# SYLLABUS OF COURSE WORK

*of*

# DOCTOR OF PHILOSOPHY

*Prepared by*

The Departments under Faculty Council of Science

## Jadavpur University

## Calcutta-700 032

INDEX



**Important points to be noted:**

- Duration of Course Work : One Semester (6 Months)
- Total Marks : 200 (Two papers 100 marks each)
- Duration of Examination: 4 Hrs. (2 Hrs. for each paper)
  - **Paper I**: Compulsory Units:
    Research Methodology & Review of Research Work: 100 Marks (2 hrs)
    (a) Research Methodology: 50 Marks
    (b) Review of Research Work: 50 Marks
  - **Paper II** : Elective Units:
    Subject Course Work: 100 Marks (2 hrs.)
- Examination will be held at the end of the Semester.
- Total Lecture Hour (periods) for Paper II (elective units): 64(sixty four).

**P.T.O**

# SYLLABUS OF COURSE WORK OF PH.D(Sc.)

## DEPARTMENT OF PHYSICS

| Courses | Subject | Full Marks |
|---|---|---|
| **Compulsory Units** | 1. Research Methodology | **50** |
| | 2. Review of Research Work | **50** |
| **Elective Units** | 1. Material Characterization Techniques. | **50** |
| | 2. Production of low temperatures and low-temperature properties of materials. | **50** |
| | 3. Physics of semiconductor structures and quantum well devices. | **50** |
| | 4. Dynamical Systems. | **50** |
| | 5. Critical phenomena and renormalization group. | **50** |
| | 6. Non-equilibrium statistical mechanics and surface growth. | **50** |
| | 7. Relativistic heavy ion Physics. | **50** |
| | 8. Environmental Radiation and Health Physics Fundamentals. | **50** |
| | 9. Advanced X-ray crystallography. | **50** |
| | 10. Biophysics. | **50** |
| | 11. Physical Cosmology. | **50** |
| | 12. Monte Carlo methods in statistical physics. | **50** |
| | 13. General Relativity. | **50** |

**N.B. :** Students to opt for any 2 elective units out of the elective units offered. 32x2 classes to be attended (100 marks) - 4 classes to be held every Saturday evening.

# COMPULSORY UNITS

## 1. Research Methodology (40 lectures)

**Definition of the Problem**: Identifying and formulating the problem.

**Techniques involved in solving the problem:**

a) Exact analytical solution of equations involved.

b) Numerically solving equations.

c) Simulating the problem on a computer. Monte Carlo or molecular dynamics approach.

d) Experimental observations and theoretical modeling

**Developing a research plan**: Research objective: information required for solving the problem: defining each major concept in operational terms: an overall description of approach, clearly stating any assumptions; details of techniques.

**Methods of data collection**: Experimental data, field data, data from other sources.

**Analyzing data:** Error analysis, statistical analysis

### Using computers in research:

**Basics of operating systems –** handling different operating systems

1. Literature survey using web, handling search engines
2. Computer usage for collecting/analyzing data – simulations using fortran/ C/ Mathematica/ Matlab/Mathcad.
3. Preparing presentations:
   i) Research papers : Using word processing software – MS Word/Latex/others, Drawing graphs and diagrams – Origin/Xmgrace/Excel/others.
   ii) Seminar presentations – Power point for oral and poster presentations

## 2. Review of Research Work: (20 lectures)

The relevance of the research from perspective of the subject. Detailed review of state of the art. Scope of the work.

# ELECTIVE UNITS

## 1. Material characterization Techniques (Total 30 Lectures)

1. Introduction: Physical and chemical properties . Necessity of characterization.
   (a) Macroscopic properties: Optical. Electrical, dielectric, magnetic, mechanical
   (b) Microscopic properties – chemical structure, composition, surface characterization. (1)
2. Probing bulk and nano-structure – XRD, TEM, HRTEM, Neutron scattering. (8)
3. Surface structure and topography – SEM, STM, LEED, AFM(6)
4. Microstructure – UVVIS, Raman, FTIR, Optical microscopy, small angle scattering(6)
5. Phase changes, crystalline and amorphous fractions – DSC(2)
6. Thermo-gravimetric methods – TGA, DTA(2)
7. Mechanical properties: Elastic properties, strength measurements in bulk and thin films, nano-indentation, Physics of fracture – Griffith's theory of brittle fracture, ductile fracture, length scale issues and size effects (5)

## 2. Production of low temperatures and low-temperature properties of materials. (Total 30 Lectures)

i) **Production and measurement of low temperature**: [Total 12 lectures]

The range of low temperature; Need of vacuum; Different pumps to produce vacuum of required order (Rotary pump, Diffusion pump etc.); Properties of liquid oxygen, liquid nitrogen and liquid helium; Construction of Thermostat and Cryostat. Measurement of low temperature using different techniques.

ii) **Physical properties of solid at low temperature:** [Total 18 lectures]

**a) Spectroscopic properties:**

Infra red and visible spectra, Zeeman spectra; Formation of laser and its principles; Use of laser in Spectroscopy; Laser cooling.

**b) Transport properties:**

Dielectric constant and its measurement; Electrical properties of solid; Low temperature specific heat of solid.

**c) Magnetic Properties:**

Low temperature Magnetic susceptibilities; Electron paramagnetic resonance, Nuclear magnetic resonance etc.

**d) Hyperfine properties:**

Nuclear magnetic properties; Electric quadrupolar effect at nuclear site; Mossbauer effect and other hyperfine properties of the solids.

## 3. <u>Physics of Semiconductor Structures and Quantum Well Devices</u>

**(Total 30 Lectures)**

1. Heterostructure Growth:
2. (i) Molecular Beam Epitaxy, (ii) Metal organic Vapor Deposition, (iii) Chemical Beam Epitaxy, (iv) Other methods. - (4 Lec)
3. Lower Dimensional Structures: 2D structure, 1D structure, 0D structure. - (2 Lec)
4. Band Offset:
5. (i) Types of heterostructures (ii) Electron Affinity rule (iii) Common Anion rule (iv) Theoretical method of calculation of Band offset (v) Experimental methods. - (4 Lec)
6. Electron States:
7. (i) Effective mass approximation (ii) Energy levels of electrons in quantum well, Super lattice, Single heterojunction, Quantum wire and dot. (iii) Energy levels of holes -(4 Lec)
8. Optical Interaction Phenomena:
9. Interaction in quantum wells (ii) Excitons (iii) Absorption -(4 Lec)
10. Transport Properties:
11. (i) Solution of the transport equation for 2 DEG, (ii) Mobility, (iii) High –field velocity, (iv) Ballistic Transport -(6 Lec)
12. Structure and Principle of Operation of (i) High Electron Mobility Transistor, (ii) Resonant Tunneling Diode (iii) Quantum Well Laser (iv) Quantum Well Detector, Modulator and Switch (v) Optical Bistable Devices. - (6 Lec)

