plant cell, bacterial, fungi samples.
   b. Malachite green, safranin, Leifson flagella stain/RYU flagella stain, nitric acid, crystals of potassium chlorate (any suitable stain)
3. Introduction and visualization DNA-Proteins *insilico.*
4. Demonstration of confocal/ fluorescence microscopy at the central instrumentation facility of Bharathiar University.
5. Counting of cells using hemocytometer, observation of dead cells-Trypan blue staining.
6. Isolation of DNA: gel electrophoresis.
7. Mitosis in onion root tips – Microscopic observation

Text Book(s)

1	Cappuccino, James G., and Natalie Sherman. "Microbiology: a laboratory manual." (2005)
2	Wilson, K. and Walker, J. (2010). Principles and techniques of Biochemistry and Molecular Biology. 7th Edition. Cambridge University Press.
3	Tiwari, G. S. Hoondal, (2005). Laboratory Techniques In Microbiology & Biotechnology. Swastik publishers

Reference

1	Sri Jayachama rajendra (2018)/ pdf. Cell Biology and Genetics Lab.
2	K. R. Aneja; Laboratory Manual of Microbiology and Biotechnology, 2018. ED-TECH

Course code	IDC201	Scientific Computation and Modeling: Introduction to simple models and programming	4 Credits
Core		CORE PAPER	
Pre-requisite			Syllabus Version 2022-23

Unit 1: Introduction to Scientific Computing

Overview: Definition; Scope; Importance, Mathematical Foundation: Numerical Representation; Basic Linear Algebra, Programming Basics: Introduction; Variable; Data Types; Basic Operations; Control Structures.

Unit 2: Numerical Methods

Root Finding and Optimization: Bisection Method; Newton-Rhapson Method, Linear Systems: Gaussian Elimination; LU decomposition, Interpolation and Approximation: Lagrange interpolation; Polynomial interpolation; Least squares approximation.

Unit 3: Differential Equations

Ordinary Differential Equations (ODEs): Euler's method; Runge-Kutta methods, Partial Differential Equations (PDEs): Classification; Finite difference methods, Applications of ODEs and PDEs: Physical systems modeling; Heat equation, wave equation, and diffusion equation.

Unit 4: Data Analysis and Visualization

Data Manipulation and Analysis: Introduction to data structures; Statistical analysis using computational tools, Visualization Techniques: Plotting and graphing data; 2D and 3D visualization.

Unit 5: Advanced Topics in Scientific Computing

Parallel and High-Performance Computing: Introduction to parallel computing; Parallel algorithms and architectures; High-performance computing clusters, Machine Learning for Scientific Modeling: Basics of machine learning; Applications of machine learning, Advanced Topics in Modeling: Agent-based modeling.

Text Book(s)

Scientific Computing: An Introductory Survey" by Michael T. Heath. This book provides an overview of scientific computing, including numerical methods and algorithms, and discusses their implementation using various programming languages.

"Python for Scientists" by John M. Stewart. This book is specifically designed for scientists and engineers, providing an introduction to Python programming and its application in scientific computing.

VALUE ADDED 2: HUMAN RIGHTS

Course code	**2FB**	**Human Rights**	**L**	**T**	**P**	**C**
Value Added		Value Added 2	2	-	-	2
Pre-requisite		Awareness on Ethics and Values	**Syllabus Version**		**2023-24**	
Course Objectives:						
The main objectives of this course are to: 1. Create awareness, conviction and commitment to values for improving the quality of life through education, and for advancing social and human wellbeing						
Expected Course Outcomes:						

On the successful completion of the course, student will be able to:		
1	Understand human values and value education	K1
2	Learn their role in national development	K1
3	Understand global development with ethics and values	K1
4	Learn various therapeutic methods	K1
5	Learn and understand human rights	K1
K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyse; **K5** - Evaluate; **K6** - Create		

Unit:1	**Concept of Human Values, Value Education Towards Personal Development**	**3 Hours**

Aim of education and value education; Evolution of value-oriented education; Concept of Human values; types of values; Components of value education. Personal Development: Self-analysis and introspection; sensitization towards gender equality, physically challenged, intellectually challenged. Respect to - age, experience, maturity, family members, neighbours, co-workers. Character Formation Towards Positive Personality: Truthfulness, Constructivity, Sacrifice, Sincerity, Self-Control, Altruism, Tolerance, Scientific Vision.

Unit:2	**Value Education Towards National and Global Development**	**4 Hours**

National and International Values: Constitutional or national values - Democracy, socialism, secularism, equality, justice, liberty, freedom, and fraternity. Social Values - Pity and probity, self-control, universal brotherhood. Professional Values - Knowledge thirst, sincerity in profession, regularity, punctuality, and faith. Religious Values - Tolerance, wisdom, character. Aesthetic values - Love and appreciation of literature and fine arts and respect for the same. National Integration and international understanding.

Unit:3	**Impact of Global Development on Ethics and Values**	**3 Hours**

Conflict of cross-cultural influences, mass media, cross-border education, materialistic values, professional challenges, and compromise. Modern Challenges of Adolescent Emotions and behaviour; Sex and spirituality: Comparison and competition; positive and negative thoughts.

Unit:4	**Therapeutic Measures**	**3 Hours**

Control of the mind through a. Simplified physical exercise b. Meditation – Objectives, types, effect on body, mind and soul c. Yoga – Objectives, Types, Asanas d. Activities: (i)Moralisation of Desires (ii)Neutralisation of Anger (iii)Eradication of Worries (iv)Benefits of Blessings

Unit:5	**Human Rights**	**3 Hours**

Concept of Human Rights – Indian and International Perspectives a. Evolution of Human Rights b. Definitions under Indian and International documents 2. Broad classification of Human Rights and Relevant Constitutional Provisions. a. Right to Life, Liberty and Dignity b. Right to Equality c. Right against Exploitation d. Cultural and Educational Rights e. Economic Rights f. Political Rights g. Social Rights 3.Human Rights of Women and Children a. Social Practice and Constitutional Safeguards (i)Female Foeticide and Infanticide (ii)Physical assault and harassment (iii)Domestic violence (iv)Conditions of Working Women 4.Institutions for Implementation a. Human Rights

Commission b. Judiciary 5.Violations and Redressal a. Violation by State b. Violation by Individuals c. Nuclear Weapons and terrorism d. Safeguards.		
Unit:6	**Contemporary Issues**	**2 Hours**
Case Study, Expert Lectures, Online Seminars - Webinars		
	Total Lecture Hours	**18 Hours**
Textbook(s)		
1	Value Education – Human Rights, Bharathiar University	
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]		
1	Human Rights in India - By Prof. (Dr.) Y.S.R. Murthy | O.P. Jindal Global University - SWAYAM	
Course Designed By: **Bharathiar University**		

Semester III

Course code	**Mat301**	**Maths-3**	**4 Credits**	
Core/Elective/SBS		**CORE PAPER**		
			Syllabus Version	**2023-24**
Linear Algebra				
Change of basis and linear transformations				
Definition of eigenvectors and eigenvalues				
Calculating eigen values and eigenvectors				
Diagonalisation of matrices; matrix powers				
Orthogonal matrices, real symmetric matrices				
Characteristic and minimal polynomial, Cayley-Hamilton Theorem				
Applications of eigen vectors/diagonalisation eg Markov chains				
Inner product axioms; examples/non-examples of inner products				
Length, angle, Cauchy-Schwarz inequality in terms of inner product				
Orthogonality, projections in terms of inner product				
Gram-Schmidt algorithm				
Vector Calculus				
Functions of several variables; level curves and cross sections of surfaces				
Common surfaces including paraboloid, ellipsoid, hyperboloid				
Domains and ranges of functions of several variables				

Limits and continuity of functions of several variables; Definition of C^N
Partial derivatives, tangent plane
Differentiability of functions of several variables
Directional derivative, gradient
Chain rule and total derivative
Stationary points of surfaces, classification of stationary points using Second derivatives
Optimisation applications
Constrained extreme a using Lagrange multiplier method
Double integrals, changing order of integration
Polar co-ordinates, change of variables for double integrals
Triple integrals
Change of variables for triple integrals; cylindrical co-ordinates
Spherical co-ordinates
Vector fields, div and curl operators
Parameterisation of paths
Line integrals of scalar functions
Line integrals of vector functions
Integrals of scalar functions over surfaces, applications of surface Integrals eg. surface area, mass
Integrals of vector functions over surfaces, flux
Green's Theorem
Gauss Divergence Theorem
Stokes' Theorem
Applications of integral theorems eg. Maxwell's equations
PDEs
Fourier Series
Fourier series: Dirichlet, discontinuities and differentiation
Fourier series: Weak convergence and series summation
Linearity and Superposition
Laplace equation and harmonic functions
Fourier transform
Fourier transform: properties

Course code	**Phy301**	**Physics-3**	**4 Credits**

Core/Elective/SBS	CORE PAPER				
		Syllabus Version		2023-24	
Linear Algebra					
Change of basis and linear transformations					
Definition of eigenvectors and eigen values					
Calculating eigen values and eigenvectors					
Diagonalisation of matrices; matrix powers					
Orthogonal matrices, real symmetric matrices					
Characteristic and minimal polynomial, Cayley-Hamilton Theorem					
Applications of eigen vectors/diagonalisation eg Markov chains					
Inner product axioms; examples/non-examples of inner products					
Length, angle, Cauchy-Schwarz inequality in terms of inner product					
Orthogonality, projections in terms of inner product					
Gram-Schmidt algorithm					
Quantum Mechanics					
The Breakdown of Classical Physics					
Matter Waves and Quantum Interpretation					
Quantum Mechanics in One Dimension					
Expectation Values, Observables and Operators					
Tunneling Phenomena					
Quantum Mechanics in 3-dimensions					
Hydrogen atom, hydrogenic ions, helium atom					
Hydrogen molecule ion, hydrogen molecule					
Thermodynamics					
Temperature and the Zeroth Law of Thermodynamics. Thermal equilibrium.					
Transport, conduction, conductivity, diffusion in gases.					
The two-state paramagnet and the Einstein model of a solid; quantum Deviations from classical equipartition. Partition function, Interacting systems, large systems, Stirling's approximation					
Heatengines, Carnot Cycle, Otto Cycle, Stirling Cycle.					
PDEs					
Fourier Series					
Fourier series: Dirichlet, discontinuities and differentiation					
Fourier series: Weak convergence and series summation					
Linearity and Superposition					

