DDU GORAKHPUR UNIVERSITY, GORAKHPUR

DEPARTMENT OF MATHEMATICS AND STATISTICS

Syllabus

based on

National Education Policy- 2020

under

Choice Based Credit System (CBCS)

for

Ph. D. COURSE WORK

in

MATHEMATICS

(Effective from Session 2024-2025)

Course Work for Ph. D. Mathematics Students Based on CBCS

The course Work for Ph. D. Mathematics will be spread in only one semester (six months).

Objectives

01. Impart teaching so that the students could develop critical thinking ability about the fundamental aspects of mathematics.

02. Imparting knowledge in research work in various emerging fields of mathematics and its applications.

03. Train the students with mathematical knowledge and computation techniques for carrying out scientific investigations independently.

Subject Prerequisites

To study this subject a student must had the subject(s) Mathematics in class PG/ UG Honors with Research.

Programme Outcomes (POs)

P01. Knowledge in the topics required for undertaking specialized research in various fields of Mathematical Sciences.

PO2. Identification of unsolved relevant problem in a specific field.

PO3. Articulating ideas and strategies for addressing a research problem.

PO4. Undertaking original research on a particular topic.

PO5. Effectively communicating research, through journal publications and conference presentations to the mathematics community.

PO6. Disseminating research to a broader audience.

PO7. Understand the role of pure and applied mathematics in various fields of Mathematical Sciences.

Programme Specific Outcomes (PSOs)

PSO1. To develop deep understanding of the fundamental axioms in mathematics and capability of developing ideas based on them.

PSO2. To provide advance knowledge of topics in pure mathematics particularly in Analysis, Differential Geometry and Differentiable Manifolds empowering the students to proceed with the area at higher level.

PSO3. To develop the understanding of applied mathematics and motivating the students to use Mathematical modeling techniques as a tool in the study of other scientific domains.

PSO4. To encourage students for research studies in the fields of Differential Geometry, Differential Geometry of Manifolds, Differentiable Manifolds, Structures of Differentiable Manifolds, Tensor Analysis, General Relativity, Cosmology and Gravitation, Mathematical Modeling, Bio Mathematics, Mathematical Biology, Mathematical Epidemiology, Analysis, Real Analysis, Complex Analysis, Functional Analysis, Topology, Wavelet Analysis, Fixed Point Theory, Summability Theory, Number Theory and Cryptography, Coding Theory, Riemannian Geometry, Finsler Geometry, Differential Equations, Integral Transform, Fuzzy Set Theory, Fluid Dynamics, Hydro Dynamics, Algebra, Group Theory, Congruences Theory, Ring Theory, Field Theory, Discrete Mathematics, Optimization Theory, Operations Research, Numerical Analysis, Mathematical Computing, Hydro Statics and related fields.

PSO5. To provide students a wide variety of employment options as they can adopt research as a career or take up teaching jobs or can go for any other profession.

PSO6. To inculcate problem solving skills, thinking and creativity through presentations.

PSO7. To help students in their preparation.

PSO8. To enable the students being life-long learners who are able to independently expand their Mathematical expertise when needed.

DDU Gorakhpur University, Gorakhpur

Department of Mathematics and Statistics

Course Work for Ph. D. (Mathematics) Program

Every student admitted for the Ph. D. program in Mathematics will be required to pass a one semester (six months) course work of minimum 12 credits. The division of this 12 credits course work is in three papers/courses. Paper/Course I based on Research and Publication Ethics (02 credits) and Paper/Course II based on Research Methodology (05 credits) courses are compulsory for all Ph. D. students of Mathematics. Paper/Course III which is compulsory one based on Innovative Research Approaches in Mathematics (05 credits) courses is research theme-specific courses. The course work of mathematics is as follows:

Course Nature	Paper/ Course	Course Code	Course Title	Credit
Compulsory Course				
Research and Publication Ethics Course	I	RPE- 600	Research and Publication Ethics	1+1
				2 Credits
Compulsory Course				
Research Methodology Couse	II	MAT- 601	Research Methodology	5+0
				5 Credits
Compulsory Course				
Innovative Research Approaches Couse	III	MAT- 602	Innovative Research Approaches in Mathematics	5+0
				5 Credits
Thesis				Non-Credit
Total				12 Credits

Note: The division of theory and internal marks of each paper will be decided by University (as per common ordinance for examination and assessment).

