SYLLABUS

For

Ph.D. Coursework in

MATHEMATICS

(in CBCS format)

(Effective from the academic session 2018 – 2019 and onwards)

DEPARTMENT OF MATHEMATICS

BANKURA UNIVERSITY

BANKURA

Bankura University
Department of Mathematics
Ph.D. Course Work Syllabus

Important points to be noted:

- ❖ Duration of Course Work: One Semester (6 Months)
- ❖ Total Marks: 200 (Two papers 100 marks each)
- ❖ Examination will be held at the end of the Semester.

Structure:

	Topics and the way of Evaluation			Marks Distribution (Credits)	Lectures per week
Paper – I Compulsory Units	Group A Research Methodology (CODE : BKU/MATH/CW/CRM)			50 (2)	2 hours
	Group B Computer Applications (CODE : BKU/MATH/CW/CCA)			50 (2)	
Paper-II A Elective units	Some Elective Papers to be Chosen such that their total Marks will be 50	Theory of Semi groups (CODE : BKU/MATH/CW/EU1)	25	50 (2)	2 hours
		Lattice Theory (CODE : BKU/MATH/CW/EU2)	25		
		Riemannian Manifolds (CODE : BKU/MATH/CW/EU3)	25		
		Contact Manifolds (CODE : BKU/MATH/CW/EU4)	25		
		General Relativity (CODE : BKU/MATH/CW/EU5)	25		
		Astrophysics & Accretion Phenomena (CODE : BKU/MATH/CW/EU6)	25		
		Mathematical Modeling of Biological Systems (CODE : BKU/MATH/CW/EU7)	25		
		Mathematical Modeling of Biological Events (CODE : BKU/MATH/CW/EU8)	25		
		Introduction to Fuzzy Sets (CODE : BKU/MATH/CW/EU9)	25		
		Introduction to Fuzzy Analysis (CODE : BKU/MATH/CW/EU10)	25		
		Higher order Methods for Flow Simulation and Optimization (CODE : BKU/MATH/CW/EU11)	50		
		Introduction to Iterative methods for Linear and Nonlinear Equations (CODE : BKU/MATH/CW/EU12)	25		
Part II B		Literature review		50 (2)	

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N.B.: For **paper – I** (Group A), ***in end semester examination, students have to answer 25 short type questions (out of 40 questions, each question carries on 2 marks, examination time: 2hrs)*** and for **paper – I** (Group B), ***in end semester examination, one presentation should be given which has to be prepared using LaTex-Beamer or Powerpoint on some research topic in consultation with the supervisor(s) (together with Viva Voce).***

For **paper – II** (Group A), students to opt for **two elective units** out of the following elective units offered. ***For a 25 marks paper students have to answer 5 questions of 5 marks each (8 questions will be given) (examination time: 2hrs for 50 marks)*** and for **paper –II** (Group B), students have to submit a written report based on his/her review work under the supervision of his/her respective supervisor in the Mathematics Department of Bankura University.

Detailed Syllabus

Paper – I (Compulsory Course)

Group A: Research Methodology: [Total 25 Lectures, 50 marks]

Introduction to Research Methodology: Objectives of Research, Motivations in Research, Ethics in Research, Plagiarism, Pedagogical Research, Research Methods v/s Methodology: Zorne's Lemma, Axiom of Choice, Well ordering principle; Proposition, Theorem, Lemma, Corollary : their differences and relations, Evolution of Mathematical Research.

Defining the Research Problem: What is Research Problem? Selecting the problem, Necessity of - and -Techniques in defining the problem, writing a research proposal.

Review of Literature: Purpose of the Review, Identification of the related Literature, Organizing the related Literature, archive.

The Research Report: General format of the Research report, writing technical research report, writing a research paper, proof reading, Keywords and Phrases, Mathematical subject classification, References, cross-References, Fast Track Communication, Short Communication, Erratum, Science Citation Index. MathSciNet, Zentralblatt(Z-Math), Scopus, i-index, h-index, impact factor.