## 4. <u>DYNAMICAL SYSTEMS</u>: (TOTAL 30 Lectures)

a) Basic Concepts of Phase Space trajectories. Dynamical Systems. Examples from Harmonic oscillators with Damping/Forcing. Differentiating between Dissipative Systems, Conservative Systems and Growing Systems. --(**2 lectures**)

b) One Dimensional Dynamical Systems: Fixed Points. Stability Analysis. Bifurcations: Transcritical, Pitchfork (Super/Sub-critical), Saddle Node. Examples. -- (**3 lectures**)

c) Two Dimensional Dynamical Systems**:** Spirals, Saddles, Centres. Bifurcations. Supercritical and Subcritical Hopf Bifurcations. Predator-Prey Model. --(**4 lectures**)

d) Limit Cycles: Definition. VanderPol Oscillator. Perturbative treatment. Existence of Limit Cycles: Poincare Benedixon Theorem. The example of Glycolysis. Relaxation Oscillations. --(**4 lectures**)

e) Algebraic methods of dealing with Anharmonic Oscillations: First Integrals, Approximations methods: Pade, Linsdstedt-Poincare, Multiple time Scale, Coordinate Perturbation. Nonperturbative averaging methods. Rapidly Oscillating Forcing: Kapitza's Mean Field Method. --(**7 lectures**)

f) Three Dimensional Dynamical Systems: Lorenz model. Limit Cycles, Chaos. strange Attractors, Fractal Dimensions, Correlation Index, Mori Conjecture. Logistic Maps. Period Doubling, Cascading and Feigenbaum's study. --(**10 lectures**)

## 5. <u>CRITICAL PHENOMENA AND RENORMALIZATION GROUP</u>:

**(TOTAL 30 lectures.)**

i) Critical Phenomena: The problem (Critical exponents, Universality etc.). Phase transitions in various dimensions. Magnetic systems and liquid-gas transitions. Correlation Functions. --(2 lectures)

ii) Landau theory of phase transitions. Calculation of critical exponents. --(3lectures)

iii) Mean Field Theory. Calculation of Critical exponents. --(4 lectures)

iv) Scaling theories of Widom and Kadanoff. Derivation of various scaling relations. --(3 lectures)

v) Introduction to Renormalization Group. Fixed points. Relevant and Irrelevant variables. Relation between Critical exponents from RG. -- (4 lectures)

vi) Momentum space RG: Going from discrete to continuous picture. Partition function. Functional integration. Landau-Ginzburg model. Consistency with Landau model. Scaling in momentum space. Dimensional analysis. Scaling and Anomalous dimensions. Evaluation of Partition Function in the Gaussian model. RG treatment of the Gaussian model. -- (6 lectures)

vii) The phi-4 model: RG treatment to second order. The cases of dimensionality greater than, lesser than and equal to 4. Epsilon expansion and calculation of critical exponents. -- (8 lectures)

## 6. <u>Basic tools of Non-equilibrium Statistical Mechanics</u>:

**--(TOTAL 30 lectures)**

i) Langevin Approach. Brownian Motion. Calculation of moments. Oscillator coupled to a reservoir; Fokker-Planck approach: Studying phenomena in terms of Probability evolution. Examples. Fluctuation-Dissipation theorem. Miscellaneous applications. --(10 lectures)

ii) Fractal concepts: Deterministic and random fractals. Determination of Fractal Diemensions. Examples: Percolation clusters, Diffusive growth, Laplacian growth. --(4 lectures)

iii) The phenomenon of Surface Growth: Roughening, Dynamic Scaling, Significance of correlations. Growth models: Random and Ballistic depositions. Edward Wilkinson model. Kardar-Parisi-Zhang model. Introduction to Dynamic Renormalization Group(DRG). Solution of the growth equations using DRG. --(10 lectures)

iv) Non-equilibrium Statistical Mechanics and Surface growth: Basic tools of Non-equilibrium Statistical Mechanics: Langevin Approach. Brownian Motion. Calculation of moments. Oscillator coupled to a reservoir; Fokker-Planck approach: Studying phenomena in terms of Probability evolution. Examples. Fluctuation-Dissipation theorem. --(6 lectures)

## 7. Relativistic Heavy Ion Physics (Total 30 Lectures)

i) Fundamentals of Quantum Chrodynamics – (Lec.-5)
ii) Phase Transition in Strongly Interacting Matter-QGP (Lec.-2)
iii) Relativistic Kinematics-(Lec.-3)
iv) Sources of Relativistic and Ultrarelativistic Nuclei-(Lec.-2)
v) Detection Techniques-(Lec.-3)
vi) Cross Section and Collision Geometry-(Lec.-2)
vii) Overview of Relativistic Heavy Ion Collision Models-(Lec.-2)
viii) Experimental Data and Application Statistical Methods(Lec.-3)
ix) Experimental Results-(Lec.-4)
x) Heavy Ion Physics & LHC-(Lec.-2)
xi) Future Programmes-(Lec.-2)

## 8. Environmental Radiation & Health Physics Fundamentals

**(Total 30 Lectures)**

a) Environmental Radiations & Interaction of Radiations With Matter (Lec-8)
b) Sources of Environmental Radiations(Lec.-3)
c) Dosimetric Quantities, Units and Applications(Lec.-3)
d) Measurement Techniques(Lec.-4)
e) Counting Statistics and Error Prediction(Lec.-3)
f) Biological Effects of Ionizing Radiations & Risk Models(Lec.-4)
g) Effects of Non-ionizing E-M Radiations(Lec.-3)
h) Standards and Regulations(Lec.-2)

## 9. Advanced X-ray crystallography for Ph D course work

**(Total 30 Lectures)**

i) Symmetry in crystals, space groups and cell transformation (Lec 2)
ii) Principle of X-ray powder diffraction, Measurement of X-ray powder diffraction patterns, Powder diffractometers, Principles of goniometer design in powder diffractometry, Monochromatic radiation, Bragg-Brentano geometry, Debye-Scherrer geometry. (Lec 1)
iii) Sample preparation for X-ray powder diffractometry, Sample mounting, Particle size requirement, Sample thickness and uniformity, Effects of sample preparation on powder diffraction data, Data acquisition, Quality of experimental data. (Lec 1)
iv) Preliminary data processing and phase analysis, Use of crystallographic data base, Phase identification and quantitative analysis, Different methods of quantitative phase analysis. (Lec 2)
v) Indexing powder diffraction pattern, Basic relations, The indexing problems, Geometrical ambiguities, Different indexing programs, Figures of merit, Precise lattice parameters and least-squares method. (Lec 5)

vi) The Rietveld method, Rietveld method basics, Background contribution, Peak-shape function, profile parameters, Quality of Rietveld refinemet, Different R-factors. (Lec. 6)
vii) Crystallite size and lattice strain determination from line broadening, The Scherrer equation, The Fourier method of Warren and Averbach, Method of integral breadths. (Lec. 2)
viii) Radial distribution studies of non-crystalline materials, Experimental requirements, Correction and Scaling of experimental intensities to absolute (electron) units, Practical examples. (Lec. 2)
ix) EXAFS, EDX, XFS, XPS. (Lec. 2)
x) Diffraction of X-rays by liquids and liquid crystals, Information obtained from X-ray studies of liquid crystalline materials. (Lec. 2)
xi) Protein crystallography: Basics of protein structure, Secondary structure elements, α-helix and β-sheet, Tertiary structure; Phasing methods: Isomorphous replacement, Molecular replacement, Multiple anomalous dispersion; Non-crystallographic symmetry and density modifications. (Lec. 5)

