DEPARTMENT OF POST GRADUATE STUDIES AND RESEARCH
IN MATHEMATICS AND COMPUTER SCIENCE
R. D. UNIVERSITY, JABALPUR

Ph.D. Course Work in Mathematics
(From 2025-26 onwords)
Course Work
(According to Ph.D. Ordinance – 11)
(As per UGC Notification No. F.4-1(UGC-NET Review Committee)/2024 (NET)/140648 dated March 27, 2024/7)

Ph.D. student shall be required to undertake course work of 18 credits/ 600 marks of one semester, for which he/she has to deposit a prescribed fee. The course work shall be treated as Pre – Ph. D. preparation. All courses prescribed for Ph. D. course work shall be inconformity with the credit hour instructional requirement and shall specify content, instructional and assessment method. The examination scheme of credit/marks is as approved by the university. The course work comprises of:

S.No.	Title of Paper	Max. Marks	Min. Passing Marks	Credit
I	Research Methodology	100	50	4
II	Review of Published Research in the relevant field	100	50	3
III	Computer Application	100	50	3
IV	Advance course in the relevant subject (Any one)	100	50	3
V	Research and Publication Ethics	100	50	2
VI	Comprehensive Viva- Voce	100	50	3

A candidate shall have to obtain minimum 50% passing marks or equivalent grade (C) in all the papers separately.

The candidate has to obtain a minimum of 55% of marks or its equivalent grade point in aggregate in the course work in order to be eligible to continue in the Ph.D. program.

If a student obtains F or Ab grade in a course/ subject, he/she will be treated to have failed in that course. He/she have to reappear in the examinations of the course as and when conducted or arrange by the UTD in next semester. If the student fails in aggregate, then he can opt up to, maximum of any two papers to re appear in the examination. Marks obtained earlier in continuous assessment may be carried forward and added to the marks obtained in repeat end semester examination to decide the grade in the repeat course. If he/she further fails in the course, he/she shall not be given another chance and he/she shall be out of the Ph. D. program. No students shall be allowed to repeat the course to improve the grade if he/she passes the course.

Research Methodology

Unit-I :

Introduction to research methodology: Meaning, Objectives and types of research, Motivation in research, Research approaches and Research methods verses methodology, Significance of research, Criteria of good research, Research design, Components.

Unit-II :

Research problem : What is research problem? Identification and Selection of Research problem. Formulation of Research objectives. Domain and boundaries of research problem. Research problem analysis. Variables and parameters, Technique selection.

Unit-III :

Writing of research paper: Research and scientific method, Survey method, Experimental method, Research process, Research paper preparation, Synopsis writing, Writing a research project, Research support agencies, Preparation of project report, Writing a dissertation, Writing thesis, Writing of review articles, Plagiarism prevention.

Unit-IV :

Research presentation: Presentation of project proposal, Presentation of project report, Presentation at research degree meeting. A poster presentation of research paper, Direct (Oral) presentation of research. Presentation of Talk, Presentation and Delivering of Plenary Lecture, Virtual/ Tele presentation.

Unit-V :

Testing of Hypothesis: Definition, elements of testing of hypothesis – simple and compound hypothesis, null and alternate hypothesis, degrees of freedom, level of significance, errors of two kinds, Parametric test-t, F, Z Chi-square etc. and non-parametric tests- Run, median, Mann Whitney etc. for testing of hypothesis, Limitations of tests of hypothesis.

Reference books :

