GANDHI INSTITUTE OF TECHNOLOGY AND MANAGEMENT (GITAM)
(Deemed to be University)
VISAKHAPATNAM * HYDERABAD * BENGALURU

Accredited by NAAC with A^+ Grade

REGULATIONS AND SYLLABUS

of

B.Sc. Blended

(w.e.f. 2019-20 admitted batch)

B.Sc. (Blended) Program Educational Objective:

The PEOs are broad statements that describe the career and professional accomplishments that the program is preparing its graduates to achieve in a few years (for example, three years) after receiving the degree. The PEOs of the B.Sc. (Blended) program are as follows:

PEO1. The BSc (Blended) graduates' courses are well planned academically for the student to pursue post-graduation either in India or abroad.

PEO2. The BSc (Blended) graduates will be well prepared to adapt to a career in research and development in a field that needs knowledge from different sciences.

PEO3. The BSc (Blended) graduates will be able to engage in society professionally and serve the betterment of humankind and nature.

PEO4. The BSc (Blended) graduates will develop leadership qualities and a spirit of teamwork.

PEO5. The BSc (Blended) graduates will develop the skill of applying computer science languages to science applications.

PEO6. The BSc (Blended) graduates will be well proficient in communication skills and be able to express the importance of science in world peace.

Programme Outcomes (POs)

Programme Outcomes (POs) are attributes of the programme's graduates that indicate the graduates' ability and competence to work as science professionals upon graduation. Program Outcomes are statements that describe what students are expected to know or be able to do by graduation. They must relate to the students' knowledge and skills from the programme. All outcomes indicate that the student is well prepared to achieve the program's educational objectives down the road. The following POs have been chosen by the GITAM School of Science, GITAM (Deemed to be a university). The B.Sc. (Blended) curriculum at GU has been designed to meet all Programme Outcomes.

The students will be able to

PO1. Apply their broad knowledge of science across a range of fields, with in-depth knowledge in at least one area of study, while demonstrating an understanding of the local and global contexts in which science is practised;

PO2. Articulate the methods of science and explain why current scientific knowledge is both contestable and testable by further inquiry;

PO3. apply appropriate methods of research, investigation and design to solve problems in science, including the planning and/or conduct of a significant project, problem or investigation;

PO4. Recognize the need for information; effectively search for, evaluate, manage and apply that information in support of scientific investigation or scholarly debate;

PO5. Employ highly developed conceptual, analytical, quantitative and technical skills and are adept with a range of technologies;

PO6. Evaluate the role of science in addressing current issues facing local and global communities, for example, climate change, health and disease, food security, sustainable energy use;

PO7. Work effectively in groups to meet a shared goal with people whose disciplinary and cultural backgrounds may differ from their own;

PO8. Communicate clearly and convincingly about science ideas, practice and future contributions to expert and non-expert audiences, matching the mode of communication to their audience.

Program Specific Outcomes

The Programme Specific Outcomes (PSOs) are specific statements that describe the professional career accomplishments that the program is designed. The PSOs of the B.Sc. (Blended) are designed in such a way that at the end:

PSO1. Learning outcomes, graduate attributes, and academic standards are explicitly articulated and monitored. It is supported by a quality assurance programme backed by the University of Melbourne and the Indian Institute of Science Education and Research (IISER- Tirupati).

PSO2. The curriculum of the course is designed based on the hierarchy of sciences. This curriculum is sufficiently broad to encompass and integrate the critical elements of maths, physics, chemistry and biology and rigorous enough to prepare students for transition into a variety of majors in the third year. It is also sufficiently applied and contextual so that students who would typically not consider themselves capable or willing to participate in a particular discipline at the tertiary level (e.g., mathematics), can be engaged and comfortable in a mandatory subject.

PSO3. The students are encouraged to pursue breadth courses like computer sciences, psychology, economics or any engineering subjects as a part of their curriculum (interdisciplinary courses).

PSO4. The BSc (Blended) students inculcate a sense of research as they have to pursue a research project in their third year (spread over the 5^{th} and 6^{th} semesters).

PSO5. It is primarily designed to prepare graduates for further study in postgraduate science and related areas, particularly internationally. Still, it is also well-suited to workforce participation in science-related companies with industry-specific workplace training.

				Maximum Marks		Pass Marks	
Semester 1		**Credits**	**T/P**	**CE**	**SE**	**CE**	**SE**
MTH101	Calculus	5	T	50	50	20	20
PHY101	Introductory Classical Physics	3	T	50	50	20	20
CHM101	Introductory and Organic Chemistry	3	T	50	50	20	20
BIO101	The Diversity of Life	3	T	50	50	20	20
PHY102	Physics Practical	2	P	100		40	
CHM102	Chemistry Practical	2	P	100		40	
BIO102	Biology Practical	2	P	100		40	
IDS101	English for IELTS -1	2	P	100		40	
IDS102	Environmental Awareness	2	P	100		40	
		24					

				Maximum Marks		Pass Marks	
Semester 2		**Credits**	**T/P**	**CE**	**SE**	**CE**	**SE**
MTH201	Algebra	5	T	50	50	20	20
PHY201	Modern Physics	3	T	50	50	20	20
CHM201	Inorganic and Physical Chemistry	3	T	50	50	20	20
BIO201	Biology of Cells	3	T	50	50	20	20
PHY202	Physics Practical	2	P	100		40	
CHM202	Chemistry Practical	2	P	100		40	
BIO202	Biology Practical	2	P	100		40	
IDS201	Scientific Computation and Modelling: Introduction to Python Programming	2	P	100		40	
IDS202	English for IELTS -2	2	P	100		40	
		24					

				Maximum Marks		Pass Marks	
Semester 3		**Credits**	**T/P**	**CE**	**SE**	**CE**	**SE**
MTH301	Vector Calculus and Differential Equations	5	T	50	50	20	20
PHY301	Quantum Mechanics and Thermodynamics	3	T	50	50	20	20
CHM301	Chemistry: Reactions and Synthesis	3	T	50	50	20	20
BIO301	Functional Biology of Organisms	3	T	50	50	20	20
PHY302	Physics Practical	2	P	100		40	
CHM302	Chemistry Practical	2	P	100		40	
BIO302	Biology Practical	2	P	100		40	
IDS301	Scientific Computation and Modelling: Introduction to R Programming	2	P	100		40	
IDS302	MOOC-1/VDC/any non-science subject	2		100		40	
		24					

				Maximum Marks		Pass Marks	
Semester 4		**Credits**	**T/P**	**CE**	**SE**	**CE**	**SE**
MTH401	Probability and Statistics	5	T	50	50	20	20
PHY401	Electricity, Magnetism, Special Relativity, and Optics	3	T	50	50	20	20
CHM401	Chemistry: Structure and Properties	3	T	50	50	20	20
BIO401	Genetics, Evolution and Ecology	3	T	50	50	20	20
PHY402	Physics Practical	2	P	100		40	
CHM402	Chemistry Practical	2	P	100		40	
BIO402	Biology Practical	2	P	100		40	
IDS401	Scientific Computation and Modelling: Project-based programming	2	P	100		40	
IDS402	MOOC-2/Non - Science Elective	2		100		40	
		24					

Semester 5	MATHEMATICS	Credits	T/P	CE	SE	CE	SE
MTH501	Algebraic structures –I	3	T	50	50	20	20
MTH502	Number theory	3	T	50	50	20	20
MTH503	Linear Programming	3	T	50	50	20	20
MTH504	Real Analysis	3	T	50	50	20	20
MTH505	Linear Programming Lab (XL solver or Lindo)	2	P	100		40	
MTH506	Scientific Computation and Modelling: SciLab	2	P	100		40	
MTH507	Functions of Several variables and Transform Techniques	2		100		40	
**	Non - science Elective	2		100		40	
PRJ501	Graduate Level Thesis	2	P	100		40	
		22					

				Maximum Marks		Pass Marks	
Semester 5	**PHYSICS**	**Credits**	**T/P**	**CE**	**SE**	**CE**	**SE**
PHY501	Classical Mechanics	3	T	50	50	20	20
PHY502	Quantum Mechanics	3	T	50	50	20	20
PHY503	Solid State Physics	3	T	50	50	20	20
PHY504	Electrodynamics	3	T	50	50	20	20
PHY505	Physics Lab 505	2	P	100		40	
PHY506	Scientific Computation and Modelling: SciLab	2	P	100		40	
PHY507	Physics of Nanomaterials	2	T	100		40	
**	Non - science Elective	2	T	100		40	
PRJ501	Graduate Level Thesis	2	P	100		40	
		22					

				Maximum Marks		Pass Marks	
Semester 5	**CHEMISTRY**	**Credits**	**T/P**	**CE**	**SE**	**CE**	**SE**
CHM501	Chemical kinetics, Thermodynamics & Quantum chemistry	3	T	50	50	20	20
CHM502	Catalysis and Industrial processes	3	T	50	50	20	20
CHM503	Design and Synthesis of Organic Molecules	3	T	50	50	20	20
CHM504	Introduction to analytical chemistry	3	T	50	50	20	20
CHM505	Physical/Analytical Chemistry - LAB	2	P	100		40	
CHM506	Inorganic/Organic Chemistry - LAB	2	P	100		40	
CHM507	Molecular Modelling in Chemistry	2	T	100		40	
**	Non - science Elective	2	T	100		40	
PRJ501	Graduate Level Thesis	2	P	100		40	
		22					

				Maximum Marks		Pass Marks	
Semester 5	**BIOLOGY**	**Credits**	**T/P**	**CE**	**SE**	**CE**	**SE**
BIO501	Biochemistry	3	T	50	50	20	20
BIO502	Molecular Biology	3	T	50	50	20	20
BIO503	Cell Biology	3	T	50	50	20	20
BIO504	Computational Biology	3	T	50	50	20	20
BIO505	Biochemistry and Cell Biology Lab	2	P	100		40	
BIO506	Molecular and Computational Biology Lab	2	P	100		40	
BIO507	Analytical techniques for Biotechnology	2	T	100		40	
**	Non - science Elective	2	T	100		40	
PRJ501	Graduate Level Thesis	2	P	100		40	
		22					

				Maximum Marks		Pass Marks	
Semester 6	**MATHEMATICS**	**Credits**	**T/P**	**CE**	**SE**	**CE**	**SE**
MTH601	Algebraic structures –II	3	T	50	50	20	20
MTH602	Numerical Methods	3	T	50	50	20	20
MTH603	Complex Analysis	3	T	50	50	20	20
MTH604	Graph Theory	3	T	50	50	20	20
MTH605	Scientific Computation and Modelling: Projects using Python	2	P	100		40	
MTH606	Core Lab - 2	2	P	100		40	
MTH607**	Partial Differential Equations	2	T	100		40	
**	Non - science Elective	2	T	100		40	
PRJ601	Graduate Level Thesis	2	P	100		40	
		22					

				Maximum Marks		Pass Marks	
Semester 6	**PHYSICS**	**Credits**	**T/P**	**CE**	**SE**	**CE**	**SE**
PHY601	Statistical Mechanics	3	T	50	50	20	20
PHY602	Subatomics Physics	3	T	50	50	20	20
PHY603	Atomic and Molecular Spectroscopy and Lasers	3	T	50	50	20	20
PHY604	Digital and Analog Electronics	3	T	50	50	20	20
PHY605	Physics Lab 605	2	P	100		40	
PHY606	Digital and Analog Electronics Lab	2	P	100		40	
PHY607**	Introduction to Biophysics	2	T	100		40	
**	Non-science Elective	2	T	100		40	
PRJ601	Graduate Level Thesis	2	P	100		40	
		22					