## 10. <u>Biophysics</u> (Total 30 Lectures)

i) **Physics of self assembly of amphiphiles**: (2 Lec.)
Monolayer, micelles, bilayers etc.
ii) **Intermolecular and surface forces relevant to bio-systems**: (1 Lec)
Vander Waals, hydration, steric, hydrophobic forces etc.
iii) **Cell & its organelles - structure and function (2 Lec)**
iv) **DNA/RNA/Protein - structure and function (5 Lec)**
v) **Physico-chemical processes and techniques- (3 Lec)**
Diffusion/Osmosis/Centrifugation/Viscosity/Column chromatography/Gel electrophoresis/Autoradiography.
vi) **Physics of Membranes**- (6 Lec)
   a) Cell Membranes
   b) The Structure of Membranes
   c) Model membranes as biomimetic systems: liposomes or vesicles, methods for preparing giant unilamellar and large unilamellar vesicles. Measurement of mechanical properties of membranes using micropipette aspiration. Effect of additives, such as cholesterol, peptides etc on the membranes. Active membranes.
   d) Conformational Properties of Membranes
   e) Passive Membrane Transport
   f) Active Membrane Transport
   g) Transport of Charged Particles through Membranes
   h) Molecular Reception.
vii) **Physics of the Nerve Impulse**- (3 Lec)
   a) The Axon and the Nerve Impulse,
   b) Propagation of the Nerve Impulse
   c) Generation of the Nerve Impulse
   d) Ionic Channels
   e) Synaptic Transmission.

viii) **Photo biological Process**- (3 Lec)

a) Photosynthesis
b) Two Photochemical Systems
c) Chloroplasts
d) The Mechanism of Photosynthesis
e) Vision
f) The Molecular Mechanism of Photosynthesis
g) Bacteriorhodopsin

ix) **Experimental techniques**- (3 Lec)

a) Electron Microscopy
   (i) Scanning Electron Microscopy
   (ii) Transmission Electron Microscopy
b) Confocal fluorescence microscopy, Fluorescence spectroscopy.

x) **Bio-Instrumentation** - (2 Lec)

a) X-Ray Diffractometer (XRD)
b) Dynamic Thermal Analyser/Thermogravimetric Analyzer (DTA/TGA)
c) Fourier Transform Infrared (FTIR) Spectrometer
d) UV-Vis Spectrophotometer
e) Fluorimeter

## 11. <u>Physical Cosmology</u> (Total 30 Lectures)

**i) The expansion of the Universe:** **[**14 lectures**]**

- **Cosmological principles:** Cosmological principles, the Robaertson Walker metric, the redshifts, Hubble's law, Distances at small redshift.
  [3 lectures]
- **Dynamics of expansion:** Basics of Friedman – Roberson Walker cosmology, Cosmological parameters, Dark matters, Age of the Universe, Particle horizon, Event horizon, Models with $\Lambda$ term, Luminosity distance, Angular diameter distance, Source counts. [4 lectures]
- **Distances at large redshifts:** Accelerated expansion, Discovery of accelerated expansion, Discovery of early deceleration, Equation of state w parameter, The cosmological constant problems. [4 lectures]
- **Intergalactic absorption:** Optical depth, Resonant absorption, 21 cm absorption, Lyman $\alpha$ absorption, Gunn Peterson trough. [3 lectures]

**ii) Relics of the big bang:** **[3 lectures]**

Expectations and discovery of the microwave background radiation, Black body radiation, RayleighJeans formula, Balloon and Rockets experiments, COBE, FIRAS, WMAP experiments and its implication, Power spectrum of the CMB.

**iii) The early Universe:** **[6 lectures]**

- **Thermal history:** FermiDirac, BoseEinstein distributions, Time vs. temperature, Effective number of species, Neutrino decoupling, Heating by electronpositron annihilation, Neutrino masses and chemical potentials.
  [3 lectures]

- **Cosmological nucleosynthesis:** Neutronproton conversion, Equilibrium nuclear abundances, Deuterium bottleneck Helium abundance, Deuterium abundance $He^3$ abundance, Lithium abundance, $\Omega\, h^2$. [3 lectures]

**iv) Formation of the large scale structure: [7 lectures]**

- **Linear perturbations after recombination:** Hydrodynamic and field equation, Factorization of perturbations, Effect of vacuum energy, Power spectral function P(k), correlation function, Direct measurement of P(k), Rms fluctuation $\sigma_R$, measurements of P(k), Baryon acoustic oscillations, Cosmic variance in measuring P(k). [5 lectures]
- **Nonlinear growth:** Spherically symmetric collapse, Calculation of $\sigma_R$, Press Schechter mass function. [2 lectures]

## 12. MONTE CARLO METHODS IN STATISTICAL MECHANICS

**(Total 30 Lectures)**

i) Principles of equilibrium thermal Monte Carlo Simulation – importance sampling, Markov process, ergodicity, detailed balance. [2 periods]

ii) The Ising model and the Metropolis algorithm-implementing the Metropolis algorithm, equilibration, measurement, auto correlation functions. [6 periods]

iii) Other algorithms for the Ising model – critical exponents and their measurement, the Wolff algorithm and its properties, the Swendsen-Wang algorithm. [6 periods]

iv) Other spin models – Potts models, cluster algorithm for Potts models, continuous spin models. [4 periods]

v) Analyzing Monte Carlo data – Single and Multiple histogram methods of Ferrenberg and Swendsen Implementation. Finite size scaling – direct measurement of critical exponents. [5 periods]

vi) Monte Carlo Renormalization group – real space renormalization, calculating critical exponents. [4 periods]

vii) Random numbers – generating uniformly distributed random numbers, True random numbers, pseudo-random numbers. [3 periods]

## 13. GENERAL RELATIVITY TOTAL 30 LECTURES

**i) Special Relativity and Flat Spacetime:**

- Recapitulation of the basics with particular emphasis on the geometric aspects of Lorentz transformation, including applications to covariant formulation of electrodynamics. [2 periods]

**ii) Mathematical Background: Manifolds and Riemannian Geometry:**

- Definition of charts and atlases, Manifolds and co-ordinate basis, Definition of Tensors, Multiplication and contraction of tensors, Derivative and differentiation of tensor
- Covariant differentiation and the notion of The Christoffel connection, Invariant interpretation of the covariant derivates, General properties of the covariant derivative, Covariant differentiation along a curve, Parallel transport and the geodesic equation.