COURSE CONTENTS

Compulsory Course

Course Code	Paper/Course	Course Title	Total Credit
RPE- 600	I	Research and Publication Ethics	1+1

Course Objectives: This course is designed to enable students to

1. identify and discuss the issues and concepts salient to the research process.
2. identify and discuss the fundamental knowledge of basics of philosophy of research.
3. identify and discuss the tools/techniques for research.
4. the knowledge internet and its uses in research work.
5. familiar with the MS word, MS-Excel, Power Point and LaTex.

UNIT I

Theory: Philosophy and Ethics, Introduction to Philosophy: definition, nature, scope, concept, branches Ethics: definition, moral philosophy, nature of moral judgment and reactions. Scientific Conduct, Research ethics, research Intellectual honesty and research integrity. Copyright, scientific misconduct: falsification, fabrication, and Plagiarism (FFP), Redundant Publication: duplication and overlapping publication salami slicing. Selective reporting, and misrepresentation of data.

UNIT II

Theory: Publication Ethics: definition, introduction, and importance Best practice standard setting initiative and guidelines: COPE, WAME, etc. Conflict and interest, Publication misconduct definition, concept, problems that lead to unethical behaviour and vice versa, type, Violation of publication ethics, authorship and contributor-ship, Predatory publisher and journals, Avoiding Plagiarism. Preparing documents for MoUs, Confidentiality Agreements.

UNIT III

Practice: Open access publication and initiatives SHERPA/ROMEO online resource to check publisher copyright and self-archiving policies, Software tool to identify predatory publication developed by SPPU Journal finder/journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer, Journal Suggester, etc, Publication Misconduct, Subject Specific Ethical Issues FFP, authorship Complaints and appeals: examples and fraud from India and abroad. Software tools: Use of plagiarism software like Turnitin, Urkund and other open-source software tools.

Practice: Database and research metrics. Indexing database, Citation database: Web of Science, Scopus, etc. Research metrics: Impact factor of Journal as per journal citation report, SNIP, SJR, IPP, Cite Score Metrics: h-index, g-index, 1-10 index, altmetrics.

Books Recommended:

1. Bird, A (2006). Philosophy of Science. Routledge.

2. Macintyre, Alasdair (1967) A short history of Ethics, London

3. P. Chaddah, (2018) Ethics in Competitive Research: Do not get scooped; do not get plagiarized, ISBN:978-9387480865

4. National Academy of Sciences, national Academy of Engineering and Institute of Medicine (2009) On Being A Scientist: A guide to Responsible conduct in Research. Third Edition. National Academics Press.

5. Resnik, D. B. (2011). What is ethics in research & why is it important? National Institute of Environmental Health Sciences, 1-10. Retrieved from http://www.nichs.nih.gov/research/resources/bioethics/whatis/index.cfm

6. Beall, J. (2012. Predatory publishers are corrupting open access. Nature, 489 (7415), 179.

   littps://doi.org/10.1038/489179a

7. Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance (2019) ISBN:978-81-939482-1-7. http://www.insaindia res in/pdf/Ethics Book pdf

Course Outcomes: After the completion of the course, the student shall be able to

CO 1. explain key research concepts and issues.

CO 2. have good understanding of publication ethics and scientific conduct.

CO 3. have awareness about indexing and citation databases, open access publications and various research metrics like citations, h-index, Impact Factor etc.

Compulsory Course

Course Code	Paper/Course	Course Title	Total Credit
MAT- 601	II	Research Methodology	5+0

Objectives: This course is designed to enable students to

1. identify and discuss the issues and concepts salient to the research process.
2. identify and discuss the fundamental knowledge of basics of philosophy of science and ethics, research integrity, publication ethics.
3. identify and discuss the plagiarism tools for a valid and ethical research report.
4. familiar with the MS word, MS-Excel, Power Point and LaTex.

UNIT I

Foundation and Planning of Research: Origin of Research, objectives of research, motivation and necessity of research, Steps in Research, types of research, research approaches, significance and relevance of research, conditions for good research and criteria of good research. What is Research Problem?, selection of research problem for research, formulation of the selected research problems, choosing the research area, identification of research problem and solving research problems, pure and applied research, role of a research supervisor in research.

UNIT II

Interpretation and Report Writing: Techniques of interpretation in the field of research work undertaken, writing a synopsis, writing a research proposal, writing a research paper/article, chapter writing, writing a Ph.D. thesis, Review Articles, Proof reading, Keywords and Phrases, bibliography, referencing, Mathematical subject Classifications(MSC) and indexing, short communication, fast track communication of a research paper, Plagiarism prevention, Poster/Oral presentation of research papers, Invited talks of a conference/ workshop.