				Maximum Marks		Pass Marks	
Semester 6	**CHEMISTRY**	**Credits**	**T/P**	**CE**	**SE**	**CE**	**SE**
CHM601	Solid State chemistry & its Applications	3	T	50	50	20	20
CHM602	Bioinorganic and Coordination chemistry	3	T	50	50	20	20
CHM603	Natural product and Heterocyclic Chemistry	3	T	50	50	20	20
CHM604	Separation Techniques and Advanced Analytical Techniques	3	T	50	50	20	20
CHM605	Physical/Analytical Chemistry - LAB	2	P	100		40	
CHM606	Inorganic/Organic Chemistry - LAB	2	P	100		40	
CHM607**	Materials chemistry	2	T	100		40	
**	Non-science Elective	2	T	100		40	
PRJ601	Graduate Level Thesis	2	P	100		40	
		22					

				Maximum Marks		Pass Marks	
Semester 6	**BIOLOGY**	**Credits**	**T/P**	**CE**	**SE**	**CE**	**SE**
BIO601	Evo-Devo	3	T	50	50	20	20
BIO602	Systematics and Evolution	3	T	50	50	20	20
BIO603	Micro-organisms and Disease	3	T	50	50	20	20
BIO604	Genes and Genomes	3	T	50	50	20	20
BIO605	Development, Systematics and Evolution Lab	2	P	100		40	
BIO606	Immunology and Microbiology Lab	2	P	100		40	
BIO607		2	T	100		40	
**	Non - science Elective	2	T	100		40	
PRJ601	Graduate Level Thesis	2	P	100		40	
		22					

MATHS - MTH101

10	Logic and Proof
1	Basic set theory (review)
1	Logical connectives (conjunction, disjunction, negation, conditional, biconditional) and truth tables
1	Propositional logic, logical equivalence, logical laws
1	Quantifiers, predicate calculus
1	Real numbers and their properties; completeness property
1	Proof methods: direct proof, contrapositive
1	Proof methods: contradiction, proof by cases
1	Proof methods: induction
1	Natural numbers, integers, rational numbers
1	Real numbers

4	Complex numbers
1	Review of complex numbers including algebra, Argand plane, cartesian and polar form
1	Complex exponential
1	Fundamental Theorem of Algebra
1	de Moivre's theorem; roots of complex numbers

9	Differential calculus
5	Differential calculus: limits, derivative, differentiation rules incl. polynomials, trigonometric, exponential, log functions; product, quotient, chain rules
4	Inverse trigonometric functions and their derivatives, implicit differentiation

9	Integral calculus
1	Riemann integration
1	Fundamental Theorem of Calculus; review of standard antiderivatives
1	Techniques of integration (review): derivative present substitution, linear substitution
1	Techniques of integration (review): integration of trigonometric functions using identities
1	Techniques of integration (review): integration of rational functions including partial fractions, integration yielding inverse trig functions
1	Techniques of integration (review): trigonometric substitutions; integration by parts
1	Improper integrals
1	Applications of integration: areas between curves
1	Applications of integration: volumes of surfaces of revolution

PHYSICS - PHY101

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

6	Gravitation
1	Newton's law of gravity, superposition
2	Gravity at the earth's surface, far above the earth and within the earth
1	Work and gravitational potential energy
1	Kepler's laws: the planets and satellites
1	Orbital motion and energy

12	Thermal physics, physical chemistry, and the
1	Zeroth Law of Thermodynamics
1	Thermal expansion and absorption of heat
3	First Law of Thermodynamics; adiabatic processes, constant volume processes, enthalpy, cyclical processes, free expansions
1	Heat transfer, conduction, emission, absorption
2	Second Law of Thermodynamics, Irreversible processes, entropy, free energy
4	Real world examples - eg solar energy, geothermal, wind power

10	Elasticity, fluids and gases (Narrative)
1	Equilibrium and elasticity
1	Density and Pressure, Pascal's and Archimedes' Principles
1	Continuity and Bernoulli's Equation
1	Ideal gases (Kinetic theory of gases)
1	Mean free path, molecular speed distribution
1	Specific heat, adiabatic expansion
4	Real world examples - eg wind power, hydro, blood circulation, water in plants, materials,

CHEMISTRY - CHM101

7	General Chemistry
1	The Periodic Table
2	Molecular Structure and Bonding
3	Acids and Bases
1	Stoichiometry

17	Organic Chemistry
4	Carbon – the basis of life Structure and Bonding Alkanes (sp^3 Hybridisation)
2	Structure and Bonding Alkenes (sp^2 Hybridisation)
1	Benzene and its derivatives
1	Structure and Bonding of Alkynes (sp hybridisation)
1	Functional Groups
2	Electrophiles and Nucleophiles
1	Nucleophilic substitution reactions
1	Elimination reactions
1	Addition reactions
1	Electrophilic aromatic substitution reactions
1	Nucleophilic addition reactions
1	Organic redox reactions

BIOLOGY - BIO101

36	Evolution and the Diversity of Life
1	Theory of evolution: understanding life's
1	Evolutionary relationships (phylogenies) are summarized in classifications
1	Chemical evolution of life – Molecules to cells
1	Cell theory and the origin of life
2	Prokaryotic Cells: Bacteria and Archaea (2 lectures)
1	Evolution of the eukaryotic cell
1	Endosymbiosis
1	Protists 1 - Red and Green algae
1	Protists 2 – Chromists
1	Protists 3 - Dinoflagellates and apicomplexans, flagellates, ciliates, amoebae
1	Evolution of sex, life cycles
1	Origins of multiculticellularity
1	Slime moulds and fungi
1	Fungi 2
1	Introduction to Land Plants
1	Bryophytes
1	Evolution of vascular tissue, Lycophytes, fern allies, early fossil land plants
1	Ferns
1	Seed plants, the seed and secondary growth, Cycads and Ginkgo
1	Conifer diversity and biology
1	Angiosperm structure, biology and diversity, the flower, double fertilization.
1	Angiosperm phylogeny and evolution
1	Introduction to animals (Metazoa)
1	Simple animals
1	Protostomes-Flatworms and annelids
1	Molluscs
1	Arthropods
1	Deuterostomes, Echinoderms-Chordates
1	Fishes –sharks/rays, teleosts, coelacanth,
1	Amphibians
1	Reptiles
1	Birds
2	Mammals
1	The Primate story

12	ODEs - Designed and shared collectively by Maths, Physics, and Chemistry
1	Ordinary differential equations: definition of ODE, order, general solution, initial conditions; separable ODEs
1	Solving linear ODE using integrating factor
1	Applications of 1st order ODES: ecology models
2	Applications of 1st order ODES: chemical reaction rates, Newton's law of cooling
1	Second-order ODEs: definitions of homogeneous/inhomogeneous, linear/non-linear; solution of homogeneous constant-coefficient linear ODEs
1	Particular solutions of inhomogeneous constant coefficient linear ODEs using method of undetermined coefficients; principle of superposition
1	Applications of 2nd order ODEs: Springs

1	Applications of 2nd order ODEs: LRC series electrical circuits
3	Real world contextual examples in physics and chemistry and the application of ODEs (selection of examples depending on student cohort)

MATHS - MTH201

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

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

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

1	Linear Algebra 1
1	Solving systems of linear equations with Gaussian elimination
1	Solutions of systems of linear equations - consistency, uniqueness
1	Geometric interpretation of solutions
1	Matrices, matrix addition, multiplication, transpose and properties (review)
1	Matrix inverse
1	Determinant
1	R^n as a vector space, linear independence of vectors in R^n
1	Span of a set of vectors, subspaces of R^n
1	Basis and dimension in R^n
1	Abstract vector space axioms; examples and non-examples of vector spaces
1	Bases, dimension and co-ordinates in (finite dimensonal) abstract vector spaces
1	Definition of linear transformation and examples/non-examples
1	Linear transformations of the plane
1	Matrix representation of a linear transformation
1	Image and kernel of a linear transformation
1	Rank and nullity

PHYSICS - PHY201

18	Electricity and Magnetism
1	Electric charge, conductors and insulators
1	Coulomb's Law, superposition principle
1	Electric field, superposition principle
1	Electric flux
1	Gauss's law, applications
1	Energy and electric field; electric potential
1	Calculating potential from the field, electric potential, potential energy surfaces.
1	Electric dipoles
1	Capacitance; parallel plate capacitors
1	Energy storage in capacitors, dielectrics, series and parallel circuits
1	Conductors, electric current, electric power, Ohm's law
1	Kirchoff's rules, resistors in series and parallel circuits
1	Magnetic field, magnetic force, Lorentz force, cyclotrons
1	Lorentz force, ion velocity filter, Hall effect, Biot-Savart Law
1	Bio-Savart Law, Ampere's Law, solenoids, earth's magnetic field
1	Magnetic field due to a current, forces on current-carrying wires, Electromagnetic induction, magnetic flux
1	Lenz' Law, Faraday's law, Maxwell's equations, applications
1	Magnetic materials

7	Oscillations and Waves
2	Simple harmonic motion, pendulum, diatomic molecules
2	Damped harmonic motion, resonance - electronic circuits, evolution of populations
2	One dimensional waves , Interference and standing waves, Sound waves and the speed of sound, Intensity,
1	Doppler effect and supersonic motion, shock waves

8	Optics
1	Images and mirrors
1	Thin lenses and optical instruments
1	Young's experiment, interference
1	Thin films and the Michaelson interferometer
1	Diffraction by slits and apertures
1	Diffraction by gratings and X-ray diffraction
1	Optical Microscopy
1	Spectroscopy

12	Modern Physics and Quantum Chemistry
1	Challenges to classical physics; special relativity
1	Lorentz transformation, transformation of velocities, Doppler effect
1	Relativistic momentum and energy
1	Photons and the photoelectric effect
1	Quantum physics, blackbody radiator, matter waves
1	Schrödinger's equation and Heisenberg's Uncertainty Principle
1	Trapped particles and the tunneling particles
1	Bohr and Schrodinger models of the hydrogen atom
1	Complex atoms; Pauli Exclusion Principle, Periodic Table of Elements, selection rules and spectra
1	Nuclear physics, nuclear properties, nuclear decay
1	Nuclear fission and fusion
1	Quarks, Leptons, The Big Bang

CHEMISTRY -

12	Chemistry of Life
1	The chemical basis of life
2	Small inorganic molecules of biological importance
2	Stereochemistry and Biomolecular chirality
3	Biochemistry and Biomolecular structure
1	Enzymes and catlysed reactions
1	Bioenergetics
2	Metabolism

21	Inorganic Chemistry
2	Ionic Compounds and their Solutions
3	Structures of Solids
4	Main Group Chemistry
4	Redox reactions and electrochemistry
1	The transition metals : a survey
4	Coordination Chemistry
2	Bonding in complex ions
1	Transition metals in biological systems

BIOLOGY - BIO201

32	The Biology of Cells
2	Introduction to Cell Biology
	Theme: The cell contained
2	The plasma membrane
2	Cell walls, extracellular matrix, cellulose synthesis, other cell wall components
1	Cytoplasm: content, chemistry and properties
2	Cytoskeleton, actin filaments, microtubules
	Theme: Information flow in the cell
2	Nucleus, chromosomes, DNA
2	Genes and the genetic code
2	Control of gene expression
	Theme: Endomembrane system and intracellular trafficking
3	ER and ribosome, proteins and enzymes
1	Golgi apparatus
2	Vesicles, transport and secretion, Lysosomes
	Theme: Harvesting energy
2	Mitochondria, ATP, energetic reactions, electron transport pathways, cellular respiration
2	Chloroplasts, photosynthesis, historical experiments, pigments, photosystems
	Theme: Multicellularity and the Dividing Cell
2	Cell division, cell cycle, mitosis, cytokinesis, division and distribution of organelles
1	Meiosis, formation of haploid cells
2	Communication and signaling, recognizing and responding
2	Cell differentiation and multicellularity

MATHS - MTH301

11	Linear Algebra
1	Change of basis and linear transformations
1	Definition of eigenvectors and eigenvalues
1	Calculating eigenvalues and eigenvectors
1	Diagonalisation of matrices; matrix powers
1	Orthogonal matrices, real symmetric matrices
1	Characteristic and minimal polynomial, Cayley-Hamilton Theorem
1	Applications of eigenvectors/diagonalisation eg Markov chains
1	Inner product axioms; examples/non-examples of inner products
1	Length, angle, Cauchy-Schwarz inequality in terms of inner product
1	Orthogonality, projections in terms of inner product
1	Gram-Schmidt algorithm