Laplace equation and harmonic functions
Fourier transform
Fourier transform: properties

Course code	**Chem301**	**Chemistry-3**	**4 Credits**			
Core/Elective/SBS		**CORE PAPER**				
			Syllabus Version	**2023-24**		

Reactions and Synthesis 1
Organic Synthesis C-C bond Forming Reactions: Grignard Reagents And Organolithiums. Formation and reaction with Carbonyl compounds.
Organometallic Reagents in Synthesis: Applications of Organocerium And Organocuprate reagents.
Carbonyl Compounds and Reactions: Carbonyl compounds, Tautomerism as a general phenomen,keto-enoltautomerismofcarbonylcompounds,mechanismofketo-enol tautomerism
Generating enolate anions, suitable base catalysts for enolisingaldehydes,ketonesesterandβ-dicarbonylcompounds,generalα-Substitution reaction
Reactions of enols and enolates, α-substitution with H/D^+ Stereochemical consequences and deuterium incorporation, Halogenation of carbonyl compounds, The haloform reaction
Halogenation of carbonyls, Hell-Volhard-Zelinsky reaction, Synthetic Applications of a-halocarbonyl compounds
Alkylation of enolates, LDA, scope and limitations
Aldol reaction, mechanism and retro synthesis, inter-and-intra-Molecular variants, mixed Aldol reaction
Claisen reaction, mechanism and retro synthesis, mixed Claisen and Deickman reaction.
Malonate Diester Chemistry, Acetoacetate chemistry, Synthesis of Substituted acetic acid and acetone derivatives, Scope, Mechanism and
Retro synthesis.
Michael addition Chemistry, reaction of enolates with various Michael electrophiles
Kinetic and Thermo dynamic enolates, Enamines and silylenol ethers

Reactions and Synthesis 2
Redox (and important acid-base) Reactions: Oxidation of elements by halogens and dioxygen. Metal and main group halides and oxides. Discussion of selected syntheses, chemistry and structures of halides and oxides including amphoteric behaviour and hydroxide/aqua ion formation. Thermodynamic vs. kinetic control of reactions.
Thermodynamic aspects of halide and oxide formation. Thermodynamic parameters, their estimation and uses of tabulations. Born-Haber cycle and construction and uses of Ellingham diagrams for These systems. (Electrides and sodides?)
Oxidation of metals by protons etc. and generation of aqua ions. Comparison of TM and main group systems and hydrolysis in TM aqua ions (acid-base chemistry of coordinated water-hydroxide-oxo ligands).Connection between electrochemical and thermo dynamic parameters. Construction and uses of Latimer and Frost diagrams.
Interpretations of Frost diagrams exemplified by the more complex chemistry of main group elements, such as nitrogen. Thermodynamic content of plots (free energy of formation vs. oxidation state) and predictive power.
Nernst equation revisited and construction and uses of Poubaix diagrams combining redox and acid base reactions. Comparison of chemistry of representative elements as reflected in Pourbaix diagrams.
Exchange reactions: Solid/gas phase systems exemplified by transport reactions and preparation of solid-state materials, in vulcanology, halogen lamps etc. Solution examples of doubled composition (metathesis).Solubility trends, Common ion effect.
Hard/soft acid/base theory. Thermodynamic basis for HSAB theory. Usefulness in predicting direction of equilibrium and solubility.
Substitution Reactions: Typical reactions and synthetic applications and examples. Inert and labile complexes. Stability (K,b) and factors affecting stability (metals, ligands). Irving-Williams series, Chelate effect. Applications of chelate effect. Siderophores. antioxidants, garden products, chelation therapy in medicine.
Mechanism of substitution reactions. Square planar Pt complexes and applications. Trans effect, Pt chemistry, Applications in synthesis of action of chemotherapeutic agents.
Dissociative, interchange and associative mechanisms in substitution, racemization *etc* in octahedral complexes.

Combination of substitution and redox chemistry in TM systems. Co(III) syntheses, Cr(II) catalysed substitution. Electron transfer, inner-and outer-sphere reactions.
Metal centered reactions: Template reactions and reactions of coordinated ligands. Atom transfer reactions (redox reactions). Metal directed ligand syntheses
Thermodynamics
Ideal gases, the kinetic theory of gases, equipartition theory, Boltzmann distribution
Heat, work, internal energy. First law of thermo dynamics. Heat Capacity and enthalpy. Compression of an ideal gas under various conditions. Latent heats
Multiplicity and ideal gases. Entropy, spontaneous change and the Second Law of Thermodynamics. Interacting ideal gases and the entropy of mixing.
Gibbs Free energy and spontaneity, Helmholtz Free energy, standard free energies, free energy as a function of pressure and temperature The Fundamental equation, properties of internal energy and Maxwell's relations
Thermodynamics criteria for chemical and phase equilibria, chemical potential and partial molar quantities, the Gibbs Free Energy, minimum and equilibrium, extent of reaction and equilibrium constant, molecular description of equilibrium, response of equilibria to temperature
Thermodynamics of liquids and liquid mixtures, chemical potentials of liquids, ideal liquid mixtures and Raoult's Law, Henry's Law, vaporpressure diagrams, liquid-liquid phase diagrams, Free energy and entropy of mixing, excess functions and real solutions, solute and Solvent activity, activity coefficient, osmotic pressure

Course code	**BIO301**	**BIOLOGY-3**	**4 Credits**			
Core/Elective/SBS		**CORE PAPER**				
Pre-requisite			**Syllabus Version**	**2022-23**		
Functional Biology of Organisms						
Introduction to Functional Biology						
Animal biology (Humans as an example)						
Anatomy and Function 1: Tissues, Organs and Viscera						
Anatomy and Function 2: Skeletal &Muscular system						

Nervous system1: The central nervous system(CNS)and nervous tissues
Nervous system2: Autonomic nervous system and motor responses
Endocrine system1: Endocrine and Exocrine glands
Endocrine system2: HPA axis introduction
Respiration and Metabolism 1:Breathingin air and water
RespirationandMetabolism2:Regulationof metabolism
Cardiovascular and circulatorysystem1: Regulation of the circulatory system
Cardiovascular and circulatorysystem2: Peripheral circulation
Digestive system
Urinary and Excretion systems1: Anatomy and function
Urinary and Excretion systems 2: Osmoregulation interrestrial & aquatic environments
Thermal dynamics
Immunology1: Innate immune system
Immunology2: Adaptive/Humoral immune system
ReproductionandDevelopment1:GonadsandtheReproductivetract
Reproduction and Development2: Gametes, Fertilization and conception
Plant biology
Growth and Development
Photosynthesis
Water Balance
Phloem and translocation
Mineral nutrition and nutrient assimilation
Respiration and lipid metabolism
Reproduction
Signaling; hormones, light responses, control of flowering
Abiotic stress
Secondary metabolism and defense
Microbial physiology

PHYLAB305 - 2 Credits

1. Michealson's interferometer: To find the wavelength of given laser beam.

2. Specific charge of the electron(e/m): To find the specific charge of the electron from the path of an electron beam in crossed electric and magnetic fields of variable strength.
3. Rydberg's constant: To find Rydberg's constant using diffraction grating.
4. Photoelectric effect: To estimate Planck's constant and work function of the photoelectrons by measuring the variation of stopping potential with the frequency of light. To see the graph of current Vs voltage for different intensity and frequency of light.
5. Electron diffraction: To measure diameter of smallest diffraction rings at different anode voltages.
6. Millikan soil drop experiment: To measure to charge of the electron.

CHMLAB 306 - 2 Credits

List of Physical chemistry experiments

1. Thermodynamic data of electrochemical cell by e.m.f. measurements.
2. Determination of the equilibrium constant of tri-iodide ion formation
3. Determination of dipole moment f liquid at various temperatures
4. Dissociation constant of an acid-base indicator by spectrophotometry
5. Flame Photometric determination of Na, K, Li and Ca (Working curve method, standard addition method and Internal standard method)
6. A photometric titration of a mixture of Bi and Cu with EDTA(-745nm)
7. The reaction between potassium per sulphate and potassium iodide by colorimetry.
8. Hydrolysisconstantofanilinehydrochloridebydistributioncoefficient method.
9. Thermodynamic data of electrochemical cell by e.m.f. measurements.
10. Determination of the equilibrium constant of tri-iodide ion formation
11. Determination of dipole moment of liquid at various temperatures
12. Determination of concentration of sulfuric acid, acetic acid and copper sulphate by conduct o metric titration with sodium hydroxide.
13. Determine the formula and stability constant of a metal ion complex (Lead Oxalate) by polarography.