UNIT III

Literature Review: Literature review, review of published article and books in the field of research work undertaken, Importance of Literature review in defining a problem, including literature in research proposal, survey and peer review process, identifying gap areas from literature review; Major Research areas, Journals, Publication, Necessity of Account in Google Scholar, Research Gate, Scopus, Web of Science and ORCID in research, Conferences and Status of Research in the field of Sciences.

Intellectual Property Rights (IPR): An introduction; IP as a global indicator of innovations, Role of IPR in economic and cultural developments, Types of IPR, Patents, Copyrights.

UNIT IV

Tools/Techniques for Research: Introduction of Internet, use of WWW, using search engines and advanced search tools, Email, MS-Word, MS-Excel, Power Point, LaTex, Beamer in research work. Introduction of Mathematical software: Mathematica /MATLAB / Maple / Scilab / Sage Math / R programming / Python. Introduction of Math SciNet, ISTOR and other online journals.

Mathematical Computing Software R/Python for Research: Introduction of computer programming, Data Types, Variables, basic operators, Boolean values, loops, logical operations, Functions, Data Processing, package, the object orientated approach: classes methods, objects, the standard objective features, Exception Handling, working with files, Basic mathematical calculation such as differentiation, integration, etc.

Books Recommended:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.

2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International, 418p.

3. Day, R.A., 1992. How to write and publish a Scientific paper, Cambridge University Press.

4. Fink, A.,2009. Conducting Research Literature Reviews: From the internet to paper. Sage Publications.

5. Saxena, V.P.,2013. Lecture Notes on Research Methodology. Indra Publishing House.

6. P.K. Sinha & Priti Sinha, Computer Fundamentals, BPB Publications.

7. Dilip Datta, LaTeX in 24 Hours: A Practical Guide for Scientific Writing, Springer (2017).

8. Introduction to Information Technology, ITL Education Solutions, Pearson Education.

9. Introduction to Computer Science, ITL Education Solutions, Pearson Education.

10. George Grätzer, More Math IntoLaTeX, 4th Edition, Springer (2016).

11. Amos R. Omondi, Mark Ng'ang'a, and Ryan Marvin, Python Fundamentals: A Practical Guide for Learning Python, Complete with Real-world Projects for You to Explore, PAKCT Publishing (2019).

12. Sinha, S.C. and Dhiman, A.K., Research Methodology, Ess Publication (2002).

13. Garrett Grolemund Hands–On Programming with R: Write Your Own Functions and Simulations, O'Reilly Publication (2014).

14. Eric Matthes, Python Crash Course, William Polock 2016.

Course Outcomes: After the completion of the course, the student shall be able to

CO 1. understand the basics of this course.

CO 2.explain key research concepts and issues.

C0 3.understand some advanced computing tools and techniques for graphical representation

of data in their research work.

Compulsory Course

Course Code	Paper/Course	Course Title	Total Credit
MAT- 602	III	Innovative Research Approaches in Mathematics	5+0

Course Objectives: The paper of Innovative Research Approaches in Mathematics is introduced to Ph.D. Course work for the study of basic concepts of mathematics. The main objective of this paper is to prepare the students for research in pure and applied research in the field of mathematics.

UNIT I

Analysis: Sequences of real number and its convergence, Metric spaces and its properties, Fixed Points, Contraction mapping and Banach contraction theorem, Introduction of soft set and fuzzy set, Normed linear spaces, Banach spaces, Inner product spaces, Hilbert spaces.

Topology: Closed sets, Interior and boundary points, Accumulation points and derived sets, Bases and sub-bases, Subspaces and relative topology, Continuous functions and homeomorphism, Separable spaces.

UNIT II

Differential and Integral Equations: Introduction of differential equations, integral equations and partial differential equations, Series solution of differential equations of second order with variable coefficients.

Special Function: Introduction of Legendre's and Bessel's differential equation, Legendre's, Bessel's functions and its properties.

Mathematical Modelling: Mathematical modelling, simple situations requiring mathematical modelling, tools, techniques and classification of mathematical models, limitations of mathematical modelling.

Optimization Theory: Introduction of Non-Linear Programming and defintions, Formulation of non-Linear programming problems, General non-linear programming problems, Kuhn-Tucker conditions, Constrained optimization with equality constraints, Constrained optimization with inequality constaints.

UNIT III

Complex Analysis: Analytic functions, singularities, complex integration, Analytic Continuation, Uniqueness of analytic continuation, Infinite product.

Congruences and Cryptography: Basic properties of congruences, Introduction of cryptography, some simple cryptosystems, additive cipher, caeser cipher, affine cipher, auto key cipher, play fair cipher, hill cipher, vigenere cipher, vernam cipher.