- The Riemanian curvature tensor, Symmetries of the Riemanian tensor, General properties of the curvature tensor, The Bianchi identity, The Ricci and Einstein tensor, Weyl tensor – simple examples and explicit calculations. Symmetries of the Metric (Isometrics).
- Intrinsic geometry, Curvature and parallel transport, the Existence of flat connections/(coordinates), the geodesic derivation equation. [8 periods]

**iii) The Einstein equations (from geometry/curvature to Gravity)**

- The weak field limit and the derivative of Einstein equation, significance of the Bianchi identities, Comments on the initial value problem and the boundary conditions(Cauchy hyper-surface) [4 periods]
- The Einstein equation from a variational point of view, The Einstein-Hilbert action, The matter Lagrangian and the gravitational field equations, the Newtonian and the Post Newtonian limits (approximation), Linearization of the field equations. [6 periods]

**iv) Selected Application :**

- The Schwarzchild solution and the schwarzchild metric, Static Isotropic metrics, Solutions for static, Spherical symmetric metric, Birkoff's theorems, Basic properties of the schwarzchild metric, The schwarzchild radius, Measuring length and time in the Schwarzchild metric, Newtonian Vs. relativistic orbit,

**Perihelion procession, The event horizon, Black hole, formation of black holes, Penrose diagrams – conformal infinity, Charged black holes, external black holes, Rotating black holes, Black hole thermodynamics (statements only).**

[10 periods]

# SYLLABUS OF COURSE WORK OF PH.D(Sc.)

## DEPARTMENT OF CHEMISTRY

| Courses | Subject | Full Marks |
|---|---|---|
| Compulsory Units | A. Research Methodology | **50** |
| | B. Review of Research Work | **50** |
| **Elective Units** | I.1. Application of Spectroscopic Studies in Chemical Research | **25** |
| | I.2. Materials, Catalyses and Electrochemical Studies. | **25** |
| | I.3. Metals in Life and Reaction Dynamics | **25** |
| | I.4. Single Crystal X-Ray Structures, Supramolecular Chemistry and DFT Computation. | **25** |
| | O.1. Spectroscopy and Asymmetric Synthesis | **25** |
| | O.2. Synthesis Methodology | **25** |
| | O.3. Advanced Organic Synthesis | **25** |
| | O.4. Bio-organic Chemistry | **25** |
| | P.1. Theoretical Chemistry | **25** |
| | P.2. Chemical and Electrochemical Kinetics and Environment Related Electrochemistry | **25** |
| | P.3. Biophysical Chemistry and Surface Chemistry | **25** |
| | P.4. Photochemistry and Spectroscopy | **25** |

**N.B. :** Students to opt for **four elective units** out of the elective units offered, in the following manner:-.

i) First unit from any one of I.1., O.1 & P.1;
ii) Second unit from any one of I.2., O.2 & P.2;
iii) Third unit from any one of I.3., O.3 & P.3; and
iv) Fourth unit from any one of I.4., O.4 & P.4.

**16X4** classes to be attended.

**<u>Nomenclature of Compulsory Unit</u>**:

Illustration: I.2

Abbreviations: I: Inorganic [Similarly O: Organic; P: Physical] & the digit represents Unit No.

# COMPULSORY UNITS

## A. Research Methodology:

**Definition of problem :** Necessity of defining problem, Technique involved in defining a problem. Surveying the available literature.

**Techniques involved in solving the problem:** Different methods used to solve a problem.

**Research Design:** Subject of study; Place of study; Reason of such study; Type of data required; Method of data collection; Periods of study; Style of data presentation.

**Developing a research plan:** Research objective; Informations required for solving the problem; Each major concept should be defined in operational terms; An overall description of the approach should be given and assumption if considered should be clearly mentioned in research plan; The details of techniques to be adopted.

**Methods of data collection:** Experimental methods.

**Analysis of data:** Various measures of relationship often used in research studies, Correlation coefficients.

**Chi-Square test:** Definition of chi-square test. Significance in Statistical analysis.

### Computer:

***Basic of Computer Operating System:*** Using Windows – Directory structures – command structure (Document preparation, EXCEL, Power Point Presentation).

***Word Processing:*** Basics of Editing and Word processing.

***Numerical analysis.***

***Figure Plotting:*** Figure insertions in documents.

***Web Browsing for Research:*** Usage of Webs as a tool for scientific literature survey.

***Error Analysis:*** Basics of a measurement and its interpretation, mean, standard deviation, variance, correlation coefficient; Usage of packages (e.g. ORIGIN; EXCEL) for data analysis.

***Curve Fitting:*** Linear and Non-linear fitting of data.

## B. Review of Research Work:

The relevance of the research work from the perspective of the subject – Possible ways to apply the research work in future.

# ELECTIVE UNITS

**Unit-I.1: Application of Spectroscopic Studies in Chemical Research**
Advanced treatment of IR and UV-Visible Spectroscopy; Luminescence Spectral Studies; Mass Spectrometry at advanced level; NMR and ESR Spectrometric application; CD and ORD treatment at advanced level.

**Unit-I.2: Materials, Catalyses and Electrochemical Studies**
Magnetic properties of Materials; Optical properties of Materials; Homogeneous and Heterogeneous catalysis; Sensor; Cations and anions; Thin film semiconductors: synthesis and its application in As and Cd poisoning (as Sensors) as well as solar cells.

**Unit-I.3: Metals in Life and Reaction Dynamics**
Derivation of complex rate laws and their interpretation; proton ambiguity; how to solve rate laws; how to propose the mechanistic pathways and related matters.

<u>Bioinorganic Chemistry</u>
Metalloproteins; metalloenzymes; photosystem; experimental techniques

<u>DNA interaction</u>
Interaction of complexes with DNA monitored by (a) UV-Vis spectroscopy; (b) Fluorescence spectroscopy; (c) Cyclic voltammetry and (d) CD.
Environmental health-hazards and remediation; Electrochemical Studies

**Unit-I.4: Single Crystal X-Ray Structures, Supramolecular Chemistry and DFT Computation**
Crystal growth and data collection; Structure solution and refinement; Supramolecular Chemistry; DFT computation.

**Unit-O.1: Spectroscopy and Asymmetric Synthesis**
$^{1}H$, $^{13}C$, 2D & other nuclei; Mass Spectrometry; Asymmetric Synthesis.

**Unit-O.2: Synthesis Methodology**
Organometallic Chemistry; Green Chemistry; Combinatorial and Carbohydrate Chemistry.

**Unit-O.3: Advanced Organic Synthesis**
Application of photochemistry and radical chemistry in Organic Synthesis; Pericyclic Reactions; Total synthesis with retro synthetic analysis.

**Unit-O.4: Bio-organic Chemistry**
Biomimetics; Peptides and Proteins Chemistry; Supramolecular Chemistry.

**Unit-P.1: Theoretical Chemistry**
<u>Basic Quantum Mechanics</u>
A review of Schrödinger formulation; One-dimensional potential barrier problems; Schrödinger, Heisenberg and Interaction problems; Variation and perturbation methods; Time-dependent perturbation; applications.

<u>Statistical Mechanics and Computer Simulation</u>
An introductory review of Statistical Mechanics (Real gas, Monatomic Liquids); Introduction to the time correlation function formalism (Absorption of Radiation, Classical theory of light scattering); Computer Simulation Techniques.