List of Inorganic chemistry experiments

1. Analysis of ore(Any one)

i) Pyrolusite ore –Estimation of silica gravimetrically and Manganese volumetrically.

ii) Chromite ore–Estimation of Iron gravimetrically and Chromium volumetrically

2. Analysis of Alloy

Solder alloy– Estimation of Tin gravimetrically and Lead volumetrically

3. **Column Chromatography:** Ion exchange capacity of resine by Co and Ni.
4. **Characterization of soil and water.**

List of Organic chemistry experiments

1. **Separation of Binary Mixture (8-10samples)**
2. **Preparations: Single Stage**
   a. Ethyl benzene from acetophenone
   b. P-Nitrobenzylcyanide from Benzyl cyanide.
   c. 2,4dinitroanisolefromanisole
   d. Azo dye from Anthranilic acid
   e. Osazone from Glycose
   f. Cinnamic acid dibromide from Cinnamic acid
   g. Chalcone from P-chloro Benzaldehyde.
   h. Hippuric acid from Glycine
   i. 4-formyl resorcinol from Resorcinol.
   j. Adipic acid from Cyclohexanone
   k. 4,6 dimethyl coumarin from p-cresol.
   l. Cannizzaro reaction of aromatic aldehyde.

BIO LAB 307 - 2 Credits

1. Preparation of media, autoclaving and culturing of bacteria using different plating techniques, dilution and colony counting
2. Bacterial Growth curve
3. Grams staining (gram positive, gram negative and yoghurt samples)
4. Enzyme kinetics (effect of pH, temperature, substrate and enzyme concentration)
5. Estimation of glucose
6. Antibiotic sensitivity test: zone of inhibition

Semester IV

MATHS 401 – 4 Credits	
Probability	**No. of Lectures**
Review of probability, events, laws of probability	1
Conditional probability, independent events	1
Random variables; discrete random variables and distributions; mean, variance and standard deviation of discrete random variable	1
Bernoulli trials, binomial distribution	1
Poisson distribution and Poisson process	1
Continuous random variables and distributions, probability density functions, cumulative distribution function	1
Mean, variance, standard deviation, median and percentiles of a continuous distribution	1
Normal distribution	1
Uniform and exponential distribution	1
Distributions of functions of a random variable	1
Sums/differences/scalar multiples of random variables, independent random variables, distributions of sums/differences of independent random variables	1
Central Limit Theorem	1
Normal approximation to the binomial distribution, distribution of the sample mean	1
Distribution of sample proportion	1
Stochastic processes, Markov chains	1
Limiting behaviour of Markov chains	1
Statistics	**No. of Lectures**
Study design: bias, confounding, precision, comparison, control	1
Study design: observational studies vs designed experiments	1
Exploratory data analysis: describing and displaying categorical data (tables, frequencies, bar chart)	1

Exploratory data analysis: describing and displaying univariate numeric data (dotplots, boxplots, histograms, mean, median, quartiles/percentiles, standard deviation, variance, IQR)	1
Exploratory data analysis: describing and displaying bivariate numeric data (scatterplot, correlation)	1
Statistical modeling (single mean model, multiple means model, regression model)	1
Sampling distributions: population vs sample, parameter vs statistic; distribution of sample mean, proportion; standard error	1
Estimation: Confidence intervals, confidence interval for mean (using z), confidence interval for mean using t	1
Estimation: confidence interval for difference in mean, confidence intervals for proportion	1
Estimation: required sample size, confidence interval vs prediction interval	1
Theory of estimation: unbiasaed estimators, maximum likelihood estimators	1
Hypothesis testing: concepts and terminology, testing a single mean (z and t)	1
Hypothesis testing: errors, power, 2-sample test, paired test, testing proportion	1
Hypothesis testing: Non-parametric tests for 2 samples	1
Comparing multiple means: one-way ANOVA	1
Theory of ANOVA	1
Regresion: least squares method	1
Partitioning of variability in regression, significance testing in regression	1
Chi-squared test for independence	1
Chi-squared goodness-of-fit	1

PHYSICS 402 - 4 Credits	
Electricity and Magnetism	**No. of Lectures**
Coulomb's Law	18
Gauss's Law	
Electric Field, Potential	
Conductors, Insulators	
Laplace equation	
Curl and Stoke's theorem	
Capacitors, capacitance and energy stored in E field	

Current and continuity equation	
Magnetic field and Moving Charges	
Force on Moving charges	
Magnetic Field and vector potential	
Special relativity and E and B fields	
Induction	
Inductance and energy stored in B field	
RC circuits	
CL and RLC circuits	
Displacement current	
Complete Maxwell's Equations	
Electromagnetic Waves	
Dielectrics and Electric Dipoles	
Dielectrics	
Magnetic Dipoles	
Magnetism in Matter	
Special relativity	**No. of Lectures**
Space-time and simultaneity. Einstein axioms for special relativity. The Lorentz transformation.	2
Relativistic kinematics; length contraction, time dilation. Doppler effect. Twin paradox.	2
Relativistic dynamics. Mass-energy equivalence. Conservation of four-momentum. Centre of momentum frame. De Broglie waves and photons.	2
Einstein, the equivalence principle, gravity, gravitational lenses, gravitational waves (qualitative)	1
Nuclear reactions and thermonuclear power.	1
Optics- Applications and microscopy	**No. of Lectures**
Classical optics: Fermat's Principle	1
Fourier Optics: Huygens-Fresnel Principle	1
Fourier Optics: Fresnel diffraction integral	1
Fourier Optics: Paraxial approximation	1
Fourier Optics: Fraunhofer diffraction	1
Fourier Optics: Apertures and imaging	1
Fourier Optics: phase contrast imaging	1
Microscopy applications	4

CHEMISTRY 403 - - 4 Credits	
Structure and Properties	**No. of Lectures**
Molecular shape and simple electronic structure, Isomerism: Orbitals, hybridization and shapes of molecules, sterochemical consequences of tetrahedral carbon (isomers, enantiomers, R/S, D/L, optical rotation)	1
Stereochemistry – optical activity: Molecules with more than one chiral centre (diastereomers, meso compounds, separation of racemic mixtures)	1
Symmetry operations and elements	1
Group theory: Definition of reducible and irreducible representations, Use of group theory to determine the irreducible representation	1
Assignment of point groups	1
Leading to definition of components of character tables (irreducible representations, characters – at least the interpretation of the sign of the character)	
Simple applications, Label molecular shapes, isomers, Identify chiral molecules, Physical properties – *e.g.* dipole moment, possibleoptical isomers, Orbital symmetry labels (*e.g.* s, p & d orbitals in Td, Oh,D4h)	1
Stereochemistry and Reactions: Prochirality, chirality in Nature, Sterochemistry on atoms other than carbon, Retrosynthetic analysis	1
Stereochemistry and Mechanism (nucleophilic substitution, elimination from non-cyclic compounds)	1
Alkene addition reactions – Hydrogenation, halogenation, HX addition. Elimination Reactions epoxide ring forming reactions	1
Zeeman effect: Effect on the energies of a system by application of a magnetic field; Magnetochemistry, spin and orbital contribution to the magnetic moment	1
Magnetic resonance spectroscopies: EPR spectroscopy, hyperfine coupling application to organic radicals and to transition metal complexes	1
Nuclear Magnetic Resonance (NMR), energies of nuclei in magnetic fields	1
Chemical shift and the δ scale, resonance of different nuclei, shielding, spin-orbit coupling and coupling constants, molecular symmetry	1
^{13}C NMR, ^{1}H NMR, integration, multiplicity, chemical shift typical ranges	1

Introduction to molecular spectroscopy and spectroscopic transitions, absorbance, transmittance, the Beer-Lambert Law, intensities of spectroscopic transitions	1
Quantised vibration and simply harmonic oscillator model, wave functions,	1
Molecular vibrational modes, vibrational spectroscopy infrared and Raman spectroscopy 3N-5, 3N-6 vibrational degrees of freedom	1
Vibrational symmetry and IR/Raman activity: Symmetry properties of the vibrational degrees of freedom and to deduce IR, Raman activity. Use of internal coordinates to get symmetry properties of a subset of bands	1
Vibrational spectroscopy: Local mode approximation. Characteristic infrared absorptions (alkyl CH, alcohol, amine RN H_2 and R_2NH, carboxylic acid, amide, ester, ketone, aldehyde, nitrile RCN, alkyne, alkene, aromatic), fingerprint regions, interpretation of IR spectra	
Molecular orbital theory: Electronic spectroscopy requires understanding of electronic structure leading to Molecular orbital theory – HOMO. LUMO	1
Diatomic molecules, LCAO-MO, Symmetry of MO's	1
Photoelectron spectroscopy	1
Generalisation of the application of MO approaches to polyatomic molecules	1
Hückel Theory	1
Aromatic and Heterocyclic Chemistry of compounds with delocalised p orbitals: Benzene and Aromaticity/Antiaromaticity, Reactions of Aromatic Compounds Electrophilic aromatic substitution. Reactions of Polycyclic and Heteroaromatic Compounds. Reactions via Aromatic Transition States Electrophilic aromatic substitution on naphthalene. Electrophilic aromatic substitution on heteroaromatics (*e.g.* pyridine and pyrrol). Non C-based aromatic systems	3
Electronic spectroscopy: Chromophores and excited electronic states, electronic transitions, UV-Vis spectroscopy, Franck-Condon Principle, Franck-Condon factors	1
Fates of electronic excited states – fluorescence and phosphorescence, non-radiative transitions, internal conversion and intersystem crossing, fluorescence spectra	1
Applications – light emitting polymers	1

Organometallic chemistry. Types and broad applications of organometallic complexes and catalysts. Ligand types and examples.	1
Group 1 (LiR) and group 2 (Grignard) and p-block chemistries.EPR spectroscopy as a tool to probe electron distribution in carbocyclic and organometallic species	1
Covalent interactions in coordination compounds – rationalisation of spectrochemical series in terms of bonding interactions	1
Binary metal carbonyl complexes Synergistic bonding and the 18-electron rule. IR and NMR spectroscopy	1
Substitution at metal carbonyl. Other organometallic ligand types and complexes thereof. Alkyne and alkene complexes.*etc*.	1
Redox reaction in organometallic chemistry. Hydrogen complexes and oxidative addition reactions. Reductive elimination reactions. Activation and reactions of organometallic ligands. Insertions, migrations.	1
Catalysis involving transition metals : Catalytic systems. Water gas shift reaction, hydrogenations, acetic acid process etc. Metallocene complexes and their chemistry leading to advanced polymerization catalysts etc.	1