26	Vector Calculus
1	Functions of several variables; level curves and cross sections of surfaces
1	Common surfaces including paraboloid, ellipsoid, hyperboloid
1	Domains and ranges of functions of several variables
1	Limits and continuity of functions of several variables; Definition of C^N
1	Partial derivatives, tangent plane
1	Differentiability of functions of several variables
1	Directional derivative, gradient
1	Chain rule and total derivative
1	Stationary points of surfaces, classification of stationary points using second derivatives
1	Optimisation applications
1	Constrained extrema using Lagrange multiplier method
1	Double integrals, changing order of integration
1	Polar co-ordinates, change of variables for double integrals
1	Triple integrals
1	Change of variables for triple integrals; cylindrical co-ordinates
1	Spherical co-ordinates
1	Vector fields, div and curl operators
1	Parameterisation of paths
1	Line integrals of scalar functions
1	Line integrals of vector functions
1	Integrals of scalar functions over surfaces,
1	Integrals of vector functions over surfaces, flux
1	Green's Theorem
1	Gauss Divergence Theorem
1	Stokes' Theorem
1	Applications of integral theorems eg Maxwell's equations

9	PDEs
1	Fourier Series
1	Fourier series: Dirichlet, discontinuities and differentiation
1	Fourier series: Weak convergence and series summation
1	Linearity and Superposition
1	Wave equation
1	Heat and Diffusion equation
1	Laplace equation and harmonic functions
1	Fourier transform
1	Fourier transform: properties

PHYSICS - PHY301

#	Quantum
	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
1	Temperature and the Zeroth Law of Thermodynamics. Thermal equilibrium.
2	Ideal gases, the kinetic theory of gases, equipartition theory, Boltzmann distribution
2	Heat, work, internal energy. First law of thermodynamics. Heat capacity and enthalpy. Compression of an ideal gas under various
1	Transport, conduction, conductivity, diffusion in gases.
2	The two-state paramagnet and the Einstein model of a solid; quantum deviations from classical equipartition. Partition function.
2	Multiplicity and ideal gases. Entropy, spontaneous change and the Second Law of Thermodynamics. Interacting ideal gases and
1	Heat engines, Carnot Cycle, Otto Cycle, Stirling Cycle.
2	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
2	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
2	Thermodynamics of liquids and liquid mixtures, chemical potentials of liquids, ideal liquid mixtures and Raoult's Law, Henry's Law, vapor pressure diagrams, liquid-liquid phase diagrams Free energy and entropy of mixing, excess functions and real solutions,

CHEMISTRY - CHM301

12	Reactions and Synthesis 1
1	Organic Synthesis C-C bond Forming Reactions: Grignard Reagents and Organolithiums. Formation and reaction with Carbonyl compounds.
1	Organometallic Reagents in Synthesis: Applications of Organocerium and Organocuprate reagents.
1	Carbonyl Compounds and Reactions: Carbonyl compounds, tautomerism as a general phenomen, keto-enol tautomerism of carbonyl compounds, mechanism of keto-enol tautomerism
1	Generating enolate anions, suitable base catalysts for enolising aldehydes, ketones ester and β-dicarbonyl compounds, general α-substitution reaction
1	Reactions of enols and enolates, α-substitution with H/D$^+$ Stereochemical consequences and deuterium incorporation. Halogenation of carbonyl compounds, The haloform reaction
1	Halogenation of carbonyls, Hell-Volhard-Zelinsky reaction. Synthetic applications of a-halo carbonyl compounds
1	Alkylation of enolates, LDA, scope and limitations
1	Aldol reaction, mechanism and retrosynthesis, inter-and- intra-molecular variants, mixed Aldol reaction
1	Claisen reaction, mechanism and retrosynthesis, mixed Claisen and Deickman reaction.
1	Malonate Diester Chemistry, Acetoacetate chemistry, Synthesis of substituted acetic acid and acetone derivatives. Scope, Mechanism and
1	Michael addition Chemistry, reaction of enolates with various Michael electrophiles
1	Kinetic and Thermodynamic enolates, Enamines and silylenol ethers

12	Reactions and Synthesis 2
1	**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.
1	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
1	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 thermodynamic parameters. Construction and uses of Latimer and Frost diagrams.
1	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
1	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.
1	**Exchange reactions**: Solid/gas phase systems exemplified by transport reactions and preparation of solid-state materials, in vulcanology, halogen lamps etc. Solution examples of double decomposition (metathesis). Solubility trends. Common ion effect.
1	Hard/soft acid/base theory. Thermodynamic basis for HSAB theory. Usefulness in predicting direction of equilibrium and solubility.
1	**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
1	Mechanism of substitution reactions. Square planar Pt complexes and applications. Trans effect. Pt chemistry. Applications in synthesis of action of chemotherapeutic agents.
1	Dissociative, interchange and associative mechanisms in substitution, racemization *etc* in octahedral complexes.
1	Combination of substitution and redox chemistry in TM systems. Co(III) syntheses, Cr(II) catalysed substitution. Electron transfer, inner- and outer-
1	**Metal centred reactions** : Template reactions and reactions of coordinated ligands. Atom transfer reactions (redox reactions). Metal directed ligand

3	?

BIOLOGY - BIO301

36	Functional Biology of Organisms
1	Introduction to Functional Biology
	Animal biology (Humans as an example) (18 lectures)
1	Anatomy and Function 1: Tissues, Organs and Viscera
1	Anatomy and Function 2: Skeletal & Muscular system
1	Nervous system 1: The central nervous system (CNS) and nervous tissues
1	Nervous system 2: Autonomic nervous system and motor responses
1	Endocrine system 1: Endocrine and Exocrine glands
1	Endocrine system 2: HPA axis introduction
1	Respiration and Metabolism 1: Breathing in air and water
1	Respiration and Metabolism 2: Regulation of metabolism
1	Cardiovascular and circulatory system 1: Regulation of the circulatory system
1	Cardiovascular and circulatory system 2: Peripheral circulation
1	Digestive system
1	Urinary and Excretion systems 1: Anatomy and function
1	Urinary and Excretion systems 2: Osmoregulation in terrestrial & aquatic environments
1	Thermal dynamics
1	Immunology 1: Innate immune system
1	Immunology 2: Adaptive/Humoral immune system
1	Reproduction and Development 1: Gonads and the Reproductive tract
1	Reproduction and Development 2: Gametes, Fertilization and conception
	Plant biology (15 lectures)
2	Growth and Development
2	Photosynthesis
2	Water Balance
1	Phloem and translocation
2	Mineral nutrition and nutrient assimilation
2	Respiration and lipid metabolism
1	Reproduction
1	Signaling; hormones, light responses, control of flowering
1	Abiotic stress
1	Secondary metabolism and defence
2	Microbial physiology

MATHS - MTH401

16	Probability
1	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

20	Statistics
1	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 modelling (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

PHYSICS - PHY401

18	Electricity and
	Coulomb's Law
	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

7	Special relativity
1	Spacetime and simultaneity. Einstein axioms for special relativity. The Lorentz transformation.
2	Relativistic kinematics; length contraction, time dilation. Doppler effect. Twin paradox.

CHEMISTRY - CHM401

36	Structure and Properties
1	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 Leading to definition of components of character tables (irreducible representations, characters – at least the interpretation of the sign of the character)
1	Simple applications, Label molecular shapes, isomers, Identify chiral molecules, Physical properties – *e.g.* dipole moment, possible optical isomers, Orbital symmetry labels (*e.g.* s, p & d orbitals in T_d, O_h, D_{4h})
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, wavefunctions,
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
	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
1	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
3	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

BIOLOGY - BIO401

17	Transmission Genetics
3	Genetic variation and behaviour of genes
2	Linkage and recombination; Mapping genes
1	Chromosome maps and genetic markers
2	Sex linkage and sex determination
2	Complementation
2	Chromosomal mutations
1	Non-Mendelian inheritance
2	Extrachromosomal DNA
2	Quantitative genetics

7	Population Genetics
2	Genetic variation in populations
1	Mutation and Genetic drift
1	Natural selection
1	Mutation/Selection balance
1	Balanced polymorphism
1	Gene flow & inbreeding

5	Population Biology
1	Nature of populations; numbers, mixing (dispersal), structure in age/stage
2	Density independent, density dependent growth (exponential and logistic growth equations)
1	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

4	Communities
1	Nature of communities; Community structure: how it is described, measured; what drives it; species composition, diversity (alpha, beta, gamma)
1	Intracommunity (interspecific) interactions (bi-partite networks); Symbiosis, Predation,

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

2	Relativistic dynamics. Mass-energy equivalence. Conservation of four-momentum. Centre of momentum frame. De Broglie waves and photons.
1	Nuclear reactions and thermonuclear power.
1	Einstein, the equivalence principle, gravity, gravitational lenses, gravitational waves

10	Optics- Applications and microscopy
1	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
3	Microscopy applications

1	Electronic spectroscopy: Chromophores and excited electronic states, electronic transitions, UV-Vis spectroscopy, Franck-Condon Principle, Franck-Condon
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	Dynamics of communities (perturbation and succession)
1	Biomes (communities on a global scale)

4	Ecosystems
1	Pond ecosystem (or other integrated example)
1	Food chains and webs
1	Pyramids (numbers, biomass, energy), abstraction, defining trophic levels, the problem
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

GANDHI INSTITUTE OF TECHNOLOGY AND MANAGEMENT
GITAM School of Science

B.Sc (Blended) THIRD YEAR MATHEMATICS SYLLABUS

(Course developed in collaboration with the University of Melbourne)

Semester 5	MATHEMATICS	Lectures	Practical	Total	Credits	Total Hrs	Hrs p.w.
MTH501	Algebraic structures –I	36	9	45	3		
MTH502	Number theory	36	9	45	3		
MTH503	Linear Programming	36	9	45	3		
MTH504	Real Analysis	36	9	45	3		
MTH505	Linear Programming Lab (XL solver or Lindo)		36	36	2		
MTH506	Scientific Computation and Modelling: SciLab		36	36	2		
MTH507**	Functions of Several variables and Transform Techniques	24	6	30	2		
**	Non - science Elective	24	6	30	2		
PRJ501	Graduate Level Thesis		36	36	2		
		192	**156**	**348**	**22**	**348**	**24.9**

Semester 6	MATHEMATICS	Lectures	Practical	Total	Credits	Total Hrs	Hrs p.w.
MTH601	Algebraic structures –II	36	9	45	3		
MTH602	Numerical Methods	36	9	45	3		
MTH603	Complex Analysis	36	9	45	3		
MTH604	Graph Theory	36	9	45	3		
MTH605	Scientific Computation and Modelling: Projects using Python		36	36	2		
MTH606	Core Lab - 2		36	36	2		
MTH607**	Partial Differential Equations	24	6	30	2		
**	Non - science Elective	24	6	30	2		
PRJ601	Graduate Level Thesis		36	36	2		
		192	**156**	**348**	**22**	**348**	**24.9**

GANDHI INSTITUTE OF TECHNOLOGY AND MANAGEMENT
GITAM School of Science

MTH 501: ALGEBRIC STRUCTURES -I

GROUPS:
Binary Operation – Algebraic structure – semi group-monoid – Group definition and elementary properties Finite and Infinite groups – examples – order of a group. Composition tables with examples.

SUBGROUPS:
Complex Definition – Multiplication of two complexes Inverse of a complex-Subgroup definition – examples-criterion for a complex to be a subgroups. Criterion for the product of two subgroups to be a subgroup-union and Intersection of subgroups.

Co-sets and Lagrange's Theorem:
Cosets Definition – properties of Cosets–Index of a subgroups of a finite group–Lagrange's Theorem.