Group B: Computer Applications in Research Work (Both theoretical and Practical) [Total 25 Lectures; 50 marks]

i. Basics of operating systems

ii. Literature survey using web, handling search engines

iii. Preparing presentations: (a) Research papers: Using word processing software – MS Word, Latex, (b) Drawing graphs and diagrams (c) Seminar presentations – oral and poster presentations.

iv. Basic uses of Mathematica/Matlab/Maple.

References:

1. C R Kothari , Research Methodology: Methods and Techniques , New Age International (P) Ltd. (2010) , New Delhi
2. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. *An introduction to Research Methodology*, RBSA Publishers.
3. Handbook of Communication and Social Interaction Skills by John O. Greene, Brant Raney Burleson.
4. Trochim, W.M.K., 2005. *Research Methods: the concise knowledge base,* Atomic Dog Publishing. 270p.
5. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, SAGE Publications
6. Inderpal Singh, Research Methodology and Statistical Methods, Kalyani Publishers, Ludhiana.
7. G Kanji 100 statistical tests, Sage Publications
8. A.S. Gaur & S.S. Gaur , Statistical Methods for Practice and Research (AGuide to Data Analysis using SPSS), Sage Publications
9. C. Boyer, History of Mathematics.
10. Stellwel.

Elective Courses

(CODE : BKU/MATH/CW/EU1)
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.

References:
1. Introduction to semigroup theory: J. Howie
2. Semigroup theory: Clifford&Preston.

(CODE : BKU/MATH/CW/EU2)
Lattice Theory (25 Marks)

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

References:
1. Introduction to lattice theory: Davey&Priestley.

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(CODE : BKU/MATH/CW/EU3)
Riemannian manifolds: (Marks:25)

Riemannian manifolds, Riemannian connection, Semi-symmetric connection on Riemannian manifolds, Quarter symmetric connection on Riemannian manifolds, Einstein manifolds and its generalizations, Manifolds of constant curvature and its generalizations, Some transformations on Riemannian manifolds, Locally symmetric manifolds due to Cartan, Recurrent manifolds, Semi-symmetric manifolds, Pseudo symmetric manifolds, Ricci parallel manifolds, Ricci semi-symmetric manifolds, Ricci pseudo symmetric manifolds.

References:
[1] M. P. Do Carmo, Riemannian Geometry, Birkhauser, Boston, 1992.
[2] U. C. De and A. A. Shaikh, Differential Geometry of manifolds, Narosa Publishing House Pvt. Ltd.
[3] Luther Pfahler Eisenhart, Riemannian Geometry, Princeton University Press.
[4] W. H. Boothby, An introduction to Differentiable manifolds and Riemannian Geometry, Academic Press, New York, 1975.
[5] John M. Lee, Riemannian manifolds: An introduction to curvature, Springer-Verlag, 1997.

(CODE : BKU/MATH/CW/EU4)
Contact manifolds: (Marks:25)

Almost contact and contact manifolds, Curvature of contact metric manifolds, k-contact and (k,μ)-contact metric manifolds, Sasakian manifolds, Kenmotsu manifolds, Trans-Sasakian manifolds, Para-Sasakian manifolds, LP-Sasakian manifolds, $(LCS)_n$-manifolds, Sasakian-space-forms, Generalized Sasakian-space-forms, φ-symmetric contact metric manifolds and its generalized classes.

References:
[1] D. E. Blair, Riemannian geometry of contact and symplectic manifolds, Progress in Mathematics.
[2] U. C. De and A. A. Shaikh, Complex and contact manifolds, Narosa Publishing House Pvt. Ltd.

(CODE : BKU/MATH/CW/EU5)
General Relativity (Full Marks : 25)

Past and future Cauchy development, Cauchy surface. DeSitter and anti-de Sitter space-times. Robertson-Walker spaces. Spatially homogeneous space-time models. The Schwarzschild and Reissner – Nordstrom solutions. Kruskal diagram. Causal structure. Orientability. Causal curves. Causality conditions. Cauchy developments. Global hyperbolicity. The existence of Geodesics. The Causal boundary of space-time. Asymptotically simple spaces. Lie derivatives.