1. C.R. Kothari, Research Methodology, New Age International publishers (2004).
2. Catherine Dawson, Practice Research Methods, UBS Publishers Distributors, New Delhi (2002).
3. Ranjit Kumar, Research Methodology – A Step by step guide for Begineers (2nd Ed.). Singapore, Pearson Education (2005).
4. Michael Davis, Ethics and the University, Routledge (1999).
5. Montgomery, Douglas C. (2007), 5/e, Design and Analyis of Experiments, (Wiley India).
6. Montgomery, Douglas C. & Runger, George C. (2007), 3/e, Applied Statistics & Probability for Engineers (Wiley India).
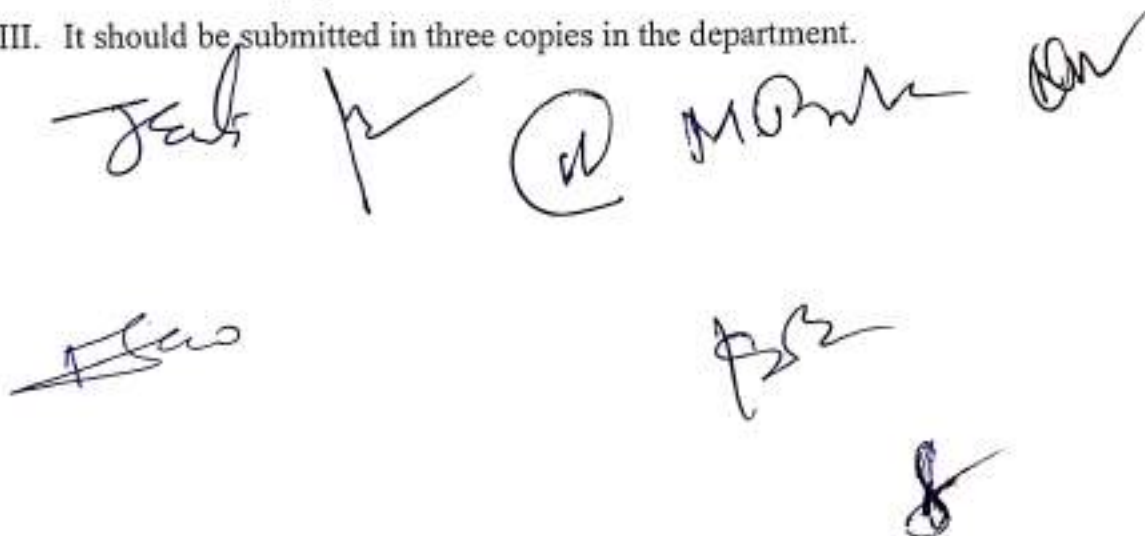
Review of Published Research in the Relevant Field This includes report writing evaluation and presentation/Viva Voce each of 50 marks

This part would be based on the study of .   research papers published in –

    I. UGC approved Journal/ SCI Journal

    II. SCI Journal/ Scopus Journal

The review should be as per specified format-

    I.   It should be in spiral binding.

    II.   The number of pages should not exceed 200.

    III. It should be submitted in three copies in the department.

Paper-III

Computer Application

UNIT – I: Basics of Computer – Characteristics of Computer, Evolution of computers, computer generations, Basic computer organization; System software, application software, introduction to operating system, MS-windows.

UNIT – II: Using Internet for research – The Internet: quick look, what is internet, major internet services, working of internet, electronic mail, www, downloading super tools for better computing Internet and the society, searching the keyword search engines, interaction, News and multimedia

UNIT – III: Word processing with MS word, starting MS word, MS environment, working with word documents, working with text, working with tables, checking spelling and grammar, printing document, spreadsheets and MS Excel, starting MS Excel, MS Excel Environment, working with Excel, workbook, working with work, Making presentation with MS Power point, MS Power point Environment, designing presentations.

UNIT – IV : LATEX – Typesetting Mathematical Text with LATEX: Sample Document, Type style, Environments, Lists, Centering, Tables, Verbatim, Vertical and Horizontal Spacing, Equation Environments, Fonts, Hats and Underlining, Braces, Arrays and Matrices, Customized Commands, Theorem–like Environments, Math Styles, Document classes and the overall structure, Titles for Documents, Sectioning Commands, Packages, Inputting Files, Inputting Pictures, Making a Bibliography, Making an Index, Slides

UNIT – V : MATLAB – Input output of data from Matlab command. File types. Creating, saving and executing the script file. Creating and executing functions file. Working with files and directories. Matrix manipulation. Creating vectors. Arithmetic operations. Relational operations. Logical operations. Matrix functions. Determinant of matrix. Graphics: Two and three dimensional plots. Subplot to Layout multiple graphs. Matlab plotting tools. Mesh and surface plots. Handle Graphics – Saving and printing.