NORMAL SUBGROUPS:
Definition of normal subgroup – proper and improper normal subgroup–Hamilton group – criterion for a subgroup to be a normal subgroup – intersection of two normal subgroups – Sub group of index 2 is a normal sub group – simple group – quotient group – criteria for the existence of a quotient group.

HOMOMORPHISM & ISOMORPHISM:
Definition of homomorphism – Image of homomorphism elementary properties of homomorphism – Isomorphism – automorphic definitions and elementary properties–kernel of a homomorphism – fundamental theorem on Homomorphism and applications.

PERMUTATIONS AND CYCLIC GROUPS:
Definition of permutation – permutation multiplication – Inverse of a permutation – cyclic permutations – transposition – even and odd permutations – Cayley's theorem.

Cyclic Groups:
Definition of cyclic group – elementary properties – classification of cyclic groups.

Books Recommended

1. First course in Abstract Algebra, by J.B. Fraleigh Published by Narosa Publishing house.
2. Modern Algebra by M.L. Khanna.
3. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
4. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
5. A text book of Mathematics for B.A. / B.Sc. by B.V.S.S. SARMA and others Published By S. Chand & Company New Delhi

GANDHI INSTITUTE OF TECHNOLOGY AND MANAGEMENT
GITAM School of Science

MTH 502: NUMBER THEORY

Divisibility- Greatest Common Divisor- Euclidean Algorithm- The Fundamental Theorem of Arithmetic Congruence's Special Divisibility Tests- Chinese Remainder Theorem- Fermat's Little Theorem-Wilson's Theorem-Residue Classes and Reduced Residue Classes –Solutions of Congruence's Number Theory from an Algebraic view point Multicative Group, Rings and Fields Quadratic Residues-Quadratic Reciprocity- The Jacobi Symbol, Greatest Integer-Function, Arithmetic Function.

Reference Books:

1. "Introduction to the Theory of Numbers by Niven, Zuckerman & Montgomery (John Wiley & Sons)
2. Elementary Number Theory by David M .Burton.
3. Elementary Number Theory, by David. M. Burt on published by 2nd Edition (UBS Publishers).
4. Introduction to Theory of Number by Davenport H., Higher Arithmetic published by Edition (John Wiley & Sons) Niven, Zuckennnn &Montgomery.(Cnmb. Univ ,Press)
5. Number Theory by Hardy &Wright published by Oxford Univ, Press.
6. Elements of the Theory of Numbers by Dence .J.B & Dence T.P published by Academic Press

MTH 503: Linear Programming

Formulation of Linear Programming Problems, Basic solution, Linear Programming Problems Graphical Approach for Solving some Linear Programs. Convex Sets
Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format
Introduction to artificial variables, two-phase method, Big-M method, and their comparison.
Duality, formulation of the dual problem, primal- dual relationships, economic, interpretation of the dual
Transportation Model: Formulation, initial feasible solution, optimal solution-MODI method, unbalanced transportation problems, degeneracy in transportation problems, Assignment Model: Formulation, optimal solution, Hungarian method, travelling salesman problem

Recommended Books

1. "Operations Research" by S.D. Sharma published by Kedarnath and Ramnath Co.
2. "Linear Programming and Network Flows" by Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali published by John Wiley and Sons, India, 2004, 2nd edition.
3. "Introduction to Operations Research" by Frederick S. Hiller and Gerald J. Lieberman published by Tata Mc Graw Hill, Singapore, 2004, 8th edition.
4. "Operations Research: An Introduction" by Hamdy A. Taha published by Prentice-Hall India, 2006, 8th edition.

MTH 504: Real Analysis

Finite and infinite sets, examples of countable and uncountable sets, Real line, bounded sets, suprema and infima, completeness property of R, Archimedean property of R, intervals. Concept of cluster points and statement of Bolzano-Weierstrass theorem.

Real Sequence, Bounded sequence, Cauchy convergence criterion for sequences. Cauchy's theorem on limits, order preservation and squeeze theorem, monotone sequences and their convergence (monotone convergence theorem without proof).

Infinite series. Cauchy convergence criterion for series, positive term series, geometric series, comparison test, convergence of p-series

Root test, Ratio test, alternating series, Leibnitz's test (Tests of Convergence without proof). Definition and examples of absolute and conditional convergence

Sequences and series of functions, Pointwise and uniform convergence. M -test, Statements of the results about uniform convergence and integrability and differentiability of functions, Power series and radius of convergence

Books Recommended

1. T. M. Apostol, Calculus (Vol. I), John Wiley and Sons (Asia) P. Ltd., 2002.
2. R.G. Bartle and D. R Sherbert, Introduction to Real Analysis, John Wiley and Sons (Asia) P. Ltd., 2000.
3. E. Fischer, Intermediate Real Analysis, Springer Verlag, 1983.
4. K.A. Ross, Elementary Analysis- The Theory of Calculus Series- Undergraduate Texts in Mathematics, Springer Verlag, 2003.

MTH505: Linear Programming Lab (Using Lindo & XL Solver)

1. Formulation of Linear programming problem
2. Graphical approach to solve LP problem
3. Problems on convex sets
4. Simplex method to solve LPP
5. Two Phase method to solve LPP
6. Big-M method to solve LPP
7. Formulation of dual problem
8. Problems on primal –dual

MTH506: Scientific Computation and Modelling: SciLab

- Introduction to Scilab environment
- Scilab datatypes, variables and constants
- Matrix operation in Scilab
- Plotting math functions in Scilab
- Changing axes properties in Scilab plots
- Plotting Bar graphs in Scilab
- Putting Latex formatted text and math symbols in Scilab plots
- Solving linear algebraic equations in Scilab
- Introduction to Xcos: The Scilab simulator
- Making simulations for Physical systems using Xcos
- Introduction to Scilab functions
- Writing your functions in Scilab
- Solving ordinary differential equations
- Calculating Fourier coefficients and Plotting Fourier Series
- Conditional branching
- Creating codes to solve the problems in Physics/Mathematics

MTH507: Functions of Several variables and Transform Techniques

Partial Differentiation I: Euler's theorem, total derivative, differentiation of implicit functions, change of variables, Jacobians, tangent plane and normal to a surface.

Partial Differentiation II: Taylor's theorem for functions of two variables, maxima and minima of functions of two variables, Lagrange's method of multipliers, differentiation under integral sign, Leibnitz rule.

Beta and Gamma functions, – Properties, relation between Beta and Gamma function.

Laplace Transforms: Transforms of elementary functions, properties of Laplace transforms, existence conditions, inverse transforms, transforms of derivatives, transforms of integrals, multiplication by tn, division by t, convolution theorem.

Applications to ordinary differential equations (By using Laplace Transforms), periodic functions, unit step function, unit impulse function

MTH601: ALGEBRAIC STRUCTURES-II

Ring Homomorphism
Definition, Examples, Properties, Field of Quotients,
Polynomial Rings
Nation and terminology, The Division Algorithm and its consequences
Factorization of Polynomials
Reducibility Tests, Irreducibility Tests Unique Factorization in Z(X) and its applications
Divisibility in Integral Domains
Irreducible and prime elements in integral Domains, Unique Factorization Domains, Euclidean Domains
Extension Fields
The Fundamental Theorem of Field theory (Kronecker's Theorem related to Extension Fields) Splitting Fields, Zeros of irreducible polynomials.
Algebraic Extensions: Characterization of extensions (Algebraic, transcendental extensions), Finite extensions, properties of Algebraic extensions
Geometric Constructions
Constructible Numbers, Angle- Trisectors and Circle –Squares, Sylow's Theorems Conjugacy Classes, The Class equation, The Sylow's Theorems Applications

MTH 602: NUMERICAL METHODS

Solution of Algebraic and Transcendental Equations: Bisection method, secant method, false position method, Newton Raphson method.

Interpolation: Difference operators and relations, difference tables, Newton's forward and backward interpolation formulae, Central Difference interpolation formula, Gauss Forward Interpolation formula, Gauss backward interpolation formula, divided difference formula, Lagrange's interpolation formula.

Linear System of Algebraic Equations: Iteration method, Jacobi method, Gauss-Seidal method.

Numerical Differentiation: Derivatives using forward, backward and central difference formulae. Numerical Integration: Newton-cotes quadrature formula, trapezoidal rule, Simpson's 1/3rd rule, Simpson's 3/8th rule.

Numerical Solutions of Ordinary Differential Equations: Introduction Picard's method, Taylor's series method, Euler's method, modified Euler's method, Runge-Kutta method, predictor - corrector method.

Text Book(s)

1. M.K. Jain, S.R.K. Iyengar, R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 5/e, New Age International, 2007.

References

1. S.S. Sastry, Introductory Methods of Numerical Analysis, 4/e, Prentice Hall of India, 2009.

MTH 603: COMPLEX ANALYSIS

Analytic Functions

Complex-Function, Limits- Continuity- Differentiability, Analyticity – Harmonic Functions

Elementary Functions

Definition and properties of Exponential Trigonometric, Hyperbolic, Logarithmic, Inverse Trigonometric and Inverse Hyperbolic Functions and Complex Exponents

Integration

Integral of Complex Valued Functions Contour Integration- Anti – Derivative Cauchy- Goursat Theorem Cauchy Integral Formula Derivative of Analysis Function and Related Results.

Series

Convergence of sequence and Series, Taylor Series – Laurent Series, Integration and Differentiation of Power Series, Uniqueness of Series

Singularities and Residues

Residue and Residue Theorems, Type of Isolated Singularities. Residue at Singularities, Evaluation of Improper Integral only of Rational Functions and functions, Involving Sine and Cosine

MTH 604: GRAPH THEORY

Graphs and Sub Graphs: Graphs, Simple graph, graph isomorphism, the incidence and adjacency matrices, sub graphs, vertex degree, Hand shaking theorem, paths and connections, cycles.
Applications, the shortest path problem, Sperner's lemma

Trees:
Trees, cut edges and Bonds, cut vertices, Cayley's formula
Applications of Trees-the connector problem.

Connectivity:
Connectivity, Blocks and Applications, construction of reliable communication Networks

Euler tours and Hamilton cycles
Euler tours, Euler Trail, Hamilton path, Hamilton cycles, dodecahedron graph, Petersen graph, Hamiltonian graph, closure of a graph.
Applications of Eulerian graphs, the Chinese postman problem, Fleury's algorithm-the travelling salesman problem.

Textbooks:

Graph theory with Applications by J.A.Bondy and U.S.R.Murthy published by Mac.Millan Press

MTH605: MATLAB Programming

Introduction to MATLAB Programming

Operations, Matrices, Loops and conditions

Approximations and Errors

Basic plotting and Vectorization – 2D and 3D Plots

Numerical Differentiation and Integration

Linear Equations

Nonlinear Equations

Regression and Interpolation

Ordinary Differential Equations (ODE)

Ordinary Differential Equations (ODE) -Practical aspects

Partial Differential Equations (PDE)

Fractals and Chaos

MTH606 - Scientific Computation and Modelling: Numerical Analysis and Programming

Non- linear Equations:

Bracketing methods; Bisection; False Position Methods, Open Methods; Newton Raphson, Secant method and Simple One Point Iteration Methods

Linear Algebraic Equations:

Gauss Elimination; LU Decomposition; Gauss Jordan and matrix inverse

Numerical Integration:

Trapezoidal rule and Simpson's Rules; Romberg Integration, Partial differential equations (PDEs) – Elliptic, parabolic and hyperbolic

Least Square Regression and Interpolation:

Linear regression; Interpolation by Newton's divided difference interpolating Polynomials Lagrange interpolating polynomials and Spline interpolation

Distributions: Random Variables, Binomial distributions, Poisson distribution and Poisson process, Normal distribution, Central Limit Theorem.

MTH 607: PARTIAL DIFFERENTIAL EQUATIONS

Partial Differential Equations:
Formation of partial differential equations, solutions of partial differential equations, Lagrange's, Charpit's methods, Homogeneous linear equations with constant coefficients, rules for finding the complementary function, rules for finding the particular integral.