Irreversible Thermodynamics

Internal heat and entropy production; Relation of entropy production with Fluxes & Forces; Phenomenological equation; Onsager reciprocal relation; Prigogine's principle of minimum entropy production at non equilibrium stationary state.

**Unit-P.2: Chemical and Electrochemical Kinetics and Environment Related Electrochemistry**

Fuel cells; Solar cells (photochemical, photovoltaic); Batteries (solid-state & conventional)- single electrode and complete cell studies; Production of $H_2$ and important chemicals of high energy; Corrosion & waste removal techniques.

Electrochemical Techniques

Polarography; Chronopotentiometry; Chronoamperometry, Chronocoulometry, Linear Potential Sweep Voltametry; Cyclic Voltametry, Impedance measurements; AC Voltametry.

Reaction Dynamics

Factors affecting the chemical reaction rate: temperature, ionic strength of the solution, catalyst, pH and dielectric constant of the medium, micelle, reverse micelle & nanoparticles; Determination of rate constant by stopped flow method & relaxation method; Flash photolysis & use of LASER

**Unit-P.3: Biophysical Chemistry and Surface Chemistry**

Thermodynamics in Biochemistry (Fundamentals and Applications); Biopolymers (Proteins, Enzymes, DNA, Carbohydrates); Biomembranes (Structure and Function); Active transport and passive transport, Multiple equilibria, Specific examples of multiple equilibria, Transport processes; General features of transport processes; Optical systems for the study of transport processes, Self organizing systems (Micelles, Lipids. Cyclodextrins, Liquid crystals, Reverse micelles, coacervates, Proteins *etc*) their interactions and solutions properties.

Preparation, Characterization and Application of nanoparticles

Surface and Biophysical Techniques: CD, SEM, TEM, EDAX, DLS, Gel Electrophoresis, Radioactivity, XPS.

**Unit-P.4: Photochemistry and Spectroscopy**

Photon molecule interactions; Absorption, fluorescence and phosphorescence; Quantum yield; Non-radiative deactivations; Excited state; Phosphorescence; Steady state and time resolved aspects; Time-resolved Fluorescence; Flash photolysis; Types of photochemical reactions; Change of properties of molecules upon photo excitation; Mutagenic effect of radiation; Laser Spectroscopy; Photoelectron Spectroscopy; Mossbauer Spectroscopy; Raman Spectroscopy.

# SYLLABUS OF COURSE WORK OF PH.D(Sc.)

## DEPARTMENT OF MATHEMATICS

| Courses | Subject | Full Marks |
|---|---|---|
| Compulsory Units | A. Research Methodology | **50** |
| | B. Review of Research Work | **50** |
| **Elective Units** | 1. Difference Equation and its Application | **25** |
| | 2. Introduction to Control Theory and its Application-I | **25** |
| | 3. Introduction to Control Theory and its Application-II | **25** |
| | 4. Introduction to Control Theory and its Application-III | **25** |
| | 5. Computational Techniques using Mathematica and Matlab | **25** |
| | 6. Numerical Simulation and Plasma system | **25** |
| | 7. Inventory Control | **25** |
| | 8. Ricci Flow | **25** |
| | 9. Some Structures on Differentiable manifold | **25** |
| | 10. Spectrum and Numerical range | **25** |
| | 11. C* - Algebra | **25** |
| | 12. Commutative Algebra | **50** |
| | 13. Computations in Commutative, Algebra | **50** |
| | 14. Topological Groups | **25** |
| | 15. Sequence Spaces | **25** |
| | 16. Integral Equations | **25** |
| | 17. Theory of Distribution | **25** |
| | 18. Introduction to the Theory of Water Waves | **25** |
| | 19. Modules, Rings, Groups and Categories | **25** |
| | 20. Lattice Theory | **25** |
| | 21. Categories and Universal Algebra | **25** |
| | 22. Theory of Semi groups | **25** |
| | 23. Theory of Semirings | **25** |
| | 24. Cosmology | **25** |
| | 25. Lagrangian and Hamiltonian formulations relativity of general relativity. | **25** |
| | 26. Rotating Black Holes | **25** |
| | 27. Geodesic Congruences | **25** |
| | 28. Hyper surfaces | **25** |

**N.B. :** Students to opt elective units of 100 marks out of the elective units offered. 16 lectures to be attended for each 25 marks.

# COMPULSORY UNITS

## A. <u>Research Methodology</u>:

**Definition of problem :** Necessity of defining problem, Technique involved in defining a problem. Surveying the available literature.

**Techniques involved in solving the problem:** Different methods used to solve a problem.

**Research Design:** Subject of study; Place of study; Reason of such study; Type of data required; Method of data collection; Periods of study; Style of data presentation.

**Developing a research plan:** Research objective; Informations required for solving the problem; Each major concept should be defined in operational terms; An overall description of the approach should be given and assumption if considered should be clearly mentioned in research plan; The details of techniques to be adopted.

**Methods of data collection:** Experimental methods.

**Analysis of data:** Various measures of relationship often used in research studies, Correlation coefficients.

**Chi-Square test:** Definition of chi-square test. Significance in Statistical analysis.

### Computer:

***Basic of Computer Operating System:*** Using Windows – Directory structures – command structure (Document preparation, EXCEL, Power Point Presentation).

***Word Processing:*** Basics of Editing and Word processing.

***Numerical analysis.***

***Figure Plotting:*** Figure insertions in documents.

***Web Browsing for Research:*** Usage of Webs as a tool for scientific literature survey.

***Error Analysis:*** Basics of a measurement and its interpretation, mean, standard deviation, variance, correlation coefficient; Usage of packages (e.g. ORIGIN; EXCEL) for data analysis.

***Curve Fitting:*** Linear and Non-linear fitting of data.

## B. Review of Research Work:

The relevance of the research work from the perspective of the subject – Possible ways to apply the research work in future.

# ELECTIVE UNITS

1. **<u>Difference Equation and its Application ( 25 Marks )</u>**

Difference Calculus, Linear first – order difference equations, Nonlinear difference equations, Higher order linear difference equations, Systems of difference equations, Stability Theory, Applications.

2. **<u>Introduction to Control Theory and its Application–I (25 marks)</u>**
   - Linear differential equations : integrating factors and the D-operator method.
   - Systems of linear differential equations : autonomous systems, bifurcations and the stability of equilibrium points.
   - Linearization of non-linear systems.
3. **<u>Introduction to Control Theory and its Application–II (25 marks)</u>**
   - Laplace transforms and Z transforms.
   - Transfer functions and feedback
   - Controllability and observability
   - Stability : the Routh-Hurwitz criterion
   - Optimal control : Euler-Lagrange equations.
4. **<u>Introduction to Control Theory and its Application–III (25 marks)</u>**
   - The Hamiltonian-Pontryagin method, bounded control functions and Pontryagin's principle, bangbang control, switching curves.
   - Complex variable methods : the Nyquist criterion
   - A brief introduction to non-linear systems.

