VIVEKANAND COLLEGE, KOLHAPUR
(AUTONOMOUS)

DEPARTMENT OF MATHEMATICS
TWO- Years PG Programme
Department/Subject Specific Core or Major (DSC)

Curriculum, Teaching and Evaluation Structure

for

M.Sc.-I Mathematics

Semester-I & II

(Implemented from academic year 2023-24 onwards)

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

Department of Mathematics

Programme Outcomes (POs):

After completing the M. Sc. Programme, the students will able to:

PO1: Demonstrate and apply the fundamental knowledge of the basic principles of sciences in various fields.

PO2: Create awareness and a sense of responsibility towards the environment and society to solve the issues related to environmental pollution.

PO3: To apply their professional, social, and personal knowledge.

PO3: Competent to pursue research or pursue a career in the subject.

PO4: Apply knowledge to build up small-scale industries for developing endogenous products.

PO5: Communicate scientific information in a clear and concise manner both orally and in writing.

PO6: Inculcate logical thinking to address a problem and become result oriented with a positive attitude.

M.Sc. in Mathematics

Program Specific Outcomes (PSOs):

PSO1: Handle the advanced technique in algebra, analysis, computational techniques, optimization, differential equations, engineering, finance and actuarial science to analyse and design algorithm solving variety of problems related to real life problems

PSO2: Adopt changing scientific environment in the process of sustainable development by using mathematical tools

PSO3: Have necessary skills and expertise in the field of research and developments through seminar, field project and on job training.

PSO4: A student be able to apply their skills and knowledge, that is, translate information presented verbally into mathematical form, select and use appropriate mathematical formulae or technique in order to process the information and draw the relevant conclusion

PSO5: Adapt to and keep pace with emerging technologies in the field of Mathematics, demonstrating an understanding of their applications, limitations, and implications.

NEP-2020 with Multiple Entry and Multiple Exit Option
M.Sc. (Mathematics) Programme Structure

M.Sc. (Mathematics) Part–I (Level-6.0)

Year	Level	Sem.	Major		RM	OJT/ FP	RP	Cum. Cr.	Degree
			Mandat	Electives					
I	6.0	SEM I	3*4+2	4	4	--	--	22	PG Diploma in Mathematics (after 3Yr UG Degree)
		SEM II	3*4+2	4	--	4	--	22	
Cum Cr. For PG Diploma in mathematics			28	8	4	4	--	44	
Exit option: PG Diploma in Mathematics (44 Credits) after Three Year UG Degree									
Year	Level	Sem.	Major		RM	OJT/ FP	RP	Cum. Cr.	Degree
			Mandat	Electives					
II	6.5	SEM III	3*4+2	4	--	--	4	22	MSc Mathematics Degree (after 3Yr UG Degree) OR MSc Mathematics Degree (after 4Yr UG Degree)
		SEM IV	3*4	4	--	--	6	22	
Cum Cr. For 1 year MSc mathematics Degree			26	8	--	--	10	44	
Cum Cr. For 2 year MSc mathematics Degree			54	16	4	4	10	88	
2 Years-4 Sem. MSc Mathematics Degree (88 credits) after Three Year UG Degree or 1 Year-2 Sem Mathematics Degree (44 credits) after Four Year UG Degree									

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

Department of Mathematics

Teaching and Evaluation Scheme

Two- Years PG Programme

Department/Subject Specific Core or Major (DSC)

First Year Semester-I & II

Sr. No.	Course Abbr.	Course code	Course Name	Teaching Scheme Hours/week		Examination, Scheme and Marks				Course Credits
				TH	PR	ESE	CIE	PR	Marks	
Semester-I										
1	DSC-I	DSC13MAT11	Modern Algebra	4	-	80	20	-	100	4
2	DSC-II	DSC13MAT12	Ordinary Differential Equations	4	-	80	20	-	100	4
3	DSC-III	DSC13MAT13	Measure And Integration	4	-	80	20	-	100	4
4	DSC-IV	DSC13MAT14	Numerical Analysis-I	2	-	40	10	-	50	2
5	DSE-I	DSE13MAT11	Operational Research	4	-	80	20	-	100	4
		DSE13MAT12	Introduction to Data Science							
		DSE13MAT13	Dynamical System-I							
6	MIN-I	MIN13MAT11	Research Methodology	4	-	80	20	-	100	4
Semester-II										
1	DSC-V	DSC13MAT21	Linear Algebra	4	-	80	20	-	100	4
2	DSC-VI	DSC13MAT22	General Topology	4	-	80	20	-	100	4
3	DSC-VII	DSC13MAT23	Advance Calculus	4	-	80	20	-	100	4
4	DSC-VIII	DSC13MAT24	Numerical Analysis-II	2	-	40	10	-	50	2
5	DSE-II	DSE13MAT21	Number Theory	4	-	80	20	-	100	4
		DSE13MAT22	Fuzzy Mathematics-I							
		DSE13MAT23	Dynamical system-II							
6	FP	FPR13MAT21	Field Project	-	-	-	-	100	100	4
	Total			**40**	**-**	**800**	**200**	**100**	**1100**	**44**

M. Sc. Part – I Semester -I MATHEMATICS

DSC-I: DSC13MAT11: Modern Algebra

Theory: 60 hrs.

Marks-100 (Credits: 04)

Course Outcomes (COs)

On completion of the course, the students will be able to:

CO1. Check solvability of groups via Sylow's theorems.

CO2. Check irreducibility of polynomial over any field.

CO3. Becomes familiar with theory of modules and submodules.

CO4. Understand concepts of rings over Rings of polynomial.

UNIT	Contents	Hours Allotted
1	Simple groups, simplicity of A_n $n > 5$, Commutator subgroups, normal subgroup and subnormal series, Jordan-Holder theorem, Solvable groups, Nilpotent group, isomorphism theorems (Statement only), Zassenhaus Lemma, Schreier refinement theorem**.**	15
2	Group action on a set, isometry subgroups, Burnside theorem, Direct product and semidirect product of groups, Sylow's theorems, p-subgroups, Group of order p^2 and pq, Class equation and applications	15
3	Ring of Polynomials, Factorization of polynomials over fields, irreducible polynomials, Eisenstein criterion, ideals in F[x], unique factorization domain, principal ideal domain, Gauss lemma, Euclidean Domain	15
4	Modules, sub-modules, quotient modules, homomorphism and isomorphism theorems, fundamental theorem for modules, completely reducible modules, free modules.	15

Recommended Books:

1. Fraleigh, J.B., A First course in Abstract Algebra, (3rd edition) Narosa publishing house, New Delhi.

Reference Books:

1. Gallian J.A., Abstract Algebra, Narosa Publications, 4th Edition, 1999.
2. Herstein I.N., Topics in Algebra, Vikas Publishing house.

M. Sc. Part – I Semester -I MATHEMATICS
DSC-II: DSC13MAT12: Ordinary Differential Equations
Theory: 60 hrs.
Marks-100 (Credits: 04)

Course Outcomes (COs)

On completion of the course, the students will be able to:

CO1. Find the linearly independent and hence general solutions of given differential equations

CO2. Find series solution of Bessel's and Legendre's differential equations.

CO3. Apply Picard's successive approximation method to find approximate solution of initial value problem.

CO4. Apply the Lipschitz condition of successive approximation.

UNIT	Contents	Hours Allotted
1	Linear Equations with constant coefficients: The second order homogeneous equation, Initial value problems for second order equations, Linear dependence and independence, A formula for the Wronskian, The non-homogeneous equations of order two, The homogeneous equations of order n.	15
2	Initial value problems for the nth order equations, The non-homogeneous equation of nth order. Linear Equations with variable coefficients: Initial value problems for the homogeneous equations. Solutions of the homogeneous equations, The Wronskian and linear independence, Reduction of the order of a homogeneous equation, The non-homogenous equations**.**	15
3	Sturm Liouville theory, Homogeneous equations with analytic coefficients, The Legendre equations. Linear Equations with regular singular points: The Euler equations, Second order equations with regular singular points**.**	15
4	The Bessel equation, Regular singular points at infinity, Existence and uniqueness of solutions: The method of successive approximations, The Lipschitz condition of the successive approximation. Convergence of the successive approximation. Existence and Uniqueness of solutions to systems, Existence and Uniqueness for linear systems, Equation of order n.	15

Recommended Books:

1. Coddington E. A.: An introduction to ordinary differential equations. Prentice Hall of India Pvt. Ltd. New Delhi.

Reference Books:

1. Simmons G. F. : Differential Equations with applications and Historical Notes, CRC Press
2. Birkoff G. and Rota G.G.: Ordinary Differential equations, John Willey and Sons
3. Coddington E.A. and Levinson: Theory of ordinary differential equations McGraw Hill, New York(1955)
4. Rainvills E.D., Elementary differential equations, The Macmillan comp., New York. (1964)

M. Sc. Part – I Semester -I MATHEMATICS

DSC-III: DSC13MAT13: Measure and Integration

Theory: 60 hrs.

Marks-100 (Credits: 04)

Course Outcomes (COs)

On completion of the course, the students will be able to:

CO1. Understand algebra of sets, open and closed sets of real number and outer measure and measurable sets

CO2. Understand the abstract measure theory and definition and main properties of the integral

CO3. Able to construct Lebesgue's measure on the real line and in n-dimensional Euclidean space.

CO4. Able to characterize Riemann and Lebesgue integrability.

UNIT	Contents	Hours Allotted
1	Open Sets, Closed Sets and Borel Sets, Lebesgue Outer Measure, The sigma algebra of Lebesgue Measurable Sets, Countable Additivity, Continuity and Borel-Cantelli Lemma, non-measurable set	15
2	Sums, Product and Composition of Measurable Functions, Sequential Pointwise limits and Simple Approximation. Littlewood's Three Principles, Egoroff's Theorem and Lusin's Theorem, Lebesgue Integration of a Bounded Measurable Function, Lebesgue Integration of a Non-negative Measurable Function.	15
3	The General Lebesgue Integral, Characterization of Riemann and Lebesgue Integrability, Differentiability of Monotone Functions, Lebesgue's Theorem, Functions of Bounded Variations: Jordan's Theorem.	15
4	Absolutely Continuous Functions, Integrating Derivatives: Differentiating Indefinite Integrals, Normed Linear Spaces, Inequalities of Young, Holder and Minkowski, The Riesz-Fischer Theorem.	15

Recommended Books:

1) Royden H. L., Fitzpateick P.M., Real Analysis. (2009) 4th edition. Prentice Hall of India, New Delhi

Reference Books: -

1) G. deBarra. Measure Theory and Integration. (1981) Wiley Eastern Ltd.
2) Rana, I. K. An Introduction to Measure and Integration. (1997) Narosa Book Company.
3) Berberian, S. K. Measure and Integration. (1965) McMillan, New York.

M. Sc. Part – I Semester -I MATHEMATICS

DSC-IV: DSC13MAT14: Numerical Analysis -I

Theory: 30 hrs.

Marks-50 (Credits: 02)

Course Outcomes (COs)

On completion of the course, the students will be able to:

CO1. Apply the methods to solve linear and nonlinear equations.
CO2. Solve differential equations using various numerical methods.
CO3. Determine eigen values and eigen vectors of a square matrix.
CO4. Construct LU decomposition of a square matrix.

UNIT	Contents	Hours Allotted
1	Transcendental & polynomial equations: Bisection method, Iteration methods based on First degree equation (Secant method, Regula-Falsi method and Newton-Raphson method). Rate of Convergence, Iterative methods (Birge-Vieta method and Bairstow method).	15
2	System of linear algebraic equations and eigen value problems: Matrix factorization methods (Doolittle's method, Crout's method), Iteration methods (Jacobi iteration method, Gauss-Seidel iteration method), convergence analysis of iterative methods, Eigen values and eigenvectors, Gerschgorin theorem, Brauer theorem, Jacobi method for symmetric matrices, Power method.	15

Recommended Books:

1) M. K. Jain, S. R. K. Iyengar, R. K. Jain, Numerical methods for scientific and Engineering Computation (Fifth Edition), New Age International Publishers 2007.

Reference Books: -

1. S. S. Sastry, Introductory methods of Numerical Analysis (Fifth Edition), PHI learning Private Limited, New Delhi 2012.
2. D. Kincaid, W. Cheney, Numerical Analysis Mathematics of Scientific Computing (Third Edition), American Mathematical Society.
3. J.C. Butcher, Numerical methods for ordinary differential equations (Second Edition), John Wiley & Sons Ltd, 2008.
4. Kendall E. Atkinson, An Introduction to Numerical Analysis (Second Edition), John Wiley & Sons 1988.

M. Sc. Part – I Semester -I MATHEMATICS

DSE-I : DSE13MAT11: Operations Research

Theory: 60 Hrs

Marks: 100 (Credits 04)

Course Outcomes (COs)

On completion of the course, the students will be able to:

CO1. Identify Convex set and convex functions.

CO2. Construct linear integer programming models and discuss the solution techniques,

CO3. Formulate the nonlinear programming models, and propose the best strategy using decision making methods

CO4. Solve multi –level decision problems using dynamic programming method.

UNIT	Contents	Hours Allotted
1	Convex sets and their properties. Lines and hyper planes convex set Important Theorems, polyhedral convex set Convex combination of vectors, convex hull, Convex polyhedron, convex cone, simplex and convex function, General formulation of linear programming Matrix form of LP problem, definitions of standard LPP., Fundamental Theorem of linear programming.	15
2	Simplex method, computational procedure of simplex method, problem of degeneracy and method to resolve degeneracy. Revised simplex method in standard form I, Duality in linear programming duality theorems, Integer linear programming, Gomory's cutting plane method, Branch and Bound method.	15
3	Dynamic programming. Bellman's principle of Optimality, solution of problems with a finite number of stages. Application of dynamic programming in production, inventory control and linear programming.	15
4	Non linear programming unconstrained problems of maximum and minimum Lagrangian method Kuhn Tucker necessary and sufficient conditions, Wolfe's method, Beale's method.	15

Recommended Books:

1. S. D. Sharma: Operations Research, Kedar Nath Ram Noth and co

Reference Books: -

1. Kanti Swarup,P. K. Gupta and Manmohan : Operations research, S. Chand& Co.
2. Hamady Taha: Operations Research: Mac Millan Co.
3. S. D. Sharma: Linear programming, Kedarnath, Romnath & Co.

M. Sc. Part – I Semester -I MATHEMATICS
DSE-I: DSE13MAT12: Introduction to Data Science
Theory: 60 Hrs
Marks: 100 (Credits 04)

Course Outcomes (COs)

On completion of the course, the students will be able to:

CO1.Having an ability to apply mathematics and science in AI and machine learning applications
CO2. Having computational thinking (Ability to translate vast data into abstract concepts and to understand database reasoning)
CO3. Having problem-solving ability- solving social issues and engineering problems
CO4. Having an ability to use techniques, skills and modern engineering tools necessary for engineering practice

UNIT	Contents	Hours Allotted
1	Data science in a big data world: Benefits and uses of data science and big data, Facts of data, The data science process, The big data ecosystem and data science	15
2	The data science process: Overview of the data science process, Retrieving data, Cleansing, integrating, and transforming data, Exploratory data analysis	15
3	Machine learning: What is the machine learning, The modelling process, Types of machines learning, Semi-supervised learning	15
4	Handling large data: General technique for handling large volume data, General programming tips for dealing with large data sets, Case study predicting malicious URLs	15

Recommended Books:

1. Davy Cielen, Arno D. B. Meysman, Mohmed Ali, Introduction to data science, Manning Publications Co., 1st edition, 2016

Reference Books:

1. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani,An Introduction to Statistical Learning: with Applications in R, Springer, 1st edition, 2013
2. Ethem Alpaydin, Introduction to Machine Learning, Third Edition 2018 PHI Learning Private Limited

M. Sc. Part – I Semester -I MATHEMATICS
DSE-I: DSE13MAT13: Dynamical System-I
Theory: 60 Hrs
Marks: 100 (Credits 04)

Course Outcomes (COs)

On completion of the course, the students will be able to:

CO1. Classify equilibrium points of the dynamical system
CO2. Construct bifurcation diagrams and analyze the system for different values of parameter.
CO3. Relate the qualitative properties of the system with the eigen values of coefficient matrix.
CO4. Construct the exponential of a matrix and apply it to solve the dynamical system.

UNIT	Contents	Hours Allotted
1	First order systems- Qualitative Analysis: Introduction: First order linear systems, equilibrium points- classification, stability, bifurcation, phase portraits, Scalar autonomous non-linear systems, Stability (linearization, equilibrium points), phase portraits- slope fields, Examples, two-parameter family.	15
2	Planer systems- Qualitative Analysis, Second order linear ODE as a system of first order ODEs, preliminaries from algebra, eigenvalues and eigenvectors, solution of planar linear systems, Phase portraits for planar systems: Real distinct eigenvalues, complex eigenvalues, repeated eigenvalues, changing co-ordinates, Classification of planar systems: the trace-determinant plane.	15
3	Higher order systems: Preliminaries from linear algebra, Higher order ODEs as a vector differential equation, real distinct, complex and repeated eigenvalues, The Exponential of a Matrix, Solving a system of first order differential equations by using exponential of a matrix, Non-autonomous systems of the form $X'(t) = AX(t) + G(t)$, Variation of parameters.	15
4	Discrete dynamical systems: Introduction to the discrete maps (iterative maps), orbit, periodic points, cobweb plots, Fixed points of a map, stability analysis of a fixed point (sink, source, saddle), Bifurcation and chaos: Standard examples (Logistic map, tent map, doubling map).	15

Recommended Book:

1.Differential equations, dynamical systems, and an introduction to chaos by M. Hirsch, S. Smale and R. L. Devaney, Elsevier Academic Press, USA, 2004.

Reference Book:

1. Hale and Kocak, Dynamics and Bifurcations, Springer, New York.
2. Alligood, Sauer and Yorke, Chaos - An Introduction to Dynamical Systems, Springer, New York.
3. Perko, Differential Equations and Dynamical Systems, Springer, New York.

M. Sc. Part – I Semester -I MATHEMATICS

MIN -I: MIN13MAT11: Research Methodology

Theory: 60 hrs.

Marks-100 (Credits: 04)

Course Outcomes (COs)

On completion of the course, the students will be able to:

CO1. understand skill of mathematical writing
CO2. revise the drafts, check the proofs
CO3. understand the copy copyright issues
CO4. Type in mathematics using latex

UNIT	Contents	Hours Allotted
1	Mathematical Writing: What Is a Theorem?, Proofs, The Role of Examples, Definitions, Notation, Words versus Symbols, Displaying Equations, Parallelism, Dos and Don'ts of Mathematical Writing. Writing a Paper: Audience, Organization and Structure, Title, Author List, Date, Abstract, Key Words and Subject Classifications.	15
2	Writing a Paper (Continued...): The Introduction, Review of Literature, Computational Experiments, Tables, Citations, Conclusions, Acknowledgements, Appendix, Reference List, Specifics and Deprecated Practices. Revising a Draft: How to Revise, Examples of Prose, Examples Involving Equations, Examples from My Writing, A Revised Proof, A Draft Article for Improvement.	15
3	Publishing a Paper: Choosing a Journal, submitting a Manuscript, The Refereeing Process, How to Referee, The Role of the Copy Editor, Checking the Proofs, Copyright Issues, SIAM Journal Article: A case study. Writing and Defending a Thesis: The Purpose of a Thesis, Content, Presentation, The Thesis Defence.	15
4	Quality indices of research publication: impact factor, H- index, science citation index. Using web for literature review: Google Scholar, Scopus, MathSciNet. Latex and Beamer for paper typing and presentations: Latex -Typesetting Mathematics, Typesetting Theorems. Making Presentations with LATEX-Beamer.	15

References:

1. Higham Nicholas J., Handbook of writing for the mathematical sciences, SIAM, 1961.
2. Stegmann J., How to evaluate journal impact factors, Nature, 390(6660), (1997), 550-550.
3. Kaltenborn K. F. and Kuhn K, The journal impact factor as a parameter for the evaluation of researchers and research, Revista Espanola de Enfermedades Digestivas, 96(7), (2004), 460-476.
4. J. E., An index to quantify an individual's scientific research output, https://arxiv.org/abs/physics/0508025
5. Garfield E., The evolution of the Science Citation Index, International Microbiology, 10, (2007), 65-69. DOI: 10.2436/20.1501.01.10
6. LATEX Tutorials A Primer, Indian TEX Users Group, Trivandrum, India, 2003 September. https://www.tug.org/twg/mactex/tutorials/ltxprimer-1.0.pdf
7. Tantau T., Wright J and Miletic V., The beamer class: User guide for version 3.42, Published as part of the beamer package (2015). http://ctan.imsc.res.in/macros/latex/contrib/beamer/doc/beameruserguide.pdf
8. Hoff Katharina, LATEX-beamer Course, (2007). http://gobics.de/katharina/beamer-script.pdf

M. Sc. Part – I Semester -II MATHEMATICS

DSC -V: DSC13MAT21: Linear Algebra
Theory: 60 hrs.
Marks-100 (Credits: 04)

Course Outcomes (COs)

On completion of the course, the students will be able to:

CO1. understand basic notions in linear algebra and use the results in developing advanced mathematics

CO2. study the properties of vector spaces, linear transformations, algebra of liner transformations and inner product spaces in detail.

CO3. construct canonical forms and bilinear forms

CO4. apply knowledge of