SYLLABUS

FOR

PH.D. COURSE WORK

IN MATHEMATICS

With effect from the academic session 2020-2021

KAZI NAZRUL UNIVERSITY
ASANSOL-713 340
WEST BENGAL
Course Structure for Ph.D. Program in Mathematics

Duration of Ph.D. course work in Mathematics shall be one year with two Semesters. Total credits for this course would be 12. There will be 8 credits in Semester I comprising of two units, one is Compulsory unit and another is Elective unit. The elective unit shall be offered by the prospective Supervisor concerned. In Semester II, there will be two compulsory units each of 2 credits.

The distribution of credits of the Course Work syllabus shall be as follows:

**Detail syllabus of the Ph.D. pre-registration course work in mathematics**

**PHDMATHC101: RESEARCH METHODOLOGY**

Total Marks: 50 (10 marks reserved for internal assessment) Credit: 4


Data: Definition, types, sources, data collection methods. Review of literatures and Bibliography.

Research report: Types, contents, styles and steps in drafting. Editing the final draft, way of writing research papers, subject classifications and write-up of Thesis. Significance of Impact factor, citation index, science citation index, IST, SCOPUS etc.

Review of articles and Research proposal. An overview of Mathematical Reviews (Author’s index, subject index) with subject classifications.


Use of Latex software, Preparation of Manuscript using Latex (Typing of Research Paper and Seminar presentation).

**COURSE II: ELECTIVE UNIT**

(One Elective Unit of 4 credits to be offered by the prospective Supervisor concerned)

For each Elective Unit Total Marks: 50 (10 marks reserved for Internal Assessment) & Credit: 4
PHDMATHC102: Computational Techniques using Mathematica and Matlab


MATLAB Programming.

PHDMATHC103: Inventory Control


PHDMATHC104: Commutative Algebra

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 complex.

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


PHDMATHC105: Integral Equations

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

PHDMATHC106: Modules, Rings, Groups and Categories

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

PHDMATHC107: Theory of Semi groups & Lattice Theory

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.

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

PHDMATHC108: Integral Transform:


Theorem, Parseval's relation, Application of Fourier transforms to Heat, Wave and Laplace equations.

Laplace Transforms: Definition and properties of Laplace transforms, sufficient conditions for the existence of Laplace Transform, Laplace Transform of some elementary functions, Laplace Transforms of the derivatives, Initial and final value theorems, Convolution theorems, Inverse of Laplace Transform, Bromwich integral theorem, Application to Ordinary and Partial differential equations.

PHDMATHC109: Fuzzy Sets and Fuzzy Logic:
Fuzzy sets—basic definitions, alpha-level sets, convex fuzzy sets, basic operations on fuzzy sets, types of fuzzy sets, Cartesian products, algebraic products, bounded sum and difference, t-norms and t-conorms.

The extension principle— the Zadeh’s extension principle, image and inverse image of fuzzy sets, fuzzy numbers, elements of fuzzy arithmetic.

Fuzzy relations and fuzzy graphs, composition of fuzzy relations, min-max composition and its properties, fuzzy equivalence relations, fuzzy graphs.

Fuzzy logic, fuzzy propositions, fuzzy quantifiers, linguistic variables, inference from conditional fuzzy propositions, compositional rule of inference.

**PHDMATHC110: Nonlinear Wave Theory**

Linear waves: Linear wave equation, dispersion relation, dispersive and dissipative waves, group velocity

Nonlinear equations of evolution: Effect of nonlinearity, diffusive waves, dispersive waves, solitary wave, soliton.

Soliton interaction: Schrodinger equation, KdV equation and their interrelationship, time independence of the eigenvalues of the Schrodinger equation and determination of scattering parameters, inverse scattering problem, soliton solution of KdV equation, soliton interaction, continuous eigenvalues of the Schrodinger operator

Solitary wave theory: Dispersion and dissipation, types of travelling wave solutions, nonanalytic solitary wave solution, analysis of Adomian decomposition method and variational iteration method on nonlinear partial differential equations

**PHDMATHC111: Fractional Calculus & Applications**

The Riemann Liouville Fractional Calculus: Fractional Integrals of some functions namely binomial function, exponential, the hyperbolic and trigonometric functions, Bessel’s functions, Hyper-geometric function and the Fox’s H-function. Dirichlet’s Formula, Derivatives of the Fractional Integral and the Fractional Integral of Derivatives. Laplace Transform of the Fractional integral, Leibniz’s Formula for Fractional Integrals. Derivatives, Leibniz’s Formula of Fractional Derivatives.
The Weyl Fractional Calculus – Definition of Weyl Fractional Integral Weyl Fractional Derivatives, A Leibniz Formula for Weyl Fractional Integral and simple applications.


PHDMATHC112: Dynamical Systems

History of dynamical system, mathematical definition, different types of dynamical systems with examples, phase variable and phase space, continuous and discrete dynamical systems, Flows and maps, orbits, fixed points, periodic points and their stabilities, Attractors and Repellors.