5. **<u>Computational Techniques using Mathematica and Matlab ( 25 Marks )</u>**

Mathematica basics. 2 D and 3 D Graphs . Basic Calculus. Ordinary Differential Equations. Partial Differential Equations and Boundary Value Problems. Mathematica Programming. Linear and Nonlinear Integral Equations.

Matrix Operations in MATLAB. Solution of Equations. Curve-fitting. Numeral Integration. MATLAB Programming.

6. **<u>Numerical Simulation and Plasma system ( 25 Marks )</u>**

   - Numerical simulation using MATLAB of some well-known non-linear differential equations.
   - Derivation of some non-linear differential equations to study non-linear wave processes in a simple plasma system.

7. **<u>Inventory Control</u> <u>( 25 Marks )</u>**

Inventory control of style goods and perishable items. Production planning for unreliable production systems. Integrated production, quality and maintenance models. Production planning and inventory control in fuzzy environment.

Supply chain – definition, decision phases, process view. Centralized supply network versus decentralized operation. Coordination. Bullwhip effect. Multi-echelon supply chains. Simple models of supply chain management.

Solving inventory/supply chain management problem using Genetic Algorithms (GAs).

8. Ricci Flow ( 25 Marks )

Ricci flow: Basics of Ricci flow. Some exact solutions to the Ricci flow. Ricci solutions, Local existence and uniqueness of Ricci flow. The maximum Principle, Evolution of curvatures under Ricci flow.

9. Some Structures on Differentiable manifold ( 25 Marks )
Some structures on differentiable manifold : Almost contact and contact Manifolds, K-contact manifolds, Sasakian manifolds, Nearly Sasakian manifolds, LP-Sasakian manifolds.

10. Spectrum and Numerical range( 25 Marks )
Resolvent set, Spectrum, Point spectrum, Continuous spectrum, Residual spectrum, Approximate point spectrum, Spectral radius, Spectral properties of a bounded linear operator, Spectral mapping theorem for polynomials, Numerical range, Numerical radius, Convexity of numerical range, Closure of numerical range contains the spectrum, Relation between the numerical radius and norm of abounded linear operator A.

11. C* - Algebra ( 25 Marks )
Definition of normed and Banach Algebra and examples,Singular and Non-singular elements, the spectrum of an element, The spectral radius. Definition of C*-Algebras and examples, Self-adjoint, Unitary, Normal, Positive and Projection elements in C*-Algebras, Commutative C*-Algebras, C*-Homomorphisms, Representation of commutative C*-Algebras, sub algebras and the spectrum, The Specrtral Theorem, Positive linear functions in C*-algebras, States and the GNS construction.

12. Commutative Algebra ( 50 Marks )

1. Regular Sequences and Depth : Regular Sequences, Grade and Depth, Depth and Projective Dimension, Some Linear Algebra, Graded rings and modules. The Koszul Complex. The Eagon-Northcott compled.

2. Cohen-Macaulay Rings : Cohen – Macaulay rings and modules, Regular rings and normal rings, Complete Intersections.

3. Determinantal Rings : Graded Hodge Algebras, Starightening Laws on Posets of Monors, Properties of Determinantal Rings.

13. Computations in Commutative, Algebra ( 50 Marks )

Applications of the software Macaulay 2 and Singular in solving computational problems in the topics of the course I. Commutative Algebra, including the follow :

i) Groebner Basis, ii) Synzygies , iii) Betti Numbers, iv) Hilbert Polynomial,
v) Ext and Tor vi) Local Cohomology.

14. Topological Groups ( 25 Marks )

Definition, Basic properties including translations in topological groups, neighbourhood system of identity, separation properties, uniform structure on topological groups.

Locally compact groups, Lie groups, Measure and integration in locally compact spaces and then in locally compact groups, Haar measure, Haar integrals.

15. Sequence Spaces ( 25 Marks )

Linear spaces, Linear metric spaces, paranorms, seminorms, norms, subspaces, dimensionality, factorspaces, basis, dimension, basic facts of normed linear spaces and Banach spaces (revision).

Sequence spaces, Matrix and linear transformations, Algebras of matrices, summability, Tauberian Theorems.

16. **Integral Equations ( 25 Marks )**

Basic definitions, regular, singular, hypersingular integral equations. Occurrence of integral equations in classical mechanics, ordinary differential equations, partial differential equations. Occurrence in continuum mechanics (elasticy, fluid mechanics).

Singular integral equations, Abel integral equations, solutions, Cauchy singular integral equations, solutions, applications.

Hypersingular integral equations, solution of simple hypersingular integral equations, applications.

Dual integral equations. Solution for trigonometric function kernels, applications.

17. **Theory of Distribution ( 25 Marks )**

Good function, Fairly good function, Generalised function, Ordinary function as generalized function . Addition of generalized function, Derivatives of generalized functions, Fourier transform of generalized functions, Limits of generalized function, Powers of $| x |$ as generalized functions, Even and odd gerneralised functions, Integration of generalized functions, Integration of generalized function, Multiplication of two generalized functions.

18. **Introduction to the Theory of Water Waves ( 25 Marks )**

1. Basic Equations 2. Havelock's Expansion Theorem 3. Construction of Source Potentials 4. Basic Problems in the theory of Water Waves.

19. **Modules, Rings, Groups and Categories ( 25 Marks )**

Tensor Product of Modules, Categories, Functions and Natural Transformations, Exact sequences, Projective, Injective and Flat Modules, Localization, Group Representation Theory.

20. **Lattice Theory ( 25 Marks )**

Types of Lattices, Postulates for Lattices, Structure and Representation Theory Complete lattices, Lattice ordered groups, lattice ordered monoids, lattice ordered rings, vector lattices.

21. **Categories and Universal Algebra ( 25 Marks )**

Limits in Categories , Monads and Algebras, Abelian Categories, Varities.

22. **Theory of Semi groups ( 25 Marks )**

Introduction : Basic Definitions and Results : Congruences, Rees congruences, Ideals, Homomorphisms etc. Green's Equivalence Relations and Regular Semigroups.
Completely Regular Semigroups : Characterization of completely regular semigroups as union of groups, semilattices of groups, Clifford Semigroups, Intra – regular Semigroups, Orthodox Semigroups, Inverse Semigroups etc.

23. **Theory of Semirings ( 25 Marks )**

Semirings : Basic Definitions and Results : Congruences, Ideals, k – ideals, h- ideals, Maximal Ideals, Prime Ideals, Semiprime Ideals, Homomorphisms, Regular Semirings, Semifields etc. ( 15 )

Semimodules : Basic Definitions and Results of Semimodules ( 10 )

24. Cosmology ( 25 Marks )

Cosmological Models : The flat space models, models with vanishing cosmological constant. Classification of Friedmann models. The deSitter model. The first models : The Einstein static model, The deSitter model. Time-scale problem,

Later models : The Eddington-Lemaitre solution, Lemaitre's model. The missing matter problem, Early epochs of the universe, Cosmological coincidences. The steady – State theory, Inflation, Horizon problem, Flatness problem.