References :
[1]The large scale structure of space-time - Hawking and Ellis (Camb. Univ. Press).
[2]General Relativity – R.M. Wald (Chicago Univ. Press).
[3]A first course in general relativity – B.F. Schultz (Camb. Univ. Press).
[4]Gravitation and Cosmology – S. Weinberg (J. Wiley and Sons).

[5]General Relativity, Astrophysics and Cosmology – Raychaudhury, Banerji and Banerjee (Springer-Verlag).
[6]General Relativity – M. Luduigsen (Camb. Univ. Press).
[7]Introducing Einstein's Relativity – R d'Inverno (Clarendon Press, Oxford).

(CODE : BKU/MATH/CW/EU6)

Astrophysics & Accretion Phenomenon.(Full Marks : 25)

Astrophysics(18L)

Compact Objects, White dwarfs, Neutron stars and Black holes. Brief history of the formation and evolution of stars.

Schwarzschild exterior solution, Birkhoff's theorem, Schwarzschild singularity, Kruskal transformation, Schwarzschild Black hole. Motion of test particles around Schwarzschild black hole. Kerr metric and Kerr black holes (without deduction of solution). Horizons of Schwarzschild and Kerr black holes.

Laws of black hole thermodynamics (statements only).

Interior of Schwarzschild metric, massive objects, Openheimer – Volkoff limit, Gravitational lensing , Quasars , Pulsars, Supernova.

Openheimer-Snydder non static dust model, Gravitational collapse.

References:

[1] The Structure of the Universe – J.V. narlikar
[2]Astrophysics – B. Basu
[4] Astrophysical Concept – M. Harmitt
[5] Galactic Structure – A. Blauaw & M. Schmidtw
[6] Large Scale Structure of Galaxies – W.B. Burton
[7] The Milky Way – B.T. Bok & P.F. Bok.
[8] Cosmic Electrodynamics – J.H. Piddington

Accretion Phenomenon(7L)

Plasma, black Body, Cherenkov & Synchroton Radiation

Accreation as source of radiation

Quasar as source of radition, Compton effect

Bremsstrallung Radition.

Accretion into compact objects, Boltzmann formula, Saha Ionization equation, H-R diagram.

References:

[1] The Structure of the Universe – J.V. narlikar
[2] Astrophysics – B. Basu
[3] Astrophysical Concept – M. Harmitt
[4] Galactic Structure – A. Blauaw & M. Schmidtw
[5] Large Scale Structure of Galaxies – W.B. Burton
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(CODE : BKU/MATH/CW/EU7)
Mathematical Modeling of Biological Systems: 25 Marks
(Qualitative Theory)

Linear difference equations:
Difference equations, existence and uniqueness of solutions, linear difference equations with constant coefficients, systems of linear difference equations, qualitative behavior of solutions to linear difference equations, Applications.
Nonlinear difference equations (Map):
Steady states and their stability, the logistic difference equation, systems of nonlinear difference equations, stability criteria for second order equations, stability criteria for higher order system.

Qualitative Analysis of the Biological Models
Strictly dominant eigenvalues, Basic Reproduction Number, Stability criteria for various disease Models,
Cobwebding Method and its Applications.

References :

[1] F. Verhulust (1996): Nonlinear Differential Equations and Dynamical Systems, Springer Verlag.
[2]W. G. Kelley and A. C. Peterson (1991): Difference Equations- An Introduction with Applications, Academic Press.
[3] J.D.Murray (1990): Mathematical Biology, Springer and Verlag.

(CODE : BKU/MATH/CW/EU8)
Mathematical Modeling of Biological Events: 25 Marks

Models for Developmental Pattern Formation:
Background, model formulation, spatially homogeneous and inhomogeneous solutions, Turing model, conditions for diffusive stability and instability, pattern generation with single species model.
Delay Differential Equations:
Formulation of Delay Differential Equations, Properties, Stability Criteria, Butler's Lemma, Condition(s) for unique positive solutions, Periodic Solutions through trigonometric functions, Transversality Conditions, Hopf-bifurcation Analysis.