Applications of Partial Differential Equations:
Classification of second order PDE, conversion to normal form, one dimensional wave equation, one dimensional heat flow, two-dimensional heat flow, method of separation of variables.

Difference Equations: Definition, formation of difference equations, linear difference equations, rules for finding the complementary function, rules for finding the particular integral.

Z-Transforms
Definition of Z-transform, elementary properties, linearity property, damping rule, shifting un to the right and left, multiplication by n, initial value theorem, final value theorem, inverse Z-transform, convolution theorem, solution of difference equations using Z-transforms.

Text Book(s)
B. S. Grewal, Higher Engineering Mathematics, 42/e, Khanna Publishers, 2012.

References
1. Erwin Kreyszig, Advanced Engineering Mathematics,9/e, Wiley, 2013.
2. N.P. Bali and Manish Goyal, A Text Book of Engineering Mathematics, 8/e, Lakshmi Publications, 2012.

B.Sc (Blended) THIRD YEAR PHYSICS SYLLABUS

(Course developed in collaboration with the University of Melbourne)

Semester 5	PHYSICS	Lectures	Practical	Total	Credits	Total Hrs	Hrs p.w.
PHY501	Classical Mechanics	36	9	45	3		
PHY502	Quantum Mechanics	36	9	45	3		
PHY503	Solid State Physics	36	9	45	3		
PHY504	Electrodynamics	36	9	45	3		
PHY505	Physics Lab 505		36	36	2		
PHY506	Scientific Computation and Modelling: SciLab		36	36	2		
PHY507	Physics of Nanomaterials	24	6	30	2		
**	Non - science Elective	24	6	30	2		
PRJ501	Graduate Level Thesis		36	36	2		
		192	**156**	**348**	**22**	**348**	**24.9**

Semester 6	PHYSICS	Lectures	Practical	Total	Credits	Total Hrs	Hrs p.w.
PHY601	Statistical Mechanics	36	9	45	3		
PHY602	Subatomics Physics	36	9	45	3		
PHY603	Atomic and Molecular Spectroscopy and Lasers	36	9	45	3		
PHY604	Digital and Analog Electronics	36	9	45	3		
PHY605	Physics Lab 605		36	36	2		
PHY606	Electronics Lab		36	36	2		
PHY607	Introduction to Biophysics	24	6	30	2		
**	Non-science Elective	24	6	30	2		
PRJ601	Graduate Level Thesis		36	36	2		
		192	**156**	**348**	**22**	**348**	**24.9**

PHY501 – CLASSICAL MECHANICS

6	Central force Problem
	Nature of orbits in an attractive inverse square field
	Kepler's laws of planetary motion. Rutherford scattering as an example of repulsive potential.
6	Mechanics of Ideal Fluids
	Streamlines and flowlines; Equation of continuity; Euler's equation of motion;
	Streamline motion - Bernoulli's equation and its applications. Definition of Newtonian and non-Newtonian fluids
10	Lagrangian and Hamiltonian formulation of Classical Mechanics
2	Generalized coordinates, constraints and degrees of freedom; D'Alembart's principle;
4	Lagrange's equation for conservative systems (from D'Alembert's principle; variational principle not required) and its application to simple cases
4	Generalized momentum; Idea of cyclic coordinates, its relation with conservation principles;
4	Definition of Hamiltonian, Hamilton's equation (derivation by Legendre transformation) and its application to simple cases.

REFERENCE BOOKS:

- Mechanics: C. Kittel, W.D. Knight, M.A. Ruderman, C.A. Helmholz and B.J. Moyer (2008) Berkeley Physics Vol 1, Tata McGraw-Hill Ltd
- Classical Mechanics: N. Rana and P. Joag (2001) Tata McGraw-Hill Education
- Classical Mechanics: J.R. Taylor (2005) University Science Books
- Feynman Lectures in Physics, Vol I , Addison-Wesley.
- Classical Mechanics: H. Goldstein, C. Poole and J. Safko (2002) 3rd edition, Pearson
- Classical Dynamics of Particles and Systems: Thornton and Marion (2003) Thomson Learning EMEA Ltd

PHY 502 – QUANTUM MECHANICS – 3 CREDITS

6	Time dependent and time independent Schrodinger equation
	Eigenstates, normalization and orthonormality.
12	Simple applications of Quantum Mechanics
	One dimensional potential well and barrier, boundary conditions, bound and unbound states.
	Reflection and transmission coefficients for a rectangular barrier in one dimension – explanation of alpha decay.
	Free particle in one dimensional box, box normalization, momentum eigenfunctions of a free particle
	Linear harmonic oscillator, energy eigenvalues from Hermite differential equation, wave function for ground state, parity of wave function.
18	Schrodinger equation in spherical polar coordinates
2	Angular momentum operators and their commutation relations;
6	eigenvalues and eigenfunctions of L2 and Lz; theorem of addition of angular momenta [statement with examples].
5	The hydrogen atom problem – stationary state wavefunctions as simultaneous eigenfunctions of H, L2 , and Lz;
5	radial Schrodinger equation and energy eigenvalues [Laguerre polynomial solutions to be assumed]; degeneracy of the energy eigenvalues.

REFERENCE BOOKS:

- Quantum Physics: S. Gasiorowicz (2003) 3rd edition, Wiley India Edition
- Quantum Physics: E.H. Wichman (2008) Berkeley Physics Course, Vol 4, Tata McGraw-Hill Ltd
- Introduction to Quantum Mechanics, David J. Griffiths, Pearson Education
- Introductory Quantum Mechanics, Richard Liboff, Addison-Wesley; 4 edition
- A Modern Approach to Quantum Mechanics, John Townsend, Viva Books
- Principles of Quantum Mechanics: R. Shankar (2010) 2nd edition, Springer

PHY503 – SOLID STATE PHYSICS – 3 CREDITS

	Crystal Structure
2	Crystalline and amorphous solids, translational symmetry
3	Elementary ideas about crystal structure, lattice and bases, unit cell, reciprocal lattice
5	fundamental types of lattices, Miller indices, lattice planes, simple cubic, f.c.c. and b.c.c. lattices
2	Laue and Bragg equations. Determination of crystal structure with X-rays.
6	Elementary band theory Kronig Penny model. Band Gap. Conductor, Semiconductor (Pand N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (04 probe method) & Hall coefficient. Effect of concentration and temperature on fermi level.
4	Dielectric properties of materials Electronic, ionic and dipolar polarizability, local fields, induced and oriented polarization – molecular field in a dielectric; Clausius-Mosotti relation.
8	Magnetic properties of materials Dia, para and ferro-magnetic properties of solids. Langevin's theory of diamagnetism and paramagnetism. Quantum theory of paramagnetism, Curie's law. Ferromagnetism : spontaneous magnetization and domain structure; temperature dependence of spontaneous magnetisation; Curie-Weiss law, explanation of hysteresis.
5	Superconductivity Introduction (Kamerlingh-Onnes experiment), effect of magnetic field, Type-I and type-II superconductors, Isotope effect. Meissner effect. Heat capacity. Energy gap. Ideas about High-Tc superconductors
8	

REFERENCE BOOKS:

- Solid State Physics: N.W. Ashcroft and N.D. Mermin (1976) College edition, Harcourt College Publishers
- Introduction to Solid State Physics: C. Kittel (2004) 8th edition, John Wiley and Sons
- Atomic and Electronic Structure of Solids, E. Kaxiras; Cambridge University Press.

PHY504 – ELECTRODYNAMICS – 3 CREDITS

8	Generalization of Ampere's Law
	Displacement Current, Maxwell's Field Equations, Wave equation for electromagnetic (EM) field and its solution
	plane wave and spherical wave solutions, transverse nature of field, relation between E and B; energy density of field, Poynting vector and Poynting's theorem, boundary conditions
8	EM Waves in an isotropic dielectric
	Wave equation, reflection and refraction at plane boundary, reflection and transmission coefficients
	Fresnel's formula, change of phase on reflection, polarization on reflection and Brewster's law, total internal reflection.
8	EM waves in conducting medium
	Wave equation in conducting medium, reflection and transmission at metallic surface – skin effect and skin depth,
	propagation of E-M waves between parallel and conducting plates – wave guides (rectangular only)
4	Dispersion
	Equation of motion of an electron in a radiation field : Lorentz theory of dispersion – normal and anomalous
	Sellmeier's and Cauchy's formulae, absorptive and dispersive mode, half power frequency, band width.
8	Scattering
	Scattering of radiation by a bound charge, Rayleigh's scattering (qualitative ideas), blue of the sky, absorption.

REFERENCE BOOKS:

- Electricity and Magnetism: E.M. Purcell (2008) Berkeley Physics Course, Vol 2, Tata McGraw-Hill Ltd
- Feynman Lectures on Physics: R.P. Feynman, R.B. Leighton and M. Sands (2011) The Millenium edition, Vol 2, Basic Books
- Introduction to Electrodynamics: D.J. Griffths (2012) Pearson Education
- Modern Electrodynamics: A. Zangwill (2013) Cambridge University Press

PHY505 – PHYSICS LABORATORY – 2 CREDITS

1. Given a XRD ray spectrum:
    a. Determine the peaks
    b. Determine the Miller indices
    c. Determine the unit cell
    d. Determine the reciprocal lattices.
2. Hysteresis Loop, coercivity, saturation magnetization. B – H curve, Losses, BH product
3. Susceptibility of Paramagnetic Materials by Quincke's Tube method, type of materials.
4. Millikan’s oil drop experiment: To measure to charge of the electron.
5. Michaelson's interferometer: To find the wavelength of given laser beam.
6. Ultrasonic Interferometer

PHY506: Scientific Computation and Modelling: SciLab

- Introduction to Scilab environment
- Scilab datatypes, variables and constants
- Matrix operation in Scilab
- Plotting math functions in Scilab
- Changing axes properties in Scilab plots
- Plotting Bar graphs in Scilab
- Putting Latex formatted text and math symbols in Scilab plots
- Solving linear algebraic equations in Scilab
- Introduction to Xcos: The Scilab simulator
- Making simulations for Physical systems using Xcos
- Introduction to Scilab functions
- Writing your functions in Scilab
- Solving ordinary differential equations
- Calculating Fourier coefficients and Plotting Fourier Series
- Conditional branching
- Creating codes to solve the problems in Physics/Mathematics

PHY507 – NANOPHYSICS – 2 CREDITS

Nanotechnology: Introduction, significance of nanotechnology, finite size effects and properties, classification of nanostructure materials, challenges and future prospects.

Properties of Nanomaterials: Microstructure and defects in nanomaterials, dislocations, twins, stacking faults and voids, grain boundaries, effect of nano-dimension on material behaviour, mechanical properties, melting point, diffusivity, grain growth characteristics, solubility, magnetic, electrical and thermal properties of nanomaterials.

Growth Techniques in Nanomaterials: Introduction, top down and bottom-up approaches, lithographic process and limitations, non-lithographic processes, plasma arc discharge, sputtering, evaporation, chemical vapor deposition, molecular beam epitaxy, sol-gel technique, electrodeposition.

Characterization Techniques of Nanomaterials: X-ray diffraction, small angle X-ray scattering, scanning electron microscopy with energy dispersive spectroscopy, transmission electron microscope, scanning tunneling microscope.

Application of Nanomaterials: Sectors influenced by nanomaterials - health, communication, energy, environment, safety, security and defence, nanophotonic devices, nanosensors, Quantum dots, MEMS & NEMS.