Reference books:
1. Fundamentals of Computers by Rajaraman, Prentice Hall India Pvt. Limited.
2. The Internet: A users guide K. L. James (PHI publication).
3. Internet Research skill Niall O Dochartaigh (SAGE publication)
4. Microsoft Office Word : Complete Concepts and Techniques by Gary B. Shelly, Thomas J. Cashman, Misty E. Vermaat, Cengage Learning Inc.

How to Do Everything with Microsoft Office Excel by Guy Hart - Davis. McGraw Hill

Learning Microsoft Power Point by Catherine Skintik, Pearson Education.

LATEX, Laslie Lamtort, Addison Wesley publication company (1994).

8. Learning LATEX. Society for Industrial and Applied Mathematics, David F. Griffiths, Desmond J. Higham, Philadelphia (1997).

9. Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers by Rudra Pratap, Oxford University Press, NY.

List of Practicals
Viva Voce
Internet

Maximum Marks = 30
Maximum Marks = 20

1. Connect the Internet; open any website of your choice and save the WebPages.
2. Search any topic related to your syllabi using any search engine and download the relevant material.
3. Send any greeting card to your friend.
4. Create your E-Mail ID on any free E-Mail Server.
5. Login through your E-Mail ID and do the following:
   a. Read your mail
   b. Compose a new Mail
   c. Send the Mail to one person
   d. Send the same Mail to various persons
   e. Forward the Mail
   f. Delete the Mail
   g. Send file as attachment
6. Surf Internet using Google to find information about your state
7. Surf Internet using Google to find Tourism information about your state
8. Surf Internet using Yahoo to find Hotels around your state
9. Surf Internet using Google to find information about educational institutes for teaching M.S in comp science in India
10. Surf Internet using Google to find information about Indian Cricket team

MS-Word

1. Create a document and
   a. Put Bullets and Numbers
   b. Apply various Font parameters.
   c. Apply Left, Right, and Centre alignments.
   d. Apply hyperlinks
   e. Insert pictures
   f. Insert ClipArt
   g. Show the use of WordArt
   h. Add Borders and Shading
   i. Show the use of Find and Replace.
   j. Apply header/footers

Implement the concept of importing a file/document.
8. Implement the concept of merging the documents.
9. Crate a student table and do the following:
    a. Insert new row and fill data
    b. Delete any existing row
    c. Resize rows and columns
    d. Apply border and shading
    e. Apply merging/splitting of cells
    f. Apply sort
    g. Apply various arithmetic and logical formulas.
10. Create your resume using General Templates.

MS-PowerPoint

1. Make a presentation of College Education System using
    a. Blank Presentation
    b. From Design Template
    c. From Auto Content Wizard
2. Make a presentation on "Wild Life" and apply the following:
    a. Add audio and video effects
    b. Apply various Color Schemes
    c. Apply various animation schemes.
    d. Apply Slide Show

MS-Excel

1. Compute the division of each and every student of a class.
2. Generation of Electricity Bill
3. Generation of Telephone Bill
4. Generation of Salary statement of an employee
5. Generation of Mark Sheet of a student.
6. To compute mean/median/mode.
7. Generate graph to show the production of goods in a company during the last five years.
8. Compare the cost, overheads and sales figures of a company for last three years through appropriate chart.
9. Create any worksheet and apply various mathematical, statistical and financial functions.

erate the following worksheet

Roll No.	Marks
2050	67
2051	49
2052	40
2053	74
2054	61
2055	57
2056	45

and do the following:

a. Create chart of the marks.
b. Compute sum of marks using autosum, autocalculate and sum function.
c. Compute average of marks.
d. Show pass or fail if marks are above 50 or less than 50
e. Put header and footer in the spread sheet.

MS-Access

1. Create a Student database in Design View, by using Wizard, and by entering data.
2. Create a query on Student database in design view and by using wizard.
3. Create forms of Student database in design view and by using wizard.
4. Create reports of student database in design view and by using wizard.
5. Create data access pages of student database in design view and by using wizard.
6. Implement the concept of Macros in MS-Access.

Latex

1. Create a Sample document in Latex
2. Create a document in Latex using Environment.
3. Create a slide document in Latex
4. Create a document with Page settings in Latex
5. Create a document and insert image, input file.
6. Create a document and packages.