References:

[1] L. Perko (1991): Differential Equations and Dynamical Systems, Springer Verlag.
[2] L.A.Segel (1984): Modelling Dynamical Phenomena in Molecular Biology, Cabbridge University Press.
[3] J.D.Murray (1990): Mathematical Biology, Springer and Verlag.
[4]Leach Edelstein-Keshet (1987): Mathematical Models in Biology, The Random House/ Birkhauser Mathematics Series.

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(CODE : BKU/MATH/CW/EU9)
Introduction to Fuzzy Sets Marks: 25

A. Fuzzy set : Basic concepts

Definition of fuzzy set and α-cut, properties of α-cut, representation of a fuzzy set in terms of α-cut, Extension principle for fuzzy set. Image and pre-image of fuzzy set under a mapping. Operations on fuzzy set. Algebra of fuzzy sets. Fuzzy function: t-Norms and t-Conorms. (10 L)

B. Fuzzy logic:

Fuzzy logic in a narrow sense; Fuzzy logic in a wide sense. Concept of linguistic variables and their values—the term sets. Modifiers and linguistic hedges. Fuzzy connectives—their interpretations. Fuzzy rules--- quantification and qualification. Fuzzy rule-based inference—compositional rule of inference. Industrial applications of fuzzy logic. (10 L)

C. Fuzzy Arithmetic:

Fuzzy numbers: Representation of a fuzzy number in terms of a family of nested intervals. Triangular fuzzy number and interval number. Arithmetic operations on fuzzy numbers. (5 L)

References:

[1] G. J. Klir, Bo Yuan, Fuzzy sets and fuzzy logic: Theory and Applications, Prentice-Hall India.
[2] Pert Hajek, Mathematics of fuzzy logic, Academic Press.

(CODE : BKU/MATH/CW/EU10)
Introduction to Fuzzy Analysis Marks: 25

- Fuzzy topology :

Different types of fuzzy topology; Gradation of openness and closedness; Closure, Closure operator. Base and sub-base of fuzzy topology; fuzzy continuity of mappings; Gradation preserving maps, fuzzy homeomorphism. (10 L)

- Fuzzy Metric Spaces:

Different types of fuzzy metric (Kramosil & Michalek, Kaleva & Seikkala). Underlying topology of a fuzzy metric space, Sequence, Cauchyness and Convergence. Completeness of fuzzy metric space. Fixed point theorems (Banach, Edelstine etc.) in fuzzy metric space. (10 L)

- Fuzzy Normed linear spaces:

Different types of fuzzy norms (Katsaras, Felbin, Bag & Samanta).
Decomposition theorems; Convergence and Cauchyness of sequences, completeness of fuzzy normed linear spaces. (5 L)

References:

[1] A. Kaufman, Introduction to the theory of fuzzy subsets, Academic Press.
[2]G. J. Klir, Bo Yuan, Fuzzy sets and fuzzy logic: Theory and Applications, Prentice-Hall India.
[3]L. Y. Ming, L. M. Kang, Fuzzy topology, World Scientific.
[4]S. C. Chang, J. N. Mordeson, Y. Yandong, Lecture Notes in Fuzzy Mathematics and Computer Science, Centre for Research in Fuzzy Mathematics, Creigton University, U.S.A.

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Higher order Methods for Flow Simulation and Optimization
(CODE : BKU/MATH/CW/EU11)
Marks : 50

(Details will be incorporated later.)

Introduction to Iterative methods for Linear and Nonlinear Equations
(CODE : BKU/MATH/CW/EU12) (Marks: 25)

Basic iterative Methods (review): Jacobi Gauss-Seidel and SOR methods, their convergence. Krylove Subspace methods: GMRES, Conjugate Gradient (CG), BCG and QMR algorithms; Methods related to Normal Equations; Preconditioned iterations: PCG methods; Multigrid methods; Newton's method and its varience.

References:

[1] C. T. Kelly: Iterative Methods for Linear and Nonlinear Equations, SIAM, Phild., 1995.
[2] Y. Saad: Iterative Methods for Sparse Linear Systems, SIAM, 2003.
[3] P. Bastian: Lecture Notes on Parallel Solution of Large Sparse Linear Systems, IWR, University of Heidelberg, Germany.
[4] W. Auzinger: Lecture Notes on Iterative Solution of Large Linear Systems, TU Wien, Austria.