25. Lagrangian and Hamiltonian formulations of general relativity. ( 25 Marks )

Lagrangian formulation in mechanics, in field theory. Lagrangian formulation in GR, Variation of Hilbert term, Variation of the boundary term, Variation of the matter action, Non-dynamical term, Bianchi identities, Hamiltonian formulation, 3 +1 decomposition, Field theory, Foliation of the boundary, Gravitational action, Gravitational Hamiltonian, Variation of the Hamiltonian, Hamilton's equations.

26. Rotating Black Holes ( 25 Marks )

Null Tetrads, three main forms of the Kerr solution, Basic properties of the Kerr solution, Singularities and horizons, Null consequences, Eddington-Finkelstein coordinates, The stationary limit, ergosphere, rotating starts, The singularity theorems, Hawking effect.

27. Geodesic Congruences ( 25 Marks )

Energy conditions; Weak, null, strong and dominant energy conditions, Averaged null, weak and strong energy condition, Violation of energy conditions; Classical scalar fields. Kinematics of a deformable medium : Two dimensional medium, expansion, Shear, rotation, general case. Three dimensional medium, congruence of time-like geodesics, Transverse metric, kinematics, Frobenius' theorem, Ray Chawdhuri's equation , Focussing theorem, Example. Interpretation of $ \ theta $ , congruence of null geodesics.

28. Hyper surfaces ( 25 Marks )

Description of hypersurfaces, Defining equations, Normal vector, Induced metric, Light cone in flat spacetime, Differentiation of tangent vector fields : lie derivatives, Tetrad formation, Tangent tensor fields, Intrinsic covariant derivative, Extrinsic curvature, Gauss-Codazzi equationz, general form, contracted form, Ricci scalar, Initial value problem; constrains, cosmological initial values, stationary and static space times, spherical space, empty flat space. Conformal flat space. Junction conditions and thin shells-Notation and assumptions, first junction condition, Riemann tensor, surface stress energy tensor, second junction condition, Oppenheimer- Shyder Collapse, Thin shell collapse.

# SYLLABUS OF COURSE WORK OF PH.D(Sc.)

## DEPARTMENT OF GEOLOGICAL SCS.

| Courses | Subject | Full Marls |
|---|---|---|
| Compulsory Units | A. Research Methodology | 50 |
| | B. Review of Research Work | 50 |
| **Elective Units** | 01. Exploration Geophysics | 50 |
| | 02. Geophysical (geoelectric) method for mineral and ground water Investigation | 50 |
| | 03. Application of Remote Sensing and GIS Techniques in Ground water Exploration | 50 |
| | 04. Geodynamics | 50 |
| | 05. Petrography in Structural Geology | 50 |
| | 06. Gemmology | 50 |
| | 07. Sedimentary basin analysis | 50 |
| | 08. Stratigraphic Correlation Techniques | 50 |
| | 09. Textural modeling -- a tool for petrogenesis of igneous and Metamorphic rocks. | 50 |
| | 10. SEDEX process with particular emphasis on Fe-Mn ore deposits. | 50 |
| | 11. Reading seminar in the subject of ore deposits related to igneous Systems. | 50 |
| | 12. Platinum group of elements: a key tracer of Earth's interior | 50 |
| | 13. Basic techniques of numerical modeling in Structural Geology and Tectonics | 50 |
| | 14. Use of Meso- and Micro-scale structures in structural analysis. | 50 |
| | 15. Carbonates through ages – its physical, chemical & biological perspectives | 50 |
| | 16. Sequence stratigraphy in the light of basin evolution | 50 |
| | 17. Geochemistry of hydrothermal ore deposits – theoretical & practical aspects | 50 |

N.B. : Students to opt for any 2 elective units out of the elective units offered. 32X2 classes to be attended.

# COMPULSORY UNITS

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***Curve Fitting:*** Linear and Non-linear fitting of data.

## B. Review of Research Work:

The relevance of the research work from the perspective of the subject – Possible ways to apply the research work in future.

# ELECTIVE UNITS

UNIT No. 01 : **Exploration Geophysics** :
Different Geophysical Methods --- Principles, Mathematical Derivations, Interpretational Procedures, Instrumentation and Field Studies & its Interpretation.

UNIT No. 02: **Geophysical (geoelectric) method for mineral and ground water Investigation:**
D.C. Resistivity profiling and sound principles, Mathematical Derivations, Instrumentations, Field Procedures & Applications for Minerals and Ground Water investigations.

UNIT No. 03: **Application of Remote Sensing and GIS Techniques in Ground Water Exploration:**
Introduction, Hydrogeochemistry, Ground water Pollution, Remote Sensing & GIS, Ground Water Geophysica, Well Hydraulics & Water Well Construction, Ground Water Provinces, Environmental Impact Analysis, Artificial Recharge – Monitoring & Assessment, Ground Water Management, Treatment of Ground Water, Urban Hydrology, Ground Water Modeling and Rural water Supply.

UNIT No. 04: **Geodynamics:**
Earth's lithosphere, Physical properties of Mantle rocks and minerals, Thermo-mechanical Instability of the Mantle, Gravity driven Geodynamic processes, Core Dynamics.

Unit No. 05: **Petrography in Structural Geology:**
Preparation of Petrographic thin sections, Analysis of Tectonic Fabric, Analysis of micro-scale structure, Deformation Mechanism, Relation between Deformation and Crystallization, Shear zone Rocks.

UNIT NO. 06: **Gemmology:**
Genesis, classification, physical & optical characteristics, etc.

UNIT No. 07: **Sedimentary basin analysis:**
Definition, Methodology of Analysis, Identification of various facies assemblages, Pattern of Sedimentation, Petrographical implications in Basin Analysis, Case studies

UNIT No 08: **Stratigraphic Correlation Techniques:**
Need for correlation, Different correlation techniques and related methodologies, relationship with evolutionary history of life, statistical analysis.

UNIT No. 09: **Textural modeling ----- a tool for petrogenesis of igneous and Metamorphic rocks.:**
Classical and advanced Techniques for Textural Analysis, Nucleation and growth of materials in Magmatic and Metamorphic Systems, Role of deformation on formation of Texture, Equilibrium and non-equilibrium textures and their Significance, modeling igneous and metamorphic textures to recover p-T-t history of rocks and melts.

UNIT No. 10: **SEDEX process with particular emphasis on Fe-Mn ore deposits:** Definition, Type of deposit and classification, Factors controlling the process, Genetic Model, Sourcesof elements, Specific examples.

UNIT No. 11: **Reading seminar in the subject of ore deposits related to igneous Systems:**
The participants will read some key and fundamental papers in the subject of ore deposits related to igneous system, especially in the field of chromite, platinum group elements (PGE) and Ni-Cu-sulfide deposits. The course will focus on extensive reading of scientific articles plus discussion to have a deeper understanding of the crystal-melt equilibria that controls fundamental processes of magmatic ore deposits.