BIOLOGY 404 - - 4 Credits	
Transmission Genetics	**No. of Lectures**
Genetic variation and behaviour of genes	3
Linkage and recombination; Mapping genes	2
Chromosome maps and genetic markers	1
Sex linkage and sex determination	2
Complementation	2
Chromosomal mutations	2
Non-Mendelian inheritance	1
Extrachromosomal DNA	2
Quantitative genetics	2
Population Genetics	**No. of Lectures**
Genetic variation in populations	2
Mutation and Genetic drift	1
Natural selection	1
Mutation/Selection balance	1
Balanced polymorphism	1

Gene flow & inbreeding	1
Population Biology	**No. of Lectures**
Nature of populations; numbers, mixing (dispersal), structure in age/stage	1
Density independent, density dependent growth (exponential and logistic growth equations)	2
R & K selection, life-histories and links to population growth parameters, (annual vs perennial life-histories, clonality)	1
Demography, Life tables, matrix models (requires simple matrix mathematics) and Epidemiology (simple functions)	1
Communities	**No. of Lectures**
Nature of communities; Community structure: how it is described, measured; what drives it; species composition, diversity (alpha, beta, gamma)	1
Intra-community (interspecific) interactions (bi-partite networks); Symbiosis, Predation, Competition, Host-parasite interactions	1
Dynamics of communities (perturbation and succession)	1
Biomes (communities on a global scale)	1
Ecosystems	**No. of Lectures**
Pond ecosystem (or other integrated example)	1
Food chains and webs	1
Pyramids (numbers, biomass, energy), abstraction, defining trophic levels, the problem of omnivory (stable isotope tracers)	1
Biogeochemical cycles (water, C, N, P) pools and fluxes, mass budget models. Rates of processes: productivity, decomposition, trophic transfer, turnover and Mean Residence Time.	1

PHY LAB-405 - 2 Credits

List of experiments

1. Verification of Stefan's Law by Electricalmethod.
2. Study of LRcircuit.
3. Study of LCRcircuit
4. To determine the self-inductance of the coil using Anderson's bridge and calculatethe value of inductive reactance (XL) of the coil at a particular frequency.
5. Measurement of wavelength of Laser by DiffractionGrating.
6. To determine the Wavelength of main spectral line of mercury light usingplane transmissiongrating.

CHM LAB-406 - 2 Credits

List of Physicalchemistryexperiments (Any3)

1. Determination of the stability constant of a complex byspectrophotometry.
2. The reaction between potassium persulphate and potassium iodide bycolorimetry.
3. Determine the formula and stability constant of a metal ion complex (Lead Oxalate) by polarography.
4. Analysis of copper oxide and copper dioxide to determine law of multipleproportions.
5. Behaviour of water at differenttemperatures

List of Inorganicchemistryexperiments (Any 3)

1. Photometric Analysis - To study complex formation between Fe (III) andsalicylic acid and find the formula and stability constant of thecomplex.
2. Simultaneous determination of Cr+2 andCu+2
3. To determine the strength of given mixture of carbonate and bicarbonate in thegiven mixture by pH metricmethod.
4. Determination of chemical oxygen demand(COD)
5. Determination of Biological oxygen demand(COD)

List of Organicchemistryexperiments **(Any 3)**

1. Organic Preparations: DoubleStage

1. Glycine – Hydantoic acid – Hydantoin
2. Benzoin – Benzil - Benzilicacid
3. P-cresol – 4,6-Dimethylcoumarin – 3-Bromo-4,6 Dimethyl Coumarin
4. Benzophenone – Oxime –Benzanilide
5. Acetanilide – p-Bromoacetanilide –p-Bromoaniline
6. Hydroquinone – Quinoline – 1,2,4 –Triacetoxybenzene.

BIOLAB-407-2 credits

List of Experiments (Any 6)

1. Study of the pond ecosystem: physical, chemical factors; biota; primary productivity estimation; role as carbon sink; community structure (overtime)

a) visit the pond, collect samples in three seasons – monsoon (already collected in July/Aug 2019), post-monsoon (Jan 2020) and summer (Mar 2020). (fieldvisits)
b) measure physico-chemical parameters, depth, turbidity, DO, primaryproductivity
c) (field+labsessions)
d) identify vegetation types, succession invegetation

2. Introductory population dynamics (Daily monitoringrequired)

a) Establish a simple culture of cladoceran species (isolated from pond sample) in lab. Study dynamics of population (growthcurves).

b) Density dependant growth – same culture, initiate the experiment with differentstarting densities.

c) Create an artificial mesocosm (tub/tank of defined area), and inoculate with Lemna./Azolla sp. (brought from nearby habitats). Monitor growth, density and biomass over time.

3. Introduction to Habitat & Communityecology

a) Visit different types of water bodies (one river/stream and one quarry/pond/lake) and conduct sampling. Study habitat ecology and community composition. (fieldsession)

b) Identify, quantify zooplankton taxa in collected samples. Calculate diversity indices. (lab session)

c) Introduction to various sampling methods (point count/line transect/quadrat) in field.Learn methods for estimating plant biomass (using GBH). (fieldsession)

Potential sites for field visits: TamhiniGhat/ Devkund waterfall (major field trip; one day long) + Pashan lake/MIT quarry (short field trip, 1-2 hrs.)

4. Functionalecology

Using established plankton cultures perform grazing experiments using range of food densities. (Lab session).

5. Solving Genetic problems which obey Mendelianlaws
6. Analyze the Human karyotype chart for different geneticdisorders
7. Use of ABO blood group data to calculate allele frequencies. (Data can be gathered both by interviews and by actual blood groupdetermination).

8. Use of PTC (phenylthiocarbamide) tasting trait to calculate allelefrequencies**.**

SEMESTER V

CHM 501- Chemical kinetics, Thermodynamics & Quantum chemistry – 4 Credits	
Topic Details	**No. of Lectures**
Chemical Kinetics • Order, molecularity, • rate laws – 1st, 2nd order kinetics • Half-life of reactions	2
Kinetics of Complex system • 2nd order reactions (Unequal concentration), • 3rd order reactions (equal concentration)	4
Photochemistry • Photochemical process • The primary quantum yield • Mechanism of decay of excited singlet state • Quenching • FRET • Effect of Temperature	6
Thermodynamics • Thermodynamics of transition • Phase Diagram • Phase Rule	8

Statistical thermodynamics • Macrostate, • Microstate, • Partition functions • Thermodynamic quantities from partition function	8
Quantum chemistry ▯ Black body radiation ▯ Heisenberg uncertainty principle ▯ Wave particle duality, Schrödinger equation, Operators, ▯ Particle in 1D/3D- Box ▯ Postulates of quantum mechanics / Eigen functions, Values ▯ Application to ¶ electrons linear conjugated hydrocarbons	8
Student work ▯ Assignments, Tutorials ▯ Reviews of various research papers, reports, books ▯ Presentations	9

Suggested Reading:

1. Peter Atkins & Juliode Paula,"*Atkins'PhysicalChemistry*"(10thedition). Chapters 16 &20
2. Atkins & de Paula "*Physical Chemistry*" 7th-10th ed
3. Principles of Chemical kinetics J E House
4. Physical Chemistry, A molecular approach by Donald A McQuarrie, John D. Simon
5. Elements of Physical Chemistry by Atkins
6. Physical Chemistry for Chemical and Biological Sciences by Raymond Chang
7. Physical Chemistry by Atkins, International Edition

CHM 502 - Catalysis and Industrial processes - – 4 Credits	
Topic Details	**Lectures**
Fundamental aspects of catalysis Homogeneous and Heterogeneous catalysis. The role of catalytic processes in modern chemical manufacturing - organometallic catalysts - catalysis in organic polymer chemistry - catalysis in petroleum industry - catalysis in environmental control.	4

Homogeneous catalysis Steam reformation, natural gas (methane), reformation of hydrocarbons, Monsanto acetic acid synthesis, alkene polymerization, Carbonylation, hydrogenation, hydroformylation, hydrogenation vs hydroformylation, Monoelectronic transfer, Shell process, Wacker acetaldehyde synthesis, photoactivated catalysis and metal cluster catalysts, Asymmetric catalysis using chiral phosphoric acids, CPA (e.g. BINOL-phosphoric acid), e.g. asymmetric hydrogenation, epoxidation, hydroformylation.	12
Heterogeneous Catalyst Ruhrchemie/Rhone-Poulenc Oxo process using aqueous biphasic catalysis, Zeolites, their structure and properties, natural vs synthetic zeolites, zeolytes as catalysts, mesoporous materials in heterogeneous catalysis, The flue gas depollution, Energy and CO2, Hydrogenation, Oxidation, Refining technology etc.	8
Applied Biocatalysts Introduction to enzymes and enzyme catalysed reactions. Classification and mechanismof reaction. Purification and characterization of enzymes. Michelis Menten kinetics, Industrial enzymes. Applications of enzymes in diagnostics, analysis, biosensors and other industrial processes and bio-transformations. Enzyme structure determination, stability and stabilisation. Enzyme immobilization and concept of enzyme engineering. Nanobiocatalysis.	6
Photocatalysis Porphyrins -phthalocyanines and semiconductor as photo catalysts in photolysis reactions - generation of hydrogen by photo catalysts - photocatalytic break down of water andharnessing solar energy - photocatalytic degradation of dyes - environmental applications.	6
Student Work - Assignments, Tutorials - Reviews of various research papers, reports, books - Presentations	9