MATLAB

1. Write a programme in MATLAB using mathematical module to solve the linear Differential equation

Choose any one paper out of the following optional papers :-

Paper-I : Homotopy

Unit-I:

The fundamental group: Path, Homotopic paths, Loop, Relation of being path homotopy is an equivalence relation, path product, $\pi_1(X,x_0)$ is a group, properties of fundamental group, simply connected space, covering path and covering homotopy property (without proof), degree of a loop, fundamental group of circle, examples of fundamental groups.

Unit-II:

Modules and their direct sum: R-module, R-homomorphism, direct product and direct sum of modules, finitely generated module, The Hom(M,N) functor, Exact sequences, Five lemma, chain complex of R-modules, homology of a chain complex, chain map, chain homotopy, induced homomorphism in homology, exact homology sequence theorem.

Unit-III:

Singular Homology: Singular simplex, Singular q-chain, Face operator, Boundary homomorphism, Singular chain complex, singular homology of a topological space, zero dimensional homology, one dimensional homology and fundamental group, Poincare-Hurewicz theorem, Computation of 1-dimensional singular homology of some spaces.

Unit-IV:

Induced homomorphism in singular homology by a continuous map, Identity axiom, Composition axiom, Topological invariance of singular homology, Reduced singular homology of a space, Acyclic space, Homotopy axiom for singular homology (Without proof), Homotopy invariance of Singular homology.

Unit-V:

Relative chain complex and relative homology of a pair, Induced homomorphism in relative homology, Identity, Composition, Homotopy, Exactness, and Commutativity axioms of relative homology, Consequences of exact homology sequence, The Excision theorem (without proof), Singular chains of small sizes, affine q-simplex, Subdivision chain map and Chain deformation,

TEXTBOOKS:

1. Fred H. Croom; Basic Concepts of Algebraic Topology, Springer-Verlag, 1978 (For Unit-I).
2. Satya Deo; Algebraic Topology - A Primer, Hindustan Book Agency, TRIM Series # 27, New Delhi, 2003 (For Units - II, III, IV, and V).

RENCE BOOKS:

1. G.E. Bredon; Topology and Geometry, Springer-Verlag, 1997.
2. James R. Munkres; Elements of Algebraic Topology, Addison Wesley, 1984.
3. James R. Munkres; Topology, 2nd Edition, PHI, 2002.
4. M. Greenberg and J. Harper; Algebraic Topology: A First Course, Benjamin/Cummings, 1981.
5. W.S. Massey; Algebraic Topology - An Introduction, Springer-Verlag, 1977.

r-II : Rational Finite Elements

Unit-I: Homogeneous cartesion co-ordinates and the representation of points at infinty, parallel lines, lines parallel to X and Y-axes, cross ratios, definition, Invariance of cross ratio, projective co-ordinates (Derivation), Barycentric, coordinates, Jacobians of transformation for Bary-centric and projective coordinate system, Principle of Duality. (c.f. Texts [1] and [3]).

Unit-II: Finite Element interpolation Theory: Introduction, Some general properties of finite elements, P-unisolvent finite elements, various C^0-quadrilateral elements, examples of C^0-quadrilateral elements, Examples of C^0- prismatic elements on R^3, Lagrangian and Hermitian finite elements, Argyris triangle, Two Hermite triangles. (p. 41 - 56 Text [2]).

Unit-III: Patchwork approximation in numerical analysis, Wedges and Pyramids, Hat function, Triangles, Wedge & Pyramid functions, Rectangular element, Parallelogram element, Definitions & notations, Polycon, 5-con of order seven, Continuity. Patchwork approximation spaces and convergence, Wedge Properties. (c.f. Text [4]).

Unit-IV: The quadrilateral, Rational Wedges, The exterior diagonal, Quadrilateral Wedge, Areal coordinates as limits of Rational Wedges, An example of quadrilateral Wedges, Projective coordinates, Integral of Products of basis functions, Polygons. (c.f. Text [4]).

Unit-V: Rational Wedges for selected Polygons, The 3-con of order four, The 4-con of order five. The Pentagon, Some elementary congruences, Wedges for 3-cons of order five & six. (c.f. Text [4]).

TEXT BOOKS:

1. Coxter, H.S.M. (1965), Introduction to Geometry, John Wiley & Sons. INC.
2. Oden J.T., Carey G.F. (1983), Finite Element, Mathematical Aspects. Vol. IV, Prentice - Hall INC. Englewood cliffs, New Jersey.
3. Perfect Hazel (1963), Topics in Geometry, Fergamon Press.
4. Wachspress, E.L. (1975), A Rational finite Element Basis, Academic Press, INC.

REFERENCE BOOKS:

1. Carey, G.F. and Oden, J.T. (1983), Finite Elements: A Second Course, Col. II Prentice Hall, INC. Englewood Clifts, New Jersey. 07632.
2. Reddy, J.N. (1984), An Introduction to the Finite Element Method, McGraw Hill Book Company.

Paper-III : Spline Approximation theory

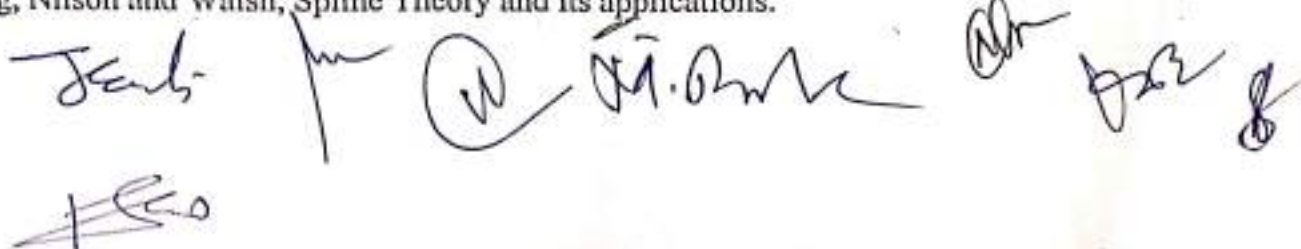**Maximum marks = 100**
(03 Credits)

Unit-I: Divided differences and its properties, Continuous broken lines interpolation, Least square approximation in $\$_2$, Construction of cubic and parabolic splines and boundary condition. Best approximation property of cubic spline.

Unit-II: Piecewise polynomial functions, A representation for piecewise polynomial functions, $P_{K, \xi}$ space, $P_{K, \xi, v}$ space, The truncated power basis for $P_{K, \xi}$ and $P_{K, \xi, v}$, B-splines and its properties, spline function space $\$_{k,t}$.

Unit-III: Curry Schoenberg Theorem, deBoor & Fix lemma, The B-representation for $f \in P_{K, \xi, v}$, conversion from one representation ·to the other, A recurrence relation for B-splines, Differentiation & Integration of B-splines.

Unit-IV: B-Spline series, B-splines are variation diminishing, Schoenberg Variation diminishing spline approximation, Local spline approximation methods and the distance from splines, The distance of a continuous function from $\$_{k,t}$. The distance of a smooth function from $\$_{k, t}$, Jackson type theorem (statement only).

Unit-V: Spline interpolation, the matrix $(B_j (T_j))$, its bandwidth, total positivity, relation between total positivity and variation diminishing, Interplay between knots and data points, Interpolation at knot averages, Best approximation property of complete splines,

TEXT BOOK:

C. De Boor, A Practice guide to splines, Springer-Verlag, New York 1978.

REFERENCE BOOKS:

1. L.L. Schumaker, Spline functions Basic Theory, John Wiley & Sons, New York, 1981.
2. Ahlberg, Nilson and Walsh, Spline Theory and its applications.

er-IV : Theory of Distribution

Maximum marks = 100
(03 Credits)

Unit-I: Support of a function and the classes $C^k(\Omega)$ of functions. The concept of test functions and their examples. Locally intergrable functions. The approximation theorem. Partitions of unity. The notion of convergence in the spaces L of unit. The notion of convergence in the spaces L of test functions. Definitions of linear and continuous functionals on the space D, The space D' of distributions. Examples of distributions. Distribution generated by a locally summable function.

Unit-II: The Vector space D' and the convergence of a sequence of distributions. Limit of a sequence of locally integrable functions. The concept of direct delta distribution. The space D^m and (D^m). The space (D^m) as a subspace of D. The concept of Radon measures.

Unit-III: Extensions of distribution differentiation of Distributions. The differentiation operator du as a continuous linear operator from D' into itself. Commutativity of differentiation and the derivative of Heavy side functions. Differentiations of distributions generated by locally integrable functions.

Unit-IV: Multiplication of distribution by a function of the class (∞). Impossibility of defining a binary multiplication in the class D. The tensor product of distribution. Associativity of tensor product and differentiation of tensor product. Convolution of distributions and existence theorem. Basic properties of convolutions.

Unit-V: The space S of rapidly decreasing functions. Fourier transform of a function in S and Fourier transform of its derivative. Inverse Fourier transform and isomorphism of Fourier transform on S. The space 'S' of tempered distributions. Examples S of tempered distributions. Order of a tempered distribution. Fourier transform of a tempered distributions, Isomorphism defined by Fourier transformation on the space S. Fourier transform of the convolution of distributions proof of the theorem that: $F(U * V) = (2\pi) E(u) * F(v)$.

TEXT BOOKS:

Fourier Transformation and linear Differential Equations: By Zofia Szmydt. D. Reidel Publishing Co. Bosten. U.S.A., 1977.

REFERENCE BOOKS:

1. A.H. Aemalian, Distribution theory and Transform Analysis, Mc Graw Hill Book company, New York, 1961.
2. A Friedman, Generalized functions and Paritial differential Equations: Prentice Hall, 1963.

er-V : Fuzzy Topology
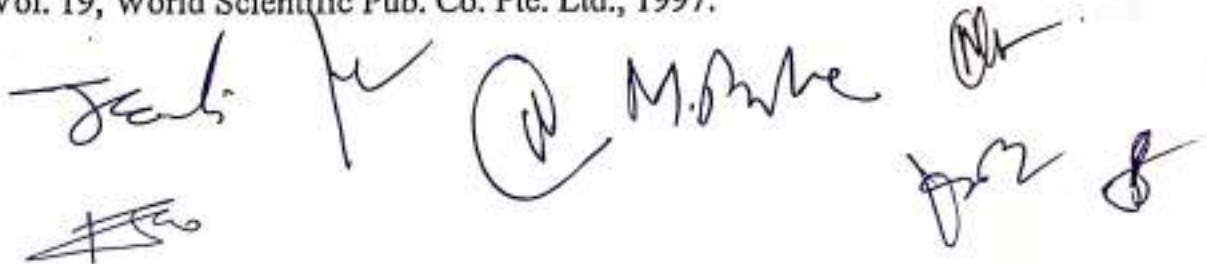
Maximum marks = 100
(03 Credits)

Unit-I: Fuzzy Sets: Basic types, Basic concepts of fuzzy sets, Examples, α-cut, Convexity of fuzzy set and its properties, Union, Intersection, and Complementation of a fuzzy set, Characteristics and significance of the Paradigm shift, Exercises.

Unit-II: Fuzzy point, Examples, Image and pre-image of a fuzzy set under a mapping, Product of fuzzy sets, Propositions, Fuzzy topological space, Closure and interior of a fuzzy set, Examples, Base and sub-base of a fuzzy topological space.

Unit-III: Concept of a Fuzzy Point and its Properties, Neighborhood structure of a fuzzy point, Quasi-coincident, Q-neighborhood, Fuzzy points and level sets, Neighborhood of a fuzzy point, Neighborhood germ, S-neighborhood.

Unit-IV: Dual point, Related Theorems, Closure and Kuratowski's theorem on 14 sets, Adherence point, The 14-set theorem (statement only), Fuzzy closure and fuzzy interior operators, Boundary point.

Unit-V: Accumulation point, Derived sets and their properties, Subspace of a fuzzy topological space, Relative fuzzy topology, Fuzzy Product Spaces, Related Propositions and Examples.

TEXT BOOKS:

1. G.J. Klir and B. Yuan, Fuzzy Sets and Fuzzy Logic: Theory and Applications, P.H.I. Pvt. Ltd., New Delhi, 1995 (For Unit – I).
2. N. Palaniappan, Fuzzy Topology, Second Ed., Narosa Publishing House, 2007 (For Units – II, III, IV, & V).

REFERENCE BOOKS:

1. G.J. Klir and T.A. Folger, Fuzzy Sets, Uncertainty, and Information, P.H.I., New Delhi, 2002.
2. Y.M. Liu and M.K. Luo, Fuzzy Topology, Advances in Fuzzy Systems – Applications and Theory, Vol. 19, World Scientific Pub. Co. Pte. Ltd., 1997.

r-VI : Mathematical Cryptography

Maximum marks = 100
(03 Credits)

it 1: Time estimates, for doing arithmetic's, Simple substitution ciphers, Divisibility and greatest common divisors, Modular arithmetic, Prime numbers, unique factorization, and finite fields, Powers and primitive roots in finite fields, Cryptography before the computer age, Symmetric and asymmetric ciphers.

it 2: Euler's formula and roots modulo pq, RSA public key cryptosystem, Implementation and security issues, Primality testing, Pollard's $\rho - 1$ factorization algorithm, Factorization via difference of squares, index calculus and discrete logarithms, Quadratic residues and quadratic reciprocity.

ilt 3: The birth of public key cryptography, Discrete logarithm problem (DLP), Diffie–Hellman key exchange, ElGamal public key cryptosystem, An overview of the theory of groups, A collision algorithm for the DLP, Chinese remainder theorem, Pohlig–Hellman algorithm, Rings, quotients, polynomials, and finite fields.

nit 4: Elliptic curves, Elliptic curves over finite fields, Elliptic curve discrete logarithm problem, Elliptic curve cryptography, The evolution of public key cryptography, Lenstra's elliptic curve factorization algorithm, Elliptic curves over F_2 and over F_{2^k}, Bilinear pairings on elliptic curves, Weil pairing over fields of prime power order.

Unit 5: Hash functions and its properties, Modern symmetric cryptosystems: DES and AES, Digital signature and its variants, RSA digital signatures, ElGamal digital signatures and DSA, Some application of digital signature.

Text Book:

1. Neal Koblitz, A Course in Number Theory and Cryptography, Springer (For Unit 1)
2. Jeffrey Hoffstein, Jill Pipher and Joseph H. Silverman. An Introduction to Mathematical Cryptography, Springer (For Rest Units)

Reference Book:

1. Alfred J. Menezes, Paul C. Van Oorschot and Scott A. Vanstone. A Handbook of Applied Cryptography, CRC Press Series
2. Oded Goldreich. Foundations of Cryptography (Basic Tools), Cambridge 2001

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PAPER-V   **100 Marks**
                     2 Credits

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Research and Publication Ethics

Unit 1: Philosophy and Ethics

Introduction to philosophy: definition, nature, and scope, concept, branches Ethics: definition, moral philosophy, nature of moral judgments and reactions

Unit 2: Scientific Conduct

Ethics with respect to science and research, Intellectual honesty and research integrity, Selective reporting and misrepresentation of data Scientific misconducts: Falsification, Fabrication, Plagiarism. Redundant publications: Duplicate and overlapping publications, Salami slicing.

Unit 3: Publication Ethics

Publication ethics: Definition, Introduction, and importance, Conflicts of interest. Best practices / standards setting initiatives and guidelines: COPE (Committee on Publication Ethics), WAME (World Association of Medical Editors), ICMJE (International Committee of Medical Journal Editors), Others Publication Misconduct: Identification of publication misconduct, Complaints and appeals, Predatory publishers and journals.

Unit 4: Open Access Publishing

Open access publications and initiatives, SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies. Software tools to identify predatory publications: Journal finder/journal suggestion tools (e.g., JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.).

Unit 5: Publication Misconduct

Group discussions Subject-specific ethical issues, FFP (Falsification, Fabrication, Plagiarism), Authorship, Conflicts of interest. Complaints and appeals: examples and fraud from India and abroad

PAPER-VI

100 Marks
3 Credits

Comprehensive viva-voce-

For Comprehensive viva-voce-

I.   The power point presentation should be elaborative.

II.   Viva-voce will be on any general topic of Mathematics