UNIT No. 12: **Platinum group of elements: a key tracer of Earth's interior:**
Geochemistry of noble metals (Os, Ir, Rh, Ru, Pt, Pd and Re) provides unique clues to the early origins of our planet. How noble metals are distributed within the Earth is the subject of intense debate. The relative effects of different processes can be assessed using PGE-patterns as well as Os isotopic systematics of the mantle materials. In this particular course basic geochemical characters of the PGEs; their fractionation, and the fundamental processes involved in the fractionation will be discussed. In addition, the use of PGE geochemistry to understand the chemical evolution of the Earth's mantle will be a significant component of this course.

UNIT No. 13: **Basic techniques of numerical modeling in Structural Geology and Tectonics:**
Fundamental Concept and basis of Numerical Modeling, Physical theories of Geological situations and Modeling Equations, mathematical and Numerical Techniques, Use of different softwares like MS Excel, Visual Basic, Ansys for Numerical Modeling.

UNIT No. 14: **Use of Meso- and Micro-scale structures in structural analysis :**
Identification of different small scale geological structures in outcrop and under microscope, Collection of data, plotting of structural elements, Basis of analysis, Process of reconstruction of evolutionary history.

UNIT No 15: **Carbonates through ages – its physical, chemical & biological perspectives :**
Distribution and distinction of carbonate deposits in rock record. Distinctions between Precambrian and Phanerozoic Carbonate deposit.Physico-chemical and biological control on carbonate deposition in Prcambrian and Phanerozoic sequence. Isotopic signatures of carbonate deposits.

UNIT No. 16**: Sequence stratigraphy in the light of basin evolution :**
Understanding basin forming processes and basin architecture. Stratigraphic Signature of a basin: Sea level change, Basin-floor wobbling, Sedimentation rate and climate. Depositional facies, Seismic Facies Seismic Expression & Configuration and log-based Sequence, Correlation Sequence, Stratigraphic Principles & Facies Tracts Carbonate Sequence Stratigraphy and Drowning Unconformity. Application of sequence stratigraphy to basin evolution

UNIT No 17: **Geochemistry of hydrothermal ore deposits – theoretical & practical aspects**:
Sources of hydrothermal components (metals, fluids); Hydrothermal alteration and ore mineralization; Metal transport by hydrothermal fluids; Stable isotope systematic of hydrothermal ore minerals and gangue minerals; Fluid inclusions studies of hydrothermal ore deposits; Microthermometric freezing-heating experiments of fluid inclusions.

# SYLLABUS OF COURSE WORK OF PH.D(Sc.)

## DEPARTMENT OF LIFE SC. & BIOTECHNOLOGY

| Courses | Subject | Full Marks |
|---|---|---|
| Compulsory Units | A. Research Methodology | 50 |
| | B. Review of Research Work | 50 |
| **Elective Units** | 1. Cell culture techniques | 20 |
| | 2. Microbiology | 20 |
| | 3. Introduction to Molecular Biology Techniques – Applications in Biotechnology.<br>❖ Introduction – Principles of Molecular Biology Techniques<br>❖ DNA Molecular Technique<br>❖ Southern Blotting<br>❖ Northern Blotting<br>❖ Polymerase Chain Reaction(PCR)<br>❖ DNA sequencing<br>❖ DNA Library Construction<br>❖ Macroarrays | 60 |

# COMPULSORY UNITS

## A. Research Methodology:

**Definition of problem :** Necessity of defining problem, Technique involved in defining a problem. Surveying the available literature.

**Techniques involved in solving the problem:** Different methods used to solve a problem.

**Research Design:** Subject of study; Place of study; Reason of such study; Type of data required; Method of data collection; Periods of study; Style of data presentation.

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***Curve Fitting:*** Linear and Non-linear fitting of data.

## B. Review of Research Work:

The relevance of the research work from the perspective of the subject – Possible ways to apply the research work in future.

# ELECTIVE UNITS

**Unit 1: <u>Cell culture techniques</u>** **No. of Classes: 10**

Introduction to course and lab safety, Brief review of basic lab techniques, Review / Introduction of microscope use: Light and fluorescence microscope, Cell culture: Introduction to sterile cell culture technique. Counting viable cells and subculture into multiwell plates. Cell counting using hemocytometers. Cell attachment (adhesion) and growth. Cell attachment (adhesion) and growth. Cell staining techniques: Culturing of primary cells, preparation of human chromosome, Application of primary cell culture techniques. Isolation of chromosomal DNA, Preparation of cellular extract, isolation of nuclear extract and cytoplasmic extract.

**Unit 2: <u>Microbiology</u>** **No. of Classes: 10**

The world of microbiology and development of microbiology as a scientific discipline, Methods of studying microbes: Introduction to various types of microbes, Growth of bacteria; Control of Microbes; Isolation, identification and characterization of bacteria Prokaryotic cell structure and function.

**Unit3: <u>Introduction to Molecular Biology Techniques–Application in Biotechnology</u>**

**No. of Classes: 40**

❖ **<u>Introduction – Principles of Molecular Biology Techniques</u>**

Introduction to basic and advanced information on DNA, RNA and proteins. Potential applications of molecular biology techniques in drug discovery and development will also reviewed.

❖ **<u>DNA Molecular Technique</u>**

Isolation and purification of DNA samples from different cell types and tissues, DNA concentration techniques, restriction digestion and analysis, ligation of DNA to create recombinant molecules and "designer genes."

❖ **<u>Southern Blotting</u>**

Agarose gel electrophoresis, DNA transfer techniques, isotopic and non-isotopic probe labeling methods, hybridization, x-film exposure, interpretation of results.

❖ **<u>Northern Blotting</u>**

Blotting of isolated and purified total and/or poly(A+) mRNA from cells and from tissues. Denaturing gel electrophoresis, RNA transfer techniques, isotopic and non-isotopic probe labeling methods, hybridization, x-film exposure, interpretation of results.

❖ **<u>Polymerase Chain Reaction(PCR)</u>**

Fundamentals of PCR, primer design, PCR amplification tools and techniques, hot-start PCR, TA cloning, TOPO cloning, characterization of PCR products, applications of the PCR technique, Long-range PCR and alternative amplification.

❖ **<u>DNA Sequencing</u>**

Basics and applied methods of DNA sequencing, modern day tools and instruments for sequencing, dideoxy sequencing, 454 sequencing, Illumina, ABI SOLID, applications of sequencing in drug discovery and development, single nucleotide polymorphism (SNP)s identification and characterization techniques, SNPs applications in modern day drug discovery, CNV identification, identification of gross chromosomal deletions. Application of high throughput sequencing in genome wide association study.

- **DNA Library Construction**

Phage library construction vs. cloning into plasmids, fundamentals of DNA library construction, random subclone generation, random fragment end-repair, enzymes and type of DNA utilized, steps involved in tittering a library, screening the library, identification and characterization of clones, competent cell preparation, and bacterial cell transformation, blue/white color selection, positive clone retrieval and sub-cloning.

- **Macroarrays**

Basics of macroarray technology, Surfaces and protocols for spotting nucleic acids, formats and designs, Identification of differentially expressed genes by differential hybridization of macroarrays.