50

Suggested Readings:

1. Weller et al. (IC), 6th ed, Ch 21, 22 & 25, Housecroft and Sharpe (HS), 4th ed, Ch 26, 24.2, 24.7, 25
2. Cotton, F.A. and Wilkinson, G. "Advanced Inorganic Chemistry", 4th Ed. John Wiley & Sons, New York.
3. Huheey, J.E.,Keiter, E.A. andKeiter, R.L. "Inorganic Chemistry: PrinciplesofStructuresandReactivity",4thEd.,LowPrintEdition,Pearson Education Ltd, Asia, Reprint in India.
4. Pecoraro, V.L. "Manganese Redox Enzymes", VCH: New York.
5. Concise Inorganic Chemistry by J.D. Lee - 5th Edition.
6. Inorganic Chemistry, - D.F. Shiver & P.W. Atkins- C.H. Longford ELBS 2nd Edition.
7. Basic Inorganic Chemistry, - F.A. Cotton and G. Wilkinson, Wiely Eastern
8. Industrial Catalysis: A practical approach by Jens Hagen Wiley (2006)
9. Industrial Catalysis: Optimizing catalysts and processes by R. I. Wijngaarden, K. R. Westerterp, and A. Kronberg
10. Handbook of Industrial Catalysts by L. Lloyd 4. Fundamentals of Industrial Catalytic Processes by C. H. Bartholomew
11. Rothenberg, G., Catalysis: Concepts and green applications, Wiley VCH, 2008
12. Gupta, B. D, Elias, A. J., Basic Oranometallic chemistry: Concepts syntheses and applications, 2nd edition, Orient Blackswan, 2013
13. Price and Stevens, Fundamentals of enzymology, Oxford University Press 2000
14. Buchholz, Kasche and Bornscheuer, Biocatalysts and Enzyme Technology, Wiley-VCH 2012
15. Polaina and MacCabe, Industrial Enzymes: Structure, Function and Applications, Springer 2007
16. B. Viswanathan, S. Kannan, R.C. Deka, Catalysts and Surfaces: Characterization Techniques, , New Delhi, 2010.
17. M. Kaneko, I. Okura, Photocatalysis: Science and Technology, Springer, 2003.

CHM 503 - Design and Synthesis of Organic Molecules – 4 Credits	
Topics	**Lectures**
Selectivity in organic synthesis Chemo-selectivity, Regioselectivity, Stereo- and enantioselectivity	2
Introduction of Pericyclic reaction Electrocyclic, sigmatropic, cycloaddition, chelotropic and ene reactions, photochemicalcycloaddition reactions, Diels-Alder reaction, Dipolar cycloadditions, retrocycloadditions, electrocyclic reactions.	6

C-C single/ double bond formation reactions	8
Mechanism of Knoevenagel, Perkin, Stobbe, Darzen, Acyloin condensations, epoxidations (Prilezhaev, Sharpless, Jacobsen), Metal catalyzed C-C bond formations (Ullmann, Buchwald-Hartwig, Heck, Suzuki, Stille reactions). Phospohorus, nitrogen and sulfur ylids, Wittig reaction, Wittig-Horner reaction, Mannich reaction, Peterson olefination, McMurry reaction, β-eliminations (Hoffman & ester pyrolysis), Cope elimination, mreduction of acetylenes.	
Oxidation and reduction reactions Oxidations of hydrocarbons (alkanes, alkenes and aromatic), alkenes to epoxides (peroxides/per acids based), Sharpless asymmetric epoxidation, Jacobsen epoxidation, alkenes to diols (Manganese, Osmium- based), Sharpless asymmetric dihydroxylation, alkenes to carbonyls with bond cleavage (manganese, osmium, ruthenium and lead based-ozonolysis), alkenes to alcohols/carbonyls without bond cleavage (hydroboration-oxidation, chromium based allylic oxidation), ketones to α-hydroxy ketones, α,β-unsaturated ketones, Hydride reducing agents, Birch reduction, CatalyticHydrogenation reaction, Carbonyl reduction reaction.	8
Target oriented synthesis Designing organic synthesis, Retrosynthetic analysis, disconnection approach, linear and convergent synthesis. Diversity-oriented synthesis: concept of forward-synthetic analysis, appendage diversity, skeletal diversity, stereochemical diversity, complexity and diversity.	6
Asymmetric Synthesis Use of chiral auxiliaries, chiron approach. Principles and use of enzymes in the syntheis of industrially important sugar / fatty acid esters, sugar nucleotide derivatives;enantiomeric pure compounds and biobased platform chemicals.	6
Student Work - Assignments, Tutorials - Reviews of various research papers, reports, books - Presentations	9

Suggested Reading:

1. *Organic Chemistry* by J.McMurray, 7th Ed., Thomson, 2008. *Principles of Organic Synthesis* by R. Norman and J.M. Coxon, 3rd Ed., Chapman and Hall, 1993. *Organic* Chemistry by J. Clayden, N. Greeves, S. Warren and P. Wothers, 2nd Ed, Oxford Press, 2012.
2. Carey, F. A. and Sundberg, R. J., "Advanced Organic Chemistry, Part B: Reactions and Synthesis", 5th Ed., Springer.
3. Clayden, J., Greeves, N. and Warren, S., "Organic Chemistry", Oxford University Press.
4. Smith, M.B., "Organic Synthesis", 3rd Ed., Academic Press.
5. Bruckner, R., "Organic Mechanisms: Reactions, Stereochemistry and Synthesis", Springer.

CHM 504 - Introduction to analytical chemistry - **– 4 Credits**	
Topics	**Lectures**
Fundamentals of Analytical Methods Statistics and chemometrics: statistical calculations, confidence limits, tests of significance, correlation coefficient, propagation of error; sampling methods: representative samples, automation of sampling and sample treatment; experimental design; quality control and assurance, volumetric and gravimetric methods; quantitative aspects of colorimetry; theory of different types of titrations: acid-base, precipitation, redox, complexometric, nonaqueous, etc.; Introduction to analytical sensors; automated method of analysis; continuous flow methods; flow injection analysis; kinetic methods of analysis; miscellaneous methods: turbidimetry, refractometry, polarimetry, optical rotatory dispersion and circular dichroism.	6
Electroanalytical methods Introduction, electrochemical cells, types of electrodes, classifications of electroanalytical methods. Analytical applications of two-electrode systems: conductometry and potentiometry; controlled potential techniques: constant potential (e.g., amperometry), potential step (e.g., pulse techniques), and potential sweep methods (e.g., cyclic voltammetry); electrogravimetry, electrophoresis, electrosynthesis, coulometry, flow electrolysis, thin-layer electrochemistry; electrochemical sensors; electrochemical technology.	8

Environmental Analytical Chemistry Sampling of air, water and soil for chemical analysis; monitoring techniques of air pollutants, air quality standards, pollutants standards index (PSI), monitoring of volatile	6
organic compounds; water pollution: water quality parameters and their determination, algal blooms and algal toxins, monitoring pesticide residues in water and soil, water treatment: municipal water treatment, waste water treatment methods.	
ANALYTICAL BIOCHEMISTRY **Body fluids** Composition of body fluids and detection of abnormal levels of certain constituents leading to diagnosis of disease., Physiological and nutritional significance of water and fat soluble vitamins and minerals. Analysis for constituents of physiological fluids, viz., urine, blood, serum. Analytical techniques for vitamins including microbiological techniques.	3
IMMUNOLOGICAL METHODS General processes of immune response, Antigen-antibody reactions, precipitation reactions, radio, enzyme, and fluoro-immuno assays. Human nutrition : Biological values and estimation of enzymes, carbohydrates, essential amino acids, proteins, andlipids	3
SPECTRAL METHODS Infra-red spectroscopy, NMR, Mass spectroscopy, Raman spectroscopy, Isotope dilution method and activation analysis, radiometric and radio-release methods Auto, X-ray and gamma radiography, Principle, Instrumentation and applications of: Differential Thermal Analysis, Differential Scanning Calorimetry, Thermometric titrations, Evolved gas analysis, HYPHENATED TECHNIQUES : Need for hyphenation, Interfacing devices and applications of GC - MS, GC - IR, MS-MS, HPLC - MS, ICP -MS, ICP - OES.	10

Student Work • Assignments, Tutorials • Reviews of various research papers, reports, books • Presentations	9

Suggested Readings:

1. D.A.Skoog, D.M.West, F.J.Holler and S.R.Crouch, Fundamentals of Analytical Chemistry 9E, 9th Ed., Brooks/Cole, 2014
2. D.A.Skoog, F.J.Holler and T.A.Nieman, Principles of Instrumental Analysis, 5th Ed., Thomson,1998.
3. Analytical Chemistry, G. D. Christian, 4th Ed. John Wiley, New York (1986)
4. Fundamentals of Analytical Chemistry, D .A. Skoog and D. M. West and F. J. Holler Holt- Saunders (1992)
5. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann, 5th Edition (1998)
6. Instrumental methods of Analysis, H. H. Willard, L. L. Merritt, Jr. J. A.Dean 6th Ed CBS (1986)
7. Instrumental methods of Analysis, H. H. Willard, L. L. Merritt Jr, J. A. Dean 7th Ed CBS (1986)
8. Introduction to instrumental analysis, R. D. Braun, Mc Graw Hill (1987)
9. General, organic and biological chemistry, H. Stephen Stoker, Cengage Learning.
10. Advance dairy chemistry, vol 3, P. F. Fox, P. L. H. McSweeney Springer.
11. Physiological fluid dynamics vol 3, Nanjanagud Venkatanarayanasastry Chandrasekhara Swamy Narosa 1992
12. Molecular Biological and Immunological Techniques and Applications for food, edited by Bert Popping, Carmen Diaz-Amigo, Katrin Hoenicke, John Wiley & sons.
13. Analytical Chemistry, G. D. Christian, 4 th Ed. John Wiley, New York (1986)
14. Fundamentals of Analytical Chemistry, D. A. Skoog and D. M. West and F. J .Holler Holt- Saunders 6th Edition (1992)
15. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann 5th Edition (1998)
16. Instrumental methods of Analysis, H. H. Willard, L. L. Merritt, Jr J. A. Dean and F. A. Settle Jr 6th Ed CBS (1986)
17. Instrumental methods of Analysis, H. H. Willard, L. L. Merritt Jr, J. A. Dean and F. A. Settle Jr 7th Ed CBS (1986)