PHY601 – STATISTICAL PHYSICS

16	Microstates and macrostates
2	Classical description in terms of phase space and quantum description in terms of wave functions.
4	Hypothesis of equal a priori probability for microstates of an isolated system in equilibrium. Interactions between two systems – thermal, mechanical and diffusive.
4	Statistical definition of temperature, pressure, entropy and chemical potential. Partition function of a system in thermal equilibrium with a heat bath
	Classical statistical mechanics
10	Maxwell-Boltzmann distribution law. Calculation of thermodynamic quantities for ideal monoatomic gases. Ergodic hypothesis and Liouville theorem and Ideal gases (monoatomic and diatomic): Translational, rotational, vibrational, electronic partition functions,thermodynamic functions
	Motivations for quantum statistics
6	Gibbs' paradox. Identical particle and symmetry requirement. Derivation of MB, FD and BE statistics as the most probable distributions (micro-canonical ensemble). Classical limit of quantum statistics.
10	Quantum statistical mechanics
	Bose-Einstein statistics: Application to radiation – Planck's law. Rayleigh Jeans and Wien laws as limiting cases, Stefan's law.
	Fermi-Dirac statistics: Fermi distribution at zero and non-zero temperatures

REFERENCE BOOKS:

- Statistical Mechanics: K. Huang (1987) 2nd edition, Wiley
- Fundamental of Statistical and Thermal Physics: F. Reif (2008) Waveland Pr Inc
- Statistical Physics of Particles: Mehran Kardar (2007) Cambridge University Press
- Statistical Physics- Reif-(2008)) Berkeley Physics Course, Vol 5, Tata McGraw-Hill Ltd

PHY602: SUBATOMIC PHYISICS

6	Bulk properties of nuclei and Nuclear structure
	Nuclear mass, charge, size, binding energy, spin and magnetic moment. Isobars, isotopes and isotones; mass spectrometer. Nature of forces between nucleons, nuclear stability and nuclear binding, the liquid drop model (descriptive) and the Bethe-Weizsacker mass formula, application to stability considerations, extreme single particle shell model (qualitative discussion with examples).
	Unstable nuclei and Nuclear Reactions
4	Alpha decay : alpha particle spectra – velocity and energy of alpha particles. Geiger-Nuttal law. Beta decay : nature of beta ray spectra, the neutrino, energy levels and decay schemes, positron emission and electron capture, selection rules, beta absorption and range of beta particles, Kurie plot. Gamma decay : gamma ray spectra and nuclear energy levels, isomeric states. Gamma absorption in matter – photoelectric process, Compton scattering, pair production (qualitative)
2	Conservation principles in nuclear reactions. Q-values and thresholds, nuclear reaction cross-sections, examples of different types of reactions and their characteristics. Bohr's postulate of compound nuclear reaction, Ghoshal's experiment.
6	Nuclear fission and fusion
	Discovery and characteristics, explanation in terms of liquid drop model, fission products and energy release, spontaneous and induced fission, transuranic elements. Chain reaction and basic principle of nuclear reactors. Nuclear fusion: energetics in terms of liquid drop model.
18	Elementary particles
	Four basic interactions in nature and their relative strengths, examples of different types of interactions. Quantum numbers – mass, charge, spin, isotopic spin, intrinsic parity, hypercharge. Charge conjugation. Conservation laws. Classifications of elementary particles – hadrons and leptons, baryons and mesons, elementary ideas about quark structure of hadrons – octet and decuplet families. Particle Accelerator and Detector Cyclotron – basic theory, synchrotron, GM counter

REFEENCE BOOKS:

- Nuclear Physics – Cottingham and Greenwood (Cambridge University Press).
- Concepts of Nuclear Physcics – R. Cohen (Tata-Mc Graw Hill).
- Paramanu o Kendrak Gathan Parichay – S. N. Ghoshal (WBSBB).

- Atomic and Nuclear Physics – S. N. Ghoshal (S. Chand).
- Nuclear Physics – S. B. Patel (New Age).
- Nuclei and Particles – E. Segre (Benjamin).
- Nuclear Physics: Principles and applications – J.S. Lilley (Willey Eastern).
- Fundamentals in Nuclear Physics: from Nuclear Structure to Cosmology – J. Basdevant, J. Rich and M. Spiro (Springer). Particle Physics – Seiden (Persian Education)

PHY603: ATOMIC AND MOLECULAR SPECTROSCOPY AND LASERS

15	Atomic Spectroscopy
	LS and JJ coupling schemes. Terms for equivalent and non-equivalent electron atom. Spectra of one and two electron systems. Electron spin, spin orbit interaction, fine structure, relativistic correction and radiation correction (Lamb Shift). Electric dipole selection rules. Intensity rules. Alkali type spectra. Zeeman effect. Paschen-Back effect. Stark effect. Hyperfine structure and isotopic shifts. Complex Spectra: Vector model for three or more valence electrons. Inverted terms.Compound doublet. Inner-Shell Excitation and Autoionization, Line intensities, Transition probabilities, oscillator strength. Forbidden transitions..
15	Molecular Spectroscopy
	Rotational spectra of diatomic molecules. Vibrational spectra of diatomic molecules. Rotation-Vibration spectra of diatomic molecules. Classification of electronic states. Electronic spectra of diatomic molecules. Franck-Condon principle. Rotational spectra of linear polyatomic molecules: Coriolis interaction and effect of l-type doubling in linear molecules. Nuclear spin statistical weights and their effect on intensities. Rotational spectra of symmetric (prolate and oblate) molecules. Vibration-rotation spectra of polyatomic molecules: Parallel and perpendicular bands of linear molecules and symmetric top (prolate and oblate) molecules.
3	Spectroscopy(elementary and qualitative)
	Experimental techniques in spectroscopy: FTIR Raman, Stoke's antiStoke's.
8	Laser Physics Spectroscopy)elementary and qualitative)

REFERENCE BOOKS:

- Banwell, C.N., Fundamentals of Molecular Spectroscopy, III Edition, Tata-McGraw Hill, 1972
- Eisberg, R. and Resnick, R., Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles, II Edition, John Wiley, 1985
- Wilson, J. and Hawkes, J. F. B., Optoelectronics- An Introduction, Prentice Hall, 1983

PHY604: DIGITAL AND ANALOG ELECTRONICS

	Digital Circuits
4	Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion, AND, OR and NOT Gates (Realization using Diodes and transistors)
5	De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Minterms and Maxterms. Conversion of a Truth Table into an Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.
4	Binary Addition. Binary Subtraction using 2's Complement Method). Half Adders and Full Adders and Subtractors, 4-bit binary Adder-Subtractor.
	Semiconductor Devices and Amplifiers:
5	Semiconductor Diodes: P and N type semiconductors. Barrier Formation in PN Junction Diode. Qualitative Idea of Current Flow Mechanism in Forward and Reverse Biased Diode. PN junction and its characteristics. Static and Dynamic Resistance. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell.
12	Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Active, Cutoff & Saturation regions Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line & Q-point. Voltage Divider Bias Circuit for CE Amplifier. h-parameter Equivalent Circuit. Analysis of single-stage CE amplifier using UGC Document on LOCF Physics 233 hybrid Model. Input & output Impedance. Current, Voltage and Power gains. Class A, B & C Amplifiers
	Operational Amplifiers (Black Box approach):
6	Characteristics of an Ideal and Practical Op-Amp (IC 741), Open-loop and closed-loop Gain. CMRR, concept of Virtual ground. Applications of Op-Amps: (1) Inverting and non-inverting Amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Zero crossing detector. Sinusoidal Oscillators: Barkhausen's Criterion for Self-sustained Oscillations. Determination of Frequency of RC Oscillator

REFERENCE BOOKS:

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
- Electronic devices & circuits, S. Salivahanan & N.S. Kumar, 2012, Tata Mc-Graw Hill
- Microelectronic Circuits, M.H. Rashid, 2nd Edn., 2011, Cengage Learning.
- Modern Electronic Instrumentation and Measurement Tech., Helfrick and Cooper, 1990, PHI Learning

- Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw Hill
- Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., OxfordUniversity Press.

PHY605 – PHYSICS LABORATORY – 2 CREDITS

1. Measurement of Resistivity & Band gap of Germanium Crystal(N-type) by Four Probe Method.
2. Verification of Hall Effect - conductor and semiconductor
3. GM counter
4. Study Zeeman's Effect
5. Statistical Aspects of Radiation
6. Spectroscopy: Electron Shell Model
7. Properties of Radiation
8. 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.

PHY606: DIGITAL AND ANALOG ELECTRONICS

- Logic gates using ICs
- Demorgan's theorem
- BJT Transistor
- Zener diode
- PN junction diode
- Solar cell
- Conversion of galvanometer to voltmeter
- Galvanometer to Ammeter
- Rectifier & filter
- Kirchhoff Law

PHY607: INTRODUCTION TO BIOPHYSICS

	Thermodynamics of living systems
2	Conservation of energy in living systems, Entropy and Life, Gibbs and Standard free energy, Equilibrium constant, Coupled reactions.
	Dynamics of biomolecules
4	Diffusion, Laws of diffusion, Active transport, Facilitated diffusion, Osmosis, Osmotic pressure, Osmoregulation, Viscosity and biological importance, Surface tension, Factors influencing surface tension, Biological importance.
	Atomic & Molecular structure
8	Structure of atom-Models & theories, Periodic table, Concept of bonding; valence of carbon; hybridizations of carbon; hybridizations of nitrogen & oxygen; molecular orbital theories, polar & non polar molecules; inductive effect; Secondary bonding: weak interactions, hydrogen bonding; dipole-dipole & dipole induced dipole interactions; London dispersion forces. Bonds within molecules-Ionic, covalent, Hydrogen, Electrostatic, Disulphide & peptide bonds, Van-der Waals forces Bond lengths & Bond energies , Bond angles, Structural isomerism; optical isomerism & optical activity.
	Physico-chemical Foundations
10	Biophysics of Water: Physicochemical properties of water, Molecular structure, Nature of hydrophobic interactions, Water Structure. Small-Molecule Solutes: Hydrophiles, Hydrophobes, Large Hydrophobic Solutes and Surfaces, Aqueous Environment of the Cell, State of water in bio- structures & its significance, Protein Hydration-Nonspecific Effects, The Hydration Shell. Acid & Bases: Acid-Base theories, Mole concept, Molarity, Molality & Normality, Ampholyte, concept of pH,measurements of pH , Henderson–Hasselbatch equation , Titration curve & pK values, Buffers & Stability of their pH , numerical problems. Redox potential : Oxidation –Reduction, examples of redox potential in biological system

REFERENCES BOOKS:

- Biochemistry by Voet and Voet
- Biological Thermodynamics by Donald T. Haynie
- Introductory Biophysics by J. R. Claycomb and J.Q.P. Tran
- Molecular and Cellular Biophysics by Meyer B. Jackson

GANDHI INSTITUTE OF TECHNOLOGY AND MANAGEMENT
GITAM School of Science

B.Sc (Blended) THIRD YEAR CHEMISTRY SYLLABUS

(Course developed in collaboration with the University of Melbourne)

Semester 5	CHEMISTRY	Lectures	Practical	Total	Credits	Total Hrs	Hrs p.w.
CHM501	Chemical kinetics, Thermodynamics & Quantum chemistry	36	9	45	3		
CHM502	Catalysis and Industrial processes	36	9	45	3		
CHM503	Design and Synthesis of Organic Molecules	36	9	45	3		
CHM504	Introduction to analytical chemistry	36	9	45	3		
CHM505	Physical/Analytical Chemistry - LAB		36	36	2		
CHM506	Inorganic/Organic Chemistry - LAB		36	36	2		
CHM507**	Molecular Modelling in Chemistry	24	6	30	2		
**	Non - science Elective	24	6	30	2		
PRJ501	Graduate Level Thesis		36	36	2		
		192	**156**	**348**	**22**	**348**	**24.9**

Semester 6	CHEMISTRY	Lectures	Practical	Total	Credits	Total Hrs	Hrs p.w.
CHM601	Solid State chemistry & its applications	36	9	45	3		
CHM602	Bioinorganic and Coordination chemistry	36	9	45	3		
CHM603	Natural product and Heterocyclic Chemistry	36	9	45	3		
CHM604	Separation Techniques and Advanced Analytical Techniques	36	9	45	3		
CHM605	Physical/Analytical Chemistry - LAB		36	36	2		
CHM606	Inorganic/Organic Chemistry - LAB		36	36	2		
CHM607**	Materials chemistry	24	6	30	2		
**	Non-science Elective	24	6	30	2		
PRJ601	Graduate Level Thesis		36	36	2		
		192	**156**	**348**	**22**	**348**	**24.9**