Phase plane analysis, hyperbolic concept of hyperbolicity, stable, unstable and center subspaces. Lyapunov and asymptotic stability, Local and global stability, Hartmann-Grobman theorem (statement only), stable manifold theorem, Lyapunov function, Lyapunov theorem on stability, periodic orbits, limit cycles, attracting and invariant sets, Poincare-Bendixson theorem, Poincare map, Lienard’s theorem (statement only) and applications. Bifurcation theory, Saddle-Node, Pitch-Fork and Transcritical bifurcations for one-dimensional continuous systems, Hopf-bifurcation, Analysis of Lorentz system.

Some important maps: Logistic map, Tent map, Baker map, Shift map and their properties.

PHDMATHC113: Prey-Predator Model

Single species population model, Multi species model, Prey Predator model in terms of differential equations. Stability of Prey Predator Model

PHDMATHC114: Optimization Techniques


Optimal Control: Performance indices, Methods of calculus of variations, simple optimal problems of mechanics.
Non-linear Programming: Formulation of Non-linear programming problem, Unconstrained optimization, Optimization with equality constraints, Kuhn-Tucker conditions for constrained optimization.


**PHDMATHC115: Advanced Complex Analysis**

The Functions $M(r)$, $A(r)$, Hadamard Theorem on Growth of $\log M(r)$, Schwarz Inequality, Borel-Carathéodory Inequality.

Entire functions, Growth of an entire function, Order and type and their representations in terms of the Taylor Coefficients, Distribution of zeros, Schottky’s theorem (without proof), Picard’s Little theorem, Weierstrass Factor theorem, The exponent of convergence of zeros, Hadamard factorization theorem, Canonical product, Borel’s first theorem, Borel’s second theorem (statement only).

Analytic continuation, Natural boundary, Analytic element, Global analytic function, Concept of analytic manifolds, Multiple valued conditions, Branch points and Branch cut, Riemann surfaces.

**PHDMATHC116: Advanced Functional Analysis**


Strict convexity and uniformly convexity of a Banach space. Uniform Convexity of a Hilbert Space. Reflexivity of a uniformly convex Banach space, Weierstrass approximation theorem in $C[a,b]$. 
**PHDMATHC117: Advanced Topology**


Nets and Filters: Directed sets, Nets and Subnets, Convergence of a Net, Ultranets, Partially ordered sets and filters, Convergence of a filter, Ultrafilters, Basis and subbase of a filter, Nets and Filters in Topology.

Tychonoff Theorem & Compactification: Tychonoff theorem, Completely regular spaces, Local compactness, One-point compactification, Stone-Cech compactification.


**PHDMATHC118: Differential Geometry and Manifolds**


Exterior algebra. Exterior derivative.

Topological groups. Lie groups and Lie algebras. Product of Two Liegroups. One parameter subgroup and exponential maps. Examples of Liegropus. Homomorphism and Isomorphism.

Lie transformation groups, General linear group.


**PHDMATHC119: Field Theory**

Field Extensions: Algebraic and Transcendental Extensions, Finite Extensions, Algebraic Closure of a field, Algebraically Closed Field, Splitting Field of a polynomial, Normal Extensions, Separable Extensions, Impossibility of some constructions by straightedge and compass.

Finite Fields and their properties, Galois group of automorphism and Galois Theory, Solution of polynomial equations by radicals, Insolvability of the general equation of degree 5 (or more) by radicals.
PHDMATHC120: Operator Theory

Bounded Linear Operators: 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 a bounded linear operator.

Banach Algebra: Definition of normed and Banach algebra and examples, Singular and non-singular elements, the spectrum of an element, The spectral radius.

Compact linear operators: Spectral properties of compact linear operators on a normed linear space, Operator equations involving compact linear operators, Fredholm alternative theorem, Fredholm alternative for integral equations. Spectral theorem for compact normal operators.

PHDMATHC201: REVIEW OF RESEARCH WORK

Total Marks: 50 (10 marks reserved for internal assessment) Credit: 2

The relevance of the research work and its perspective on the subject concerned - Possible waysof utilities for further research work.

Review of Literatures on the specific research area to be submitted by each scholar.

PHDMATHC202: RESEARCH AND PUBLICATION ETHICS

Total Marks: 50 (10 marks reserved for internal assessment) Credit: 2


Publication Ethics: definition, introduction and its importance. Best practices/standards setting initiatives and guidelines: COPE, WAME, etc. Conflicts of interest. Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types. Violation of publication ethics, authorship and contributor ship. Identification of publication misconduct, complaints and appeals. Predatory publishers and journals.
Open access publishing: Open access publications and initiatives. SHERPA/RoMEO online resource to check publisher copyright and self archiving policies. Software tool to identify predatory publications developed by SPPU. Journal finder/Journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

Use of plagiarism detection software like Turnitin, ithenticate, Urkund and other open source software tools.

Databases: Indexing databases, citation databases, Web of Science, Scopus, etc. Research Metrics: Impact factor of Journals as per Journal Citation Report, SNIP. SJR, IPP, Cite Score. Metrics: h-index, g-index, i-10index, altmetrics.