CHM 505 (Elective Course 1) - Molecular Modelling in Chemistry - **– 2 Credits**	
Topic Details	**Lectures**
Brief Review of the basic Principles of quantum mechanics of atoms and molecules. Potential energy surfaces and intermolecular interactions: Quantum mechanical abinitio calculations within Born-Oppenheimer approximation and modelling of calculated energies by model potentials for simple atoms, molecules and ions. Energy calculations using molecular mechanics.	10
Simple applications of molecular modelling: Study of an assembly of atoms or molecules (clusters and/or bulk phases). Approximation of the total potential energy asthe sum of pair potentials. Concept of large number of microstates, averages and basic principles of simulations. Study of cluster and bulk properties through simulations.	6
Modelling of water and small organic molecules: Nonpolarizable and polarizable rigid models. Flexible models and calculation of force constants. Structural, dielectric and dynamical properties of a polar medium: Continuum models versus molecular models. Calculation of free energy using molecular models.	6
Modelling of macromolecules: Study of self-organized assemblies, biomolecules like peptides, proteins, membranes and ion channels. Concept of hydrophobic and hydrophilic interactions. Use of molecular modelling in drug design, QSAR	2
Student Work • Assignments, Tutorials • Reviews of various research papers, reports, books • Presentations	9

Suggested Readings

1. A.R. Leach, Molecular Modeling : Principles and Applications, Longman (1996).
2. J. H. Jensen, Molecular Modeling Basics, CRC Press (2010).
3. C. J. Cramer, Essentials of Computational Chemistry: Theories and Models, 2nd Ed., Wiley (2004).
4. J. Israelachvili, Intermolecular and surface Forces, Academic (1991)
5. M. P. Allen and D. J. Tildesley, Computer Simulation of Liquids, Clarendon Press (1987)
6. D. Frenkel and B. Smit, Understanding Molecular Simulation : From algorithms to Applications, Academic Press (1996)
7. P.W. Atkins, Molecular Quantum Mechanics, Oxford (1997)

8. W. Koch & M. C. Holthausen, A Chemist's Guide to Density Functional Theory, Wiley
9. Szabo, Modern Quantum Chemistry: Introduction to Advanced Electronic Structure Theory, Dover Publications (1996).

CHM 506 (Elective Course 2) Introduction to forensic science & technology - **2 Credits**	
Topic Details	**Lectures**
History and development of Forensic Science Historical aspects of forensic science, Definitions and concepts of forensic science, Need of Forensic Science, Basic Principles of Forensic Science, Scope of development of forensic science. Functions of Forensic Science, Different branches of Forensic Science. Frye case and Daubert standard. Scope and development of forensic science.	6
Legal aspects of crime: Crime – Introduction Natures, causes and consequences of crime, Broad concepts of criminal Justice system, Procedures involved in the detection of crime, Filing of criminal charges, Indian police system – The Police Act, Human rights and criminal justice system in India. Set up of INTERPOL. Duties and qualification of forensic science.	3
Organizational set up of FSL in India Hierarchical set up of central forensic science laboratory, Hierarchical set up state forensic science laboratory, Government examiners of questioned documents. Chemical examiners laboratory, Finger print bureaus, National crime records bureau, Bureau of police research and development, Mobile crime laboratory, Duties of forensic scientist, code of conduct of forensic scientists. Drug enforcement administrator. Defense research and development organization.	3

Forensic Chemistry **Petroleum and Petroleum Products**: Distillation and fractionation of petroleum. Commercial uses of different petroleum fractions. Analysis of petroleum products. Analysis of traces of petroleum products in forensic exhibits. Comparison of petroleumproducts. Adulteration of petroleum products. **Cases Involving Arson**: Chemistry of fire. Conditions for fire. Fire scene patterns. Location of point of ignition. Recognition of type of fire. Searching the fire scene. Collection and preservation of arson evidence. Analysis of fire debris. Analysis of ignitable liquid residue. Post-flashover burning. Scientific investigation and evaluation of clue materials. Information from smoke staining. **Explosives: Classification of explosives** – low explosives and high explosives. Homemade explosives. Military explosives. Blasting agents. Synthesis and characteristics of TNT, PETN and RDX. Explosion process. Blast waves. Bomb scene management. Searching the scene of explosion. Mechanism of explosion. Post blast residue collection and analysis. Blast injuries. Detection of hidden explosives	8

Forensic Biology Nature and importance of biological evidence. Significance of hair evidence. Transfer, persistence and recovery of hair evidence. Structure of human hair. Comparison of hair samples. Morphology and biochemistry of human hair. Comparison of human and animal hair. Types and identification of microbial organisms of forensic significance. Identification of wood, leaves, pollens and juices as botanical evidence. Diatoms and their forensic significance	4
Student Work • Assignments, Tutorials • Reviews of various research papers, reports, books • Presentations	6

Suggested readings:

1. B.B. Nanda and R.K. Tiwari, Forensic Science in India: A Vision for the Twenty First Century, Select Publishers, New Delhi (2001).
2. M.K.BhasinandS.Nath,RoleofForensicScienceintheNewMillennium,UniversityofDelhi, Delhi(2002).
3. S.H. James and J.J. Nordby, Forensic Science: An Introduction to Scientific and Investigative Techniques, 2nd Edition, CRC Press, Boca Raton (2005)
4. 4.W.J. Tilstone, M.L. Hastrup and C. Hald, Fisher's Techniques of Crime Scene Investigation, CRC Press, Boca Raton (2013).

CHM 507 - Physical/Analytical Chemistry – LAB - 2 Credits

1. Kinetics of Alcohol Dehydrogenase-Catalysed Oxidation of Ethanol
2. To study the phase diagram of a binary system (Phenol + water) and the effect ofimpurities (e.g. NaCl). Photolysis of Ethanal.
3. To determine the energy of activation for the acid catalysed hydrolysis of methyl acetate
4. Determination of specific rotation of lactic acid/sucrose by polarimeter.
5. Determination of Na, K in a soil sample by flame photometry.
6. Determination of glucose from food sample by glucose oxidase method.
7. Use of fluorescence to do "presumptive tests" to identify blood or other body fluids
8. To study the kinetics of saponification of ester by conductometric method

CHM 508 - Inorganic/Organic Chemistry – LAB – 2 Credits

1. Oxo synthesis: - hydroformylation of propene with [HRh(CO)(PPh3)3]
2. Oligomerization of Ethylene (SHOP Process)
3. L-Amino Acids by Aminoacylase Process
4. Catalytic hydrogenations with metal catalysts based on Ni, Co, Pd, or Pt.
5. Knoevenagel condensation between aldehyde (4-diethylaminobenzaldehyde) andmalonic acid, cyanoacetic acid or malononitrile.
6. Preparation of pyridinium dichromate and its use in oxidation of benzyl alcohol
7. Synthesis of trans-9-(2-Phenylethenyl)anthracene
8. Asymmetric reduction of EAA by using Bakers yeast

CHM 509 – Project/ Dissertation - **– 2 Credits**

Project-based learning offers an opportunity to the students to work independently under guidance of a supervisor. Students will be assigned to the on campus faculty/ research scientists from various national research institutes such as NCL/ IISER/ working in chemistry research; under whose guidance he or she would work on a problem keeping the focus to enhance their own ability to critical thinking, identification of research problems and research gaps, formulate research objectives, formulation of research plan, and problem solving via execution of specific experiments, and develop specialized skills to handle specific problems. This would train the students to nurture their creativity and innovative ideas, collaboration/teamwork and leadership, communications, learning self-reliance and project management.

Adequate assessment requirements for individual marking are presentations with discussions and seminarson the working process and the results.

Semester VI

CHM 601 - Solid State chemistry & its Applications - **– 4 Credits**	
Topic Details	**Lectures**
Fundamentals Types of solids - close packing of atoms and ions - bcc, fcc and hcp voids –Gold schmidt radius ratio - derivation - its influence on structures - structures of rock salt - cesium chloride - wurtzite - zinc blende - rutile - fluroite - antifluorite - diamond and graphite-spinel - normal and inverse spinels and perovskite - lattice energy of ionic crystals -Madelung constant - Born-Haber cycle and its applications.	5
Theories Band theory of solids. Free electron Theory, zone theory, MO theory of Solids dislocation in solids: Schottky and Frenkel defects. Line defects and plane defects – nonstoichiometric compounds. Electrical properties: Energy bands, insulators, semiconductors and conductors- super conductors-dielectric properties, piezo-electricity, ferro electricity- conductivity in pure metals. Superconductivity: Occurrence, BCS theory, high temperature super conductors- introduction to nanoparticles- metal nanoparticles- particle size determination.	5
X- Ray diffraction Theory- the crystal systems and Bravais lattices - Miller indices and labelling of planes - symmetry properties - crystallographic point groups and space groups - X-ray diffraction - powder and rotating crystal methods - systematic absences and determination of lattice types - analysis of X-ray data for cubic system - structure factorand Fourier synthesis -Fundamentals of electron and neutron diffraction.	4

Chemistry of Nanostructure Materials Introduction; fundamentals of nanomaterials science, surface science for nanomaterials, colloidal chemistry; Synthesis, preparation and fabrication: chemical routes, self-assembly methods, biomimetic and electrochemical approaches; Size controls properties (optical, electronic and magnetic properties of materials) - Applications (carbon nanotubes and nanoporous zeolites; Quantum Dots, basic ideas of nanodevices)	4
Introduction to nanoscience and nanotechnology Underlying physical principles of nanotechnology: *Nanostructured Materials: Size is Everything.* fundamental physicochemical principles - size dependence of the properties of nanostructured matter -quantum confinement, single electron charging, the central importance of nanoscale morphology. Societal aspects of nanotechnology: Health, environment, hype and reality. The advent of the nanomaterial. Top down andbottom up approaches to building materials. Properties of nanomaterials such as nanoparticles, carbon nanotubes. Overview of self-assembly. Inert gas condensation, arc discharge, RF plasma, plasma arc technique, ion sputtering, laser ablation, laser pyrolysis, ball milling, molecular beam epitaxy, chemical vapour deposition method and electro deposition.	5
The basic tools of nanotechnology Scanning electron microscopy (SEM), TEM and EDAX analysis and X-ray diffraction, A brief historical overview of atomic force microscopy (AFM) and an introduction toits basic principles& applications. Optical microscope and their description,operational principle and application for analysis of nanomaterials, UV-Vis-IR spectrophotometers, Principle of operation and application for band gap measurement.	5
Metal nanoparticles Size control of metal nanoparticles and their characterization, study of their properties,optical, electronic, magnetic. Surface plasmon band and its applications, role in catalysis, alloy nano particles, stabilization in sol, glass, and other media, change of bandgap, blueshift, colour change in sol, glass, and composites, Plasmon resonance	4

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Carbon nanostructures Introduction. Fullerenes, C60, C80 and C240 nanostructures. Properties & applications (mechanical, optical and electrical). Functionalization of carbon nanotubes, reactivity of carbon nanotubes. Nano-sensors: Temperature sensors, smoke sensors, sensors for aerospace and defence. Accelerometer, pressure sensor, night vision system, nano tweezers, nano-cutting tools, integration of sensor with actuators and electronic circuitry biosensors.	4
Student Work • Assignments, Tutorials	9
• Reviews of various research papers, reports, books • Presentations	

Suggested Reading:

1. T. Pradeep, Nano: The Essentials, Tata McGraw-Hill, New Delhi, 2007.
2. G. Cao, Nanostructures and Nanomaterials – Synthesis, Properties and Applications, Imperial College Press, London, 2004, chapters 3, 4 and 5.
3. C. N. R.Rao, A. Muller and A. K. Cheetham, The Chemistry of Nanomaterials, VolumeWiley – VCH Verlag GmbH & Co. KgaA, Weinheim, 2004, Chapter 4.
4. Nanoparticles- Theory and Applications by Schmid
5. Carbon Nanomaterials by Challa
6. Nanomaterials- Synthesis, properties and applications by Rao CNR, Miller A, Cheetham AK.
7. Solid State Chemistry and it's Applications by West/ Nanoscale materials in Chemistry by Klabunde
8. Carbon Nanotubes- Basic Concepts and Physical Properties by Reich S, Thomsen C, Maultzsch

CHM 602 - Bioinorganic and Coordination chemistry - **4 Credits**	
Topic Details	**Lectures**
Metal ligands in biological system • Amino acid side chains, specialized ligands, porphyrins, enterobactin, etc. • availability of Fe, Cu and Zn • uptake of Fe, gut, transferrin and ferritin • oxygen transport • Zn-source of nucleophilic –OH, Cu-essential but toxic • photosynthesis-chlorophyll reaction center and oxygen evolving center.	6
Theories of coordination compounds VB theory - CFT - splitting of d orbitals in ligand fields and different symmetries - CFSE - factors affecting the magnitude of 10 Dq – evidence for crystal field stabilization - spectrochemical series - site selection in spinels – tetragonal distortion from octahedral symmetry - Jahn-Teller distortion - Nephelauxetic effect – MO theory - octahedral - tetrahedral and square planar complexes-bonding and molecular orbital theory - experimental evidence for -bonding.	6
Reactions Substitution reactions in square planar complexes - the rate law for nucleophilic substitution in a square planar complex - the trans effect - theories of trans effect - mechanism of nucleophilic substitution in square planar complexes - kinetics of octahedral substitution - ligand field effects and reaction rates - mechanism of substitution in octahedral complexes - reaction rates influenced by acid and bases - racemization and isomerization - mechanisms of redox reactions - outer sphere mechanisms - excited state outer sphere electron transfer reactions - inner sphere mechanisms - mixed valent complexes.	6

Electronic spectra and magnetism Microstates, terms and energy levels for d1 – d9 ions in cubic and square fields - selectionrules - band intensities and band widths - Orgel and Tanabe-Sugano diagrams - evaluation of 10 Dq and β for octahedral complexes of cobalt and nickel - charge transfer spectra - magnetic properties of coordination compounds - change in magnetic properties of complexes in terms of spin orbit coupling - temperature independent paramagnetism - spin cross over phenomena.	5
Structure Structure of coordination compounds with reference to the existence of various coordination numbers (2, 3, 4, 5 & 6) - site preferences - isomerism - trigonal prism -absolute configuration of complexes - stereo selectivity and conformation of chelate rings - coordination number seven and eight. Spectral and magnetic properties of lanthanide and actinide complexes.	5
IR and Raman spectroscopy Structural elucidation of simple molecules like N2O, ClF3, NO3-, ClO4- - effect of coordination on ligand vibrations - uses of group vibrations in the structural elucidation ofmetal complexes of urea, thiourea, cyanide, thiocyanate, nitrate, sulphate and DMSO - effect of isotopic substitution on the vibrational spectra of molecules - applications of Raman spectroscopy.	5
EPR theory and instrumentation, spin Hamiltonian, isotropic and anisotropic EPR spectra,magic pentagon rule, applications of EPR spectroscopy (i) in structure determination of coordination complexes and (ii) metalloproteins (Fe and Cu)	3
Student Work • Assignments, Tutorials • Reviews of various research papers, reports, books • Presentations	9

Suggested Reading:

1. J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry, Principles of Structure and Reactivity, 4thEdition, Harper Collin College Publishers, 1993.
2. F.A. Cotton and G.Wilkinson, Advanced Inorganic Chemistry, 4th& 5thEdns, Wiley Interscience, New York, 1998.
3. R.S. Drago, Physical Methods in Inorganic Chemistry, 3rd Edition, Wiley Eastern, 1992.
4. J. Lewis, R.G. Wilkins, Modern Coordination Chemistry, Inter Science Publisher, 1960.
5. D. F. Shriver, P. W. Atkins and C. H. Langford, Inorganic Chemistry, Oxford University Press, Oxford, l994.
6. K. Nakamoto, Infrared and Raman Spectra of Inorganic and Coordination Compounds, Part A &Part B, 2ndEdn, Wiley. 2009.
7. G. L. Miessler, D. A. Tarr, Inorganic Chemistry, 3rd Edn, Pearson Prentice Hall, 2005
8. J.E. House, Inorganic Chemistry, Elsevier, 2008.

9. Housecroft and Sharpe, 3rd ed, Chap 29; Weller et al, 6th ed, Chap 26.
10. Cotton, F.A., Wilkinson, G., Murillo, C.A. and Bochmann, M., "Advanced Inorganic Chemistry", 6th Ed., John Wiley & Sons
11. Douglas, B.E., McDaniel,D.H. and Alexander, J.J., "Concepts and Models in Inorganic Chemistry", 3rd Ed., John Wiley & Sons
12. Figgis, B.N., and Hitchman, M.A "Ligand Field Theory and Its Applications", Wiley Eastern Ltd
13. Huheey, J.E., Keiter, E.A. and Keiter, R.L., "Inorganic Chemistry Principle of Structure and Reactivity", 4th Ed, Pearson Education, Inc.

CHM 603 - Natural Product and Heterocyclic chemistry - **4 Credits**	
Topic	**Lectures**
Classification of natural products Chemical structure, classification, structure elucidation based on degradative reactions- Isolation and structural elucidation of selected alkaloids and terpenes- quinine, morphine, and reserpine, citral, juvabione and logiofolene –Insect pheromones.	5
Amino Acids, Peptides and Proteins Classification of Amino Acids, Zwitterion structure and Isoelectric point. Synthesis of amino acids-reactions - properties- Amino Acids in Nature: - Amino Acids and their Metabolites in Nature –Structure of proteins- Peptides.	5

Steroids classification- Synthesis and structure elucidation of cholesterol, conversion of cholesterol to progesterone- androsterone and testosterone-cortisone- Vitamin D – Nucleic Acids- structure of nucleosides and nucleotides-RNA and DNA, Watsons and Crick model DNA-drug interaction	5
Carbohydrates Classification of carbohydrates, reducing and non-reducing sugars, General properties of glucose and fructose, their open chain structure. Epimers, muta-rotation and anomers. Determination of configuration- Hudsons rules-Structure of sugars transformation of sugars, Preparation of alditols, glycosides, deoxysugars. Synthesis of vitamin C from glucose.	5
Heterocycles Synthesis, Properties and uses of Five membered heterocyclic ring systems with one or two hetero atoms-Furan, pyrrole, thiophene and thiazole: six membered heterocyclic ring system-Pyridine. Fused heterocyclic ring systems- Indole, quinoline. Biologically important heterocycles: Pyrimidines and purines.	8
New materials derived from heterocycles Syntheses of cyanines and related dyes. Organic sensitizers for DSSC, electron donors and acceptors for organic solar cells, optical chemo-sensors and organic semiconductorsfor thin-film transistors.	8
Student Work • Assignments, Tutorials • Reviews of various research papers, reports, books • Presentations	9

Suggested Reading:

1. I. L. Finar, Organic Chemistry Vol. I & Vol. II- Pearson Education, 6thedn.
2. F. A. Carey and R. J. Sundberg, (Eds) 3rd Edition, Part B. Plenum/Rosetta, 1990.
3. I. Fleming, Selected Organic Synthesis, John Wiley and sons, 1982.
4. Atta-ur-Rahman, Studies in Natural Products Chemistry, Vol.1 and 2, Elsevier, 1988.
5. R. Krishnaswamy, Chemistry of Natural Products; A Unified Approach, Universities Press.
6. R. J. Simmonds: Chemistry of Biomolecules: An Introduction, RSC.

7. Designing organic Synthesis by Stuart Warren1983.
8. Organic Chemistry by Cram andHammond.
9. Organic Chemistry by Clayden, Greeves, Warren andWothers

CHM 604 - Separation Techniques and Advanced Analytical Techniques - **4 Credits**	
Topic	**Lectures**
Extractionstechniques Partition law and its limitations, distribution ratio, separation factor, factors influencing extraction, multiple extractions. Extraction of metal. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non- aqueous media.	8
Chromatography Introduction and classification, theory of column chromatography, retention time, retention volume, capacity factor, concept of plate and rate theory, resolution, column performance, normal and reverse phase chromatography, paper and thin layer chromatography, ion-exchangers.	6
GC principle, instrumentation, Application Introduction, Theory, Principle, GSC and GLC, Seperation mechanism involve in GSC and GLC, Instrumentation of Gas chromatography, working of gas chromatography, gas chromatogram and qualitative –quantitative analysis. Application of Gas chromatography	4
HPLC principle, instrumentation, Application Introduction, Need of liquid chromatography, Seperation mechanism involved in adsorption and partition HPLC, Instrumentation and working of HPLC, Applications of HPLC, Introduction to supercritical fluid chromatography.	4
Mass spectrometry	6
GCMS/LCMS	2
Data Analysis	2

Quantitative chemical analysis; calculation of analytical results (calibration curve method, standard addition method, internal standards method) Significant figures: confidence and interval; Student's T-test; F-test; Q-test	
Sensor Introduction, Classifications of sensors, Sensitivity and Limit of detection, Types of Sensors- Optical, Electrochemical & Biosensor. Application of Sensor in environmental and biological samples.	4
Student Work • Assignments, Tutorials • Reviews of various research papers, reports, books • Presentations	9

Suggested Readings

1. Textbook of Quantitative Chemical Analysis- 3rd Edition, A. I.Vogel
2. Principles of Physical Chemistry 4th edition – Prutton andMarron
3. Instrumental Methods of Chemical Analysis- Chatwal andAnand
4. Basic Concept of Analytical Chemistry-2nd edition S.M.Khopkar
5. Vogel's textbook of Quantitative Inorganic Analysis-4th edition Besset Denney, Jaffrey,Mendham
6. Instrumental Methods of Chemical Analysis- 6th edition Willard, Merritt, Dean andSettle
7. Analytical Chemistry bySkoog
8. Introduction to Instrumental Analysis- R.D. Braun
9. Instrumental methods of Chemical Analysis-Willard, Dean &Merrit- 6th Edition

CHM605 (Elective Course 3) - Materials Chemistry - **2 Credits**	
Topic Details	**Lectures**
Basics of crystalline solids Crystalline solids, crystal systems, Bravais lattices, coordination number, packing factors –cubic, hexagonal, diamond structures, lattice planes, Miller indices, interplanar distances,directions, types of bonding , lattice energy, Madelung constants, Born Haber cycle, cohesiveenergy,Symmetryelements,operations,translationalsymmetriespointgroups,space gr oups, equivalent positions, close packed structures, voids, crystal structures, Pauling rules,defects in crystals, polymorphism, twinning.	8

Silica based materials Introduction to Zeolites, metallosilicates, silicalites and related microporous materials, Mesoporous silica, metal oxides and related functionalized mesoporous materials: Covalent organic frameworks, Organic-Inorganic hybrid materials, periodic mesoporous organo silica, metal organic frameworks: H_2 /CO_2 gas storage and catalytic applications	8
Composite materials Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, environmental effects on composites, applications of composites.	8
Student Work • Assignments, Tutorials • Reviews of various research papers, reports, books • Presentations	6

Suggested readings:

- Atkins P, Overton T., Rourke J. Weller M. and Armstrong F Shriver and Atkins. Inorganic Chemistry Oxford University Press, Fifth Edition,2012.
- Adam, D.M. Inorganic Solids: An introduction to concepts in solid-state structural chemistry. JohnWiley,1974.
- Poole, C.P. & Owens, F.J. Introduction to Nanotechnology John Wiley2003.
- Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning,

CHM606 (Elective Course 4) - Supramolecular chemistry - **2 Credits**	
Topic Details	**Lectures**
Introduction-the meaning of supramolecular chemistry, phenomenon of molecularrecognition and their quantification	1
Building blocks of supramolecular chemistry- acyclic receptors for neutral and charged guests, macrocycles and crown ethers, macrobicycles and cryptands,macropolycycles, cucurbiturils and cyclodextrins	8
Sensors and information processing, electro-optic phenomena, molecular machines	6
Amphiphilic molecules and their aggregation, Langmuir-Blodgettry, molecular recognition at the air-water interface	2
Discrete and polymeric metal-organic hybrid materials- guest inclusion, catalysis and other applications.	6
Future scopes	1
Student Work • Assignments, Tutorials • Reviews of various research papers, reports, books • Presentations	6

, Suggested Reading:

1. Supramolecular Chemistry: Concepts and Perspectives, J.-M. Lehn, VCH, Weinheim, 1995.
2. Principles and Methods in Supramolecular Chemistry, H. J. Schneider and A. Yatsimirsky, Wiley, New York, 2000.
3. Supramolecular Chemistry, J. W. Steed and J. L. Atwood, John Wiley & Sons, Chichester, 2009.
4. Steed, J.W. and Aswood, J.L., “Supramolecular Chemistry”, Wiley.
5. Dodziuk, H, “Introduction to Supramolecular Chemistry”, Springer, ISBN 1402002149.
6. Beer, P.D., Gale, P.A. and Smith, D.K., “Supramolecular Chemistry”, Oxford Chemistry Printers, ISBN-10: 0-19-850447-0.
7. Cragg, P., “A Practical Guide to Supramolecular Chemistry”, Wiley-VCH, ISBN: 0-470-86654-3.
8. Schneider, H.J. and Yatsimirsky, A., “Principles and Methods in Supramolecular Chemistry”, Wiley-VCH, ISBN: 0-471-97253-3.

CHM 607 - Physical/Analytical chemistry Lab - **2 Credits**

1. Preparation and characterization of MgO nanoparticle.
2. Preparation and characterization of ZnO nanoparticle.
3. Preparation and characterization of Graphene Oxide.
4. Green synthesis of metal and metal oxide nanoparticles from plant leaves extract.
5. Green synthesis of Silver nanoparticles using neem leaves.
6. Determination of Iron by UV-Visible Spectrophotometry
7. Determination of Iron by Atomic Absorption Spectrometry
8. Determination of Caffeine in Soft Drinks by High PerformanceLiquid Chromatography.
9. Environmental Monitoring of Hydrocarbons: A Chemical Sensor Perspective.

CHM 608 - Inorganic /Organic chemistry Lab - **2 Credits**

1. Synthesis and spectrophotometric study of copper complexes: (i) synthesis ofbis(salicylaldimine) copper(II) and cis-bis(glycinato) copper(II),
2. Study of the complex formation between Fe(III) and thiocyanate/salicylic acid/sulphosalicylic acid or between Ni(II) and *o*-phenanthroline, and (ii) spectrophotometric determination of formation constant of the complex (Job'smethod and molar ratio method).
3. Synthesis of tetraamminecopper (II) sulfate monohydrate [Cu(NH3)4]SO4•H2O
4. Eucalyptus oil from leaves (Steam distillation)
5. Fisher indole synthesis
6. Separation of Aminoacids/ sugars by paper chromatography and TLC
7. Synthesis of Natural product (any 2)
8. To perform colour tests for carbohydrates for reducing/non-reducing sugars.

EVSB 609 - Project/ Dissertation - 2 Credits

Project-based learning offers an opportunity to the students to work independently under guidance of a supervisor. Students will be assigned to the on campus faculty/ research scientists from various national research institutes such as NCL/ IISER/ working in chemistry research; under whose guidance he or she would work on a problem keeping the focus to enhance their own ability to critical thinking, identification of research problems and research gaps, formulate research objectives, formulation of research plan, and problem solving via execution of specific experiments, and develop specialized skills to handle specific problems. This would train the students to nurture their creativity and innovative ideas, collaboration/teamwork and leadership, communications, learning self-reliance and project management.

Adequate assessment requirements for individual marking are presentations with discussions andseminars on the working process and the results.

Summer training / Internship -

Even though summer training/internship is not mandatory and not a part of curriculum; students will be encouraged to work as summer trainee or interns in other institutes/ laboratories/ industriesdepending upon the scopes and availability during summer/winter recess.

After the period of training, it is expected that students achieve the following:

- Recognize the duties, responsibilities and ethics at a professional position.
- Ability to apply knowledge learned to solve specific problems in relevant domain of science.
- Gain exposure and practical experience in the relevant field.
- Ability to prepare technical reports for the training.
- Ability to communicate effectively in the work environment.