Elective Courses SEM V		
Subject Code	**Title of the Subject**	**Credits**
Elective Course - 1	Molecular Modelling in Chemistry	2
Elective Course - 2	Introduction to forensic Science and technology	2

Elective Courses SEM VI		
Subject Code	**Title of the Subject**	**Credits**
Elective Course - 3	Materials chemistry	2
Elective Course - 4	Supramolecular chemistry	2

CHM 501- Chemical kinetics, Thermodynamics & Quantum chemistry

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 yields • 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' Physical Chemistry"(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

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 mechanism of 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

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

Topics	Lectures
Selectivity in organic synthesis Chemo-selectivity, Regioselectivity, Stereo- and enantioselectivity	2
Introduction of Pericyclic reaction Electrocyclic, sigmatropic, cycloaddition, chelotropic and ene reactions, photochemical cycloaddition reactions, Diels-Alder reaction, Dipolar cycloadditions, retrocycloadditions, electrocyclic reactions.	6
C-C single/ double bond formation reactions 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.	8
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, Catalytic Hydrogenation 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 synthesis 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. *OrganicChemistry*byJ.McMurray,7thEd.,Thomson,2008.*PrinciplesofOrganicSynthesis*byR. 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

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 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.	6
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, and lipids	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	10

TECHNIQUES : Need for hyphenation, Interfacing devices and applications of GC - MS, GC - IR, MS-MS, HPLC - MS, ICP -MS, ICP - OES.	
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)

Elective Course 1: CHM 505 - Molecular Modelling in Chemistry

Topic Details	Lectures
Brief Review of the basic Principles of quantum mechanics of atoms and molecules. Potential energy surfaces and intermolecular interactions: Quantum mechanical ab initio 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 as the 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).

Elective Course 2: CHM506 - Introduction to forensic science & technology

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 petroleum products. 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

1. Kinetics of Alcohol Dehydrogenase-Catalysed Oxidation of Ethanol
2. To study the phase diagram of a binary system (Phenol + water) and the effect of impurities (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

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) and malonic 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 601 - Solid State chemistry & its applications

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 factor and 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 and bottom 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 to its basic	5

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.	
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
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 • Reviews of various research papers, reports, books • Presentations	9

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, Volume Wiley –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

GANDHI INSTITUTE OF TECHNOLOGY AND MANAGEMENT
GITAM School of Science

CHM 602 - Bioinorganic and Coordination chemistry

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 - selection rules - 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 of metal 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
	50

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

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 semiconductors for 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 and Wothers

CHM 604 - Separation Techniques and Advanced Analytical Techniques

Topic	Lectures
Extraction's techniques 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, Separation 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, Separation 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 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	2
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

Elective Course 3: CHM607 - Materials Chemistry

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, cohesive energy, Symmetry elements, operations, translational symmetries point groups, space groups, 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,

Elective Course 4 – CHM608 - Supramolecular chemistry

Topic Details	Lectures
Introduction-the meaning of supramolecular chemistry, phenomenon of molecular recognition 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

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 Performance Liquid Chromatography.
9. Environmental Monitoring of Hydrocarbons: A Chemical Sensor Perspective.

CHM 608 - Inorganic /Organic chemistry Lab

1. Synthesis and spectrophotometric study of copper complexes: (i) synthesis of bis (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's method 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.

GANDHI INSTITUTE OF TECHNOLOGY AND MANAGEMENT
GITAM School of Science

B.Sc (Blended) THIRD YEAR CHEMISTRY SYLLABUS

(Course developed in collaboration with the University of Melbourne)

Semester 5	BIOLOGY	Lectures	Practical	Total	Credits	Total Hrs	Hrs p.w.
BIO501	Biochemistry	36	9	45	3		
BIO502	Molecular Biology	36	9	45	3		
BIO503	Cell Biology	36	9	45	3		
BIO504	Computational Biology	36	9	45	3		
BIO505	Biochemistry and Cell Biology Lab		36	36	2		
BIO506	Molecular and Computational Biology Lab		36	36	2		
BIO507**	Genetics and Genomics	24	6	30	2		
**	Non - science Elective	24	6	30	2		
PRJ501	Graduate Level Thesis		36	36	2		
		192	**156**	**348**	**22**	**348**	**24.9**

Semester 5	BIOLOGY	Lectures	Practical	Total	Credits	Total Hrs	Hrs p.w.
BIO601	Evo-Devo	36	9	45	3		
BIO602	Systematics and Evolution	36	9	45	3		
BIO603	Micro-organisms and Disease	36	9	45	3		
BIO604	Genes and Genomes	36	9	45	3		
BIO605	Development, Systematics and Evolution Lab		36	36	2		
BIO606	Immunology and Microbiology Lab		36	36	2		
BIO607		24	6	30	2		
**	Non - science Elective	24	6	30	2		
PRJ601	Graduate Level Thesis		36	36	2		
		192	**156**	**348**	**22**	**348**	**24.9**

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BIO501 - BIOCHEMISTRY

1. Basic bio molecules and their properties

- Sugars
- Amino acids, fatty acids and nucleic acids
- Stablizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.)

2. Biological thermodynamics

Concept of free energy, energy rich compounds, free energy and oxidation reduction reactions. Energy cycle.

3. Enzymes

- Definition, classification, properties
- Lock and key hypothesis, factors affecting activity of enzymes
- Kinetics
- Coenzymes and role in biological systems
- Isoenzymes and their role
- Ligand Binding and Allostery

4. Metabolic pathways

- Carbohydrate metabolism- Glycolysis, fates of pyruvate: cori cycle fermentation, ED pathway, TCA cycle, Anapleurotic reactions, gluconeogenesis, glycogen breakdown and glycogen synthesis, Glyoxylate pathway, pentose phosphate pathway. Regulation of pathways.
- Lipid metabolism: Action of lipases, Beta oxidation of fatty acids, ketone bodies, synthesis of fatty acids, overview of cholesterol synthesis. Phospholipid synthesis
- Protein metabolism: Metabolic fates of amino acids, transamination, transfer of amino group by glutamate, urea cycle, amino acid biosynthetic families grouped by metabolic precursor

5. Techniques to purify and characterize biomolecules

Text books:

1. John Kuriyan, Boyana Konforti & David Wemmer; The Molecules of life: Physical and Chemical Principles, (2013), Garland Science

2. Lehninger Principles of Biochemistry David L. Nelson, Michael M. Cox. Publisher: W. H. Freeman, Fourth Edition

3. Jeremy M Berg; John Tymoczko; Lubert Stryer (2012), Biochemistry, 7^{th}/6^{th} edition (or older), Wiley.

BIO502 - MOLECULAR BIOLOGY (Molecular Genetics)

This subject focuses on gene structure, function and regulation, which form the molecular basis of many important biological phenomena such as short-term organismal and cellular responses to rapid changes in environmental conditions and long-term controls of development. The molecular mechanisms underlying these phenomena are frequently exploited in biotechnology, medical and agricultural applications. The modern molecular techniques used to study these processes will be presented

1. **Central Dogma in Biology**
2. **Maintenance of the genome**

- DNA, Chromosomes and Genome
- Replication of DNA
- The Mutability and Repair of DNA
- Homologous Recombination at the Molecular Level

3. **Gene expression (action and regulation)**

- Transcription and Transcription regulation
- Transcription machinery
- Concept of operon
- Gene regulation in prokaryotes and eukaryotes
- RNA Editing
- Translation
- Post translational modifications and protein folding

4. **Techniques in Molecular Biology**

- Molecular Cloning methods
- Molecular Tools for Studying Genes and Gene Activity
- Molecular genetic manipulation of a wide variety of organisms to generate defined changes in the genome

Learning outcomes

- demonstrate an understanding of current concepts of the molecular structure of genes and the molecular basis of genetic processes, including diverse molecular mechanisms for generating gene products and regulating their expression in both prokaryotes and eukaryotes.
- interpret experimental results and data from classical genetics, recombinant DNA and genomics experiments to solve specific biological problems.
- evaluate information in the field of molecular genetics through the study of primary research papers and review articles.
- synthesise basic concepts and knowledge to enable assessment of newly reported findings in the field of molecular genetics.

Text books:

1. Molecular Biology of the Gene by Watson, Baker, Levine, Losick et al. [2007] 6 Ed. Benjamin Cummings

2. Principles of Gene Manipulation by Primrose, Twyman, Old [2002] 6 Ed. Wiley-Blackwell
3. Molecular Biology by Weaver [2011] 5 Ed. McGraw- Hill Science.
4. Molecular Biology and Genomics by Mulhardt [2006] 1 Ed. Elsevier.

BIO503 - CELL BIOLOGY

Central themes in cellular biology, including: the origin and early evolution of cells, cellular division and replication, the transport of proteins and other macromolecules within cells, the compartmentalisation of cellular metabolism, the functions of organelles in protists, animals and plants, the cellular basis of differentiation, and signalling between and within cells/

Suggested topics
Origin and early evolution of cells
Single-celled organisms
Cell division and replication, cell cycle checkpoints
Microtubule cytoskeleton
Membrane structure, lipids and lipid modification, membrane proteins
Protein secretion, biogenesis of membrane proteins
Transport of proteins and other molecules in cells
Pumps, channels, transporters
Compartmentalization of cellular metabolism
Functions of organelles in protists, animals and plants
Actin/myosin cytoskeleton
Extracellular matrix, plandtand bacterial cell walls
Flagellae and cell motility
Cellular basis of differentiation
Programmed cell death
Receptors, basics of signal transduction, signalling within and between cells
Immunity and pathogenic interactions
Case studies:eg:
Biology of cancer
Stem cells and cloning
Nanofabrication in cells (eg diatom frustules, coccolithid scales)
Covid – infection, action of different vaccine types

Textbook:

BIO504 - COMPUTATIONAL BIOLOGY

This subject will introduce current topics in computational biology, focusing on case studies in a number of different biological areas, and applying a range of different mathematical and computational data handling approaches to solve or interrogate biological problems. Each topic will be developed through a series of lectures introducing the biological topic (relying on a fundamental knowledge of the molecular basis of life gained in first and second year), the types and sources of biological data, and the relevant computational approaches, based around case studies. A series of assignments in each of these topic areas, supported by tutorial classes, will illustrate the computational methodologies as they are applied to specific biological data.
Indicative biological topics include applications of computational biology in phylogenetics, population genetics and evolution; ecological and environmental modelling (including geospatial and environmental decision making); bio-imaging and cell tracking in cell biology; pathogenesis and immunology; structural biology; and metabolic engineering and biotechnology

1. **Introduction to Bioinformatics and computational biology**

Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics.

2. **Databases in Bioinformatics** Introduction, Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System.

3. **Biological and Sequence Databases**

National Center for Biotechnology Information (NCBI): Tools and Databases of NCBI, Database Retrieval Tool, Sequence Submission to NCBI, Basic local alignment search tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database. EMBL Nucleotide Sequence Database (EMBL-Bank): Introduction, Sequence Retrieval, Sequence Submission to EMBL, Sequence analysis tools. DNA Data Bank of Japan Introduction, Resources at DDBJ, Data Submission at DDBJ. Protein Information Resource (PIR): About PIR, Resources of PIR, Databases of PIR, Data Retrieval in PIR. Swiss-Prot: Introduction and Salient Features.

4. **Sequence Alignments**

Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM).

5. **Molecular Phylogeny**

Analyses Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction.

4. **Applications of Bioinformatics**

Drug Design, Microbial genome applications, Crop improvement, RNA-sequencing and transcriptomics, Infectious disease modelling, Analysis of complex ecological networks, Bayesian inference in systems biology

BIO505 – BIOCHEMISTRY AND CELL BIOLOGY LAB

BIO506 – MOLECULAR AND COMPUTATIONAL LAB

BIO507 – GENETICS AND GENOMICS

The emphasis of this subject is on understanding how evolutionary forces shape the gene pool, on the use of molecular markers in genome mapping, in dissecting polygenic traits by mapping quantitative trait loci, and in other applications such as phylogenetics and conservation biology.