UNIT IV

Tensor Analysis: Riemannian Metric, Riemannian curvature tensor, Space time, Curved Space time, Flat and Einstein space, Introduction to General theory of Relativity, Static and non-static cosmological models.

Differentiable Geometry of Manifolds: Differentiable manifold, Lie bracket, Connections, Torsion, Curvature tensor, Riemannian Manifold, Riemannian connection, Einstein manifold, Flat Manifold, Introduction of almost complex and contact manifolds.

UNIT V

Mathematical Methods: Fourier transforms and its properties, Summation of a series by Arithmetic Mean, Abel summability, Approximation of functions by trigonometric polynomials, Wavelet Transforms and its properties.

Numerical Methods and Fluid Dynamics: Errors, Hermite's interpolation formula, Crout's method for finding the inverse of matrix, Numerical Double Integration by Trapezoidal and Simpson rules, Basic terminology in fluid motion, Stream lines, Path lines, Streak lines, Velocity potential, Vorticity vector, Vortex lines, Equation of continuity by Euler's and Lagrange's methods.

Books Recommended:

1. Aliprantis C.D.,Principle of Real Analysis (third Edition); Academic Press, 1998.

2. Walter Rudin, 'Principles of Mathematical Analysis', Third Edition, Tata McGraw – Hill International book company.

3. Conway J.B. ,Functions of one Complex Variables, Springer/ Narosa, New Delhi.

4. Mark J. Ablowitz and A.S. Fokas: Complex Variables: Introduction and Applications, Cambridge University Press, South Asian Edition, 1998.

5. George F. Simmons : Introduction to Topology and Modern Analysis, McGraw-Hill

   Book Company.

6. K.D. Joshi: Introduction to General Topology, Wiley Eastern Ltd.

7. P.K. Jain, O.P. Ahuja and K. Ahmad: Functional Analysis, New Age International (P) Ltd. and Wiley Eastern Ltd., New Delhi, 1997.

8. B. Choudhary and S. Nanda: Functional Analysis with Applications, Wiley Eastern Ltd., 1989.

9. Delfs, H., Knebl, H., Introduction to Cryptography, Springer.

10. Niven and Zuckerman: An Introduction to the theory of numbers, Wiley Eastern Ltd.

11. I.N. Herstein : Topics in Algebra, Wiley Eastern Ltd., New Delhi.

12. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul : Basic Abstract Algebra (Second Edition),

   Cambridge University Press, Indian Edition.

13. B. S Grewal: Higher Engineering Mathematics, Khanna Publication, 2015.

14. J.N. Sharma, RK Gupta, Special functions, Krishna Prakashan Media (P) Ltd, 2020.

15. V. Lakshmikantham and V. Raghavendra, A text Book of Ordinary Differential Equations, Tata McGraw Hill,1997.

16. F. Chorlton: A Text Book of Fluid Dynamics, CBS Publishers and Distributors, New Delhi, 2002.

17. J.K. Sharma: Operations Research – Theory and Applications, Macmillan India Ltd.

18. S. S. Sastry, Introductory methods of Numerical Analysis.

19. Fourier Analysis, Javier Duoandikoetxea, American Mathematical Society.

20. C.K.Chui, A first course in wavelets, Academic press NY 1996.

21. M. A. Khamsi and W. A. Kirk, An Introduction to Metric Spaces and Fixed Point Theory, John Wiley & Sons, New York, 2001.

22. U.C.De and A.A.Shaaikh: Complex and Contact Manifolds, Narosa Publishing House, New Delhi 2009.

23. K.S.Amur, D.J.Shetty and C.S.Bagewadi: An Introduction to Differential Geometry, Narosa Publishing House, New Delhi 2010.

24. David C. Kay, Tensor Analysis, Schaum's Outline Series, McGraw Hill 1988.

25. S. R. Roy and Raj Bali : Theory of Relativity; Jaipur Publishing House, 2008.

26. Steven Weinberg : Gravitation and Cosmology : Principles and applications of General Relativity; Wiley Publ.,2005.

27. J.N. Kapur: Mathematical Models in Biology and Medicine, Affiliated East-West Press Pvt. Ltd., New Delhi, 1985.

28. G.F. Simmons: Differential Equations with Applications and Historical Notes, McGraw Hill Education India,1991.

Course Outcomes: After completing the course, the student shall be able to

CO 1. understand the basics of this course.

CO 2. understand the use of this course in different field of pure and applied mathematical.

CO 3. think and develop new ideas in this course.