1. **Classical population genetics**
2. **Impact of natural selection**
3. **Processes of speciation**
4. **Conservation genetics**
5. **Evolution of development**
6. **Phylogenetic reconstruction**
7. **Development of saturated linkage maps**
8. **Physical mapping of genomes**
9. **Mapping quantitative trait loci**
10. **Comparative genomics**
11. **Functional genomics**
12. **High-through out methods of scoring genetic polymorphisms.**

BIO601 -EVO-DEVO: EVOLUTIONARY DEVELOPMENTAL BIOLOGY

Evo-Devo is a modern field of biology that integrates information from developmental biology, genomics, molecular biology and evolutionary theory in order to explain the evolution and diversification of plants and animals by changes in the regulation and/or interactions of genes controlling development. This subject is composed of two parts. The first part is a comparative study of the embryology/ontogeny of selected animal and plant groups. The second part investigates the emergence of the field of evo-devo from its beginnings in pre-evolutionary classical embryology through the seminal discoveries in genetics and cell and molecular biology. Examples will be drawn from case studies of comparisons of normal development, spontaneous mutations, and experimentally manipulated examples.

1. Concepts of Evolutionary developmental biology

- Introduction to developmental biology from a historical and evolutionary perspective
- Ontogeny, Recapitulation and Epigenesis: Haeckel, von Baer, the biogenetic law,
- Evolutionary morphology: Fritz Muller (using embryology to discover relationships),

Implications of similarity in early developmental stages (eg Darwins observations that Barnacle larvae are arthropod-like, not molluscan; Tunicates are Chordates); D'Arcy Thomson – On Growth and Form (minor changes in shape lead to major changes in morphology)

- The Modern Synthesis (early 20thC): Ronald Fischer- Integration of Darwin's Theory of Natural Selection with Mendel's laws of genetics; Gene-protein-structure; Gene mutation-change in biochemical pathway; Gavin de Beer: Changes in timing of developmental events - Heterochrony, neoteny

2. Ontogeny of some animal and plant groups, as well as their organ systems, in a phylogenetic perspective

- Gametogenesis: oogenesis and spermatogenesis; fertilization
- Types and patterns of cleavage, blastulation
- Gastrulation in amphioxus, frog and chick up to formation of three germinal layers
- Organogenesis in frog, chick
- Apical meristem in ferns (single cell) and angiosperms; phyllotaxis – observed and experimental.
- Stem cells, progenitor cells, cell lineages, determination, commitment and differentiation
- Dedifferentiation, redifferentiation, transdifferentiation

3. Developmental genetics:

- Discovery of homeotic genes in *Drosophila*; Homeobox genes as a eukaryotic feature
- The concept of Deep Homology; Highly conserved genes control dissimilar organs in different organisms; eg pax-6 in eyes of insects, cephalopods and vertebrates.
- Homeobox genes and the Gene Toolkit: Regulation of transcription factors; HOX genes in animals – axis development and segmentation in flies and vertebrates – morphogens and organisers; Hen's Teeth; MADS-box genes in plants and the ABC model of flower development; Leaf symmetry genes;
- Embryo regulatory networks: Pleiotropy; Origins of novelty are not mutations in genes, but variation in the toolkit; Case-studies (eg. *Distal-less* affecting snake's legs, fruit fly antennae, butterfly wing spots, vertebrate mandibles)

- Epigenetics
- Origins of novel features; variations in the toolkit, consolidation of epigenitic changes, developmental bias and constraint\

BIO602 - MICROORGANISMS AND DISEASE

This subject will investigate the antagonistic interactions with microorganisms that lead to diseases in plants and animals. After investigation the diversity and biology of the major microorganism groups, selected pathogenic examples will be used to illustrate the range and different strategies for lifecycles, transmission, infection and parasitism, and the actions of drugs in the context of both parasite and host biology. Plant and animal defenses and responses, and their evolution over time, will be investigated in the context of the evolution of the host/parasite relationship.

1. **Prokaryote diversity and biology**

- Bacteria and Archaea; Bacterial growth, reproduction, and genetics; Transformation
- Pathogenic examples (selected examples as case studies)

2. **Protist diversity and biology**

- Major groups of protists (emphasis on major pathogenic lineages)
- Protist cell biology (eukaryotic); Evolution of protistan parasitism (from autotrophy); obligate v. facultative parasites
- Pathogenic examples (selected examples as case studies): Animal Blood and tissue - Plasmodium, Toxoplasma, Babesia (Apicomplexans); Trypanosoma, Leishmania (Kinetoplastids); Naegleria (Amoebae); Dinoflagellates (in fish, crustacea, bivalves). Animal gut and digestive - Entamoeba (Amoebae); Balantidium (Ciliate); Giardia (Diplomonad); Trichomonas (Parabasalids); Cryptosporidium, Cystoisospora (Apicomplexa). Plants - Phytomonas (Kinetoplastid disease of coconuts and oil palms); Phytopthora (Oomycete – potato blight). Red alga on red alga (substitution of nuclei).

3. **Fungal diversity and biology**

- Fungal diversity and life cycles, major lineages
- Pathogenic examples (selected examples ascase studies): Microsporidians; Chytrids - Batrachochytrumdendrobatidis (chytridiomucosis in amphibians), Synchytriumendobioticum (potato disease). Fungal Pathogens of animals - Pneumocystis jiroveci, other respiratory tract fungi; Candida albicans; Tinea. Fungal pathogens of plants

4. **Helminth diversity and biology**

- Nematodes; Trematodes (flukes); Cestodes (tapeworms)

Themes for case studies to include: Transmission and lifecycle, Modes of infection; Biology of infection and parasitism; Drugs and their mode of action in context of host and microbe biology (eg Metronidazole to treat gut protists targets enzyme that converts pyruvate to acetate)

5. **Animal responses (immunology)**

- Immune system and its evolution; Immunisation in mammals

6. **Plant responses**

- Inducible defence; Microbe-associated molecular pattern (MAMP)-triggered immunity; R-genes (resistance to intracellular effectors)
- Hypersensitive response; Phytoalexins
- Plant Systemic Immunity: Systemic Acquired Resistance (SAR): Induced Systemic Resistance (ISR)

BIO603 - SYSTEMATICS AND EVOLUTION

This subject will introduce the general principles and modern methods of evolutionary biology: how to discover the phylogeny (relationships) of organisms using both morphological characters and molecular (DNA) data; how to use this information to improve the classification systems; how to study aspects of evolution, coevolution and historical biogeography; and how to integrate information from living and fossil organisms to discover the past and date evolutionary events. Examples of the diversity and evolution of Indian plants - both fossil and living forms - will be used throughout this subject.

Topics

1. Principles of classification of organisms at species rank and above including:
- purpose of classification,
- monophyly/paraphyly/polyphyly,
- species concepts,
- practical approaches to species delimitation (molecular/morphological/behavioural),
- rules of nomenclature

2. Method for phylogenetic inference from morphological and molecular data including key concepts of:
- Homology/analogy, synapomorphy,
- Parsimony v. likelihood and Bayesian methods
- types of molecular markers, including sequencing/genotyping methods/technology (Sanger, high throughput etc.),
- properties of nuclear and organellar genomes,
- some processes of molecular evolution (transitions/transversions, gene duplications, indels, polyploidy)

3. Analysis of phylogenetic data, including the use of computer programs for assembling and analyzing morphological and molecular datasets, including concepts of:
- Gene trees vs species trees: paralogy/orthology, incomplete lineage sorting
- “capture” of organellar genomes through introgression,
- concatenation vs concordance approaches to phylogenetic analysis

4. Importance of biological collections to the discipline of systematics and familiarity with common curatorial practices and use of specimen data:
- collecting methods,
- vouchering,
- specimens as objects for classifying,
- distribution mapping,
- databasing of specimens and name information,
- ancient DNA techniques

5. Use of phylogenies to infer rates of speciation and extinction

6. Inference of evolutionary and biogeographic patterns within and between species including:

- Historical biogeography: cf. ecological biogeography, vicariance/dispersal, molecular dating, patterns of diversity, endemism, phylogenetic diversity (focus on broad-scale/higher-level patterns)
- Phylogeography (focus on within-species patterns; could tie back to species delimitation, introgression etc.)

7. Biogeographic patterns in the Indian biota

BIO604 - ANALYSIS OF BIOLOGICAL DATA

A capacity to interpret data is fundamental to making informed decisions in everyday life. The design of experiments, analysis, and interpretation of biological data also lie at the very heart of the scientific enterprise. You cannot be a scientist without an understanding of data and design. This subject introduces the fundamental concepts in data science for biology, with emphasis on modern statistical methods. Drawing on real biological problems and datasets, as well as drawing on data collected by the class, the lectures cover foundational concepts in experimental design and statistical modelling. The subject emphasises hands-on problem solving. As well as a solid grounding in statistical methodology, you will also develop practical skills, developing your capacity to design experiments, collect data, and analyse those data using the R statistical environment.

Topics

1. Statistics and biology. Data, what it is, data types. Displaying data, principles of graphical summary. Types of study; population and sample; sampling. Measures of location: proportion, mean, median, mode. Measures of spread: quartiles, IQR, SD, Variance

2. Introduction to probability. Conditional probability, and independence. Random variables and probability distributions. Common pdfs for biological data + CLT

3. Point estimation. Sampling and estimation. Sampling and standard errors. Confidence intervals

4. Sampling distributions and interval estimation (z) and (t). Bootstrap inference. Inference and Models NHST. Hypotheses with numerical data: One sample z-test

5. NHST in perspective. Goodness of fit .Contingency analysis. Comparing means from paired data. Comparing population means

6. Experimental design: space, time; blocking and randomisation; controls, bias, replication, and balance. Precision and Power

7. The linear model. Analysis of variance. Comparing models (likelihood)

8. Correlation, covariance. Linear regression. Inference for regression. Extending the regression model (Multiple regression). Multiple regression (interactions, polynomials). Analysis of covariance. Two-way ANOVA w interactions. Shrinkage estimation methods

9. GLM. Logistic regression

10. Model selection: AIC; BIC; Stepping; CrossValidation

11. Law of total probability, and Bayes. Introduction to Bayesian inference

BIO605 – DEVELOPMENT, SYSTEMATIC AND EVOLUTION LAB

BIO606 – IMMUNOLOGY AND MICROBIOLOGY LAB

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PRJ501 – GRADUATE LEVEL THESIS – 2 CREDITS

TY Research Project

To run over two semesters in Third Year (Semesters 5 and 6)

Semester 5 is an introduction to the Field of Research, and is largely literature-based.

Semester 6 is experimental, and is largely laboratory-/field-based

Semester 5

Student to choose a Field of Research, and develop a Semester 6 research project in that area.

	Activity	Volume of Work	Due	Marks
1	Write an essay explaining the Field of Research	1500 words	Wk 4	30
2	Write a literature review relevant to the Research Project topic (review c. 10 papers)	1500 words	Wk 8	30
3	Prepare a Research Proposal for the Research Topic (format consistent with a funding proposal) Full research methodology as an appendix – materials and methods	1000 words	Wk12	20
4	Short oral presentation of Research Proposal	15 mins +5 mins Q&A	Wk12	20

Semester 6

Student to conduct and report on the Research Project.

	Activity	Volume of Work	Due	Marks
1	Write a Research Report in the style of a scientific journal article	2000 words	Wk 10	50
2	Based on feedback from marker, revise the Research Report and resubmit with justifications of revision changes		Exam week	10
3	Prepare a Poster on the Research Project (Power point slide; readable when printed at A3)		Wk12	20
4	Oral presentation of Research Project (presentation to be videoed for ePortfolio)	20 mins +10 mins Q&A	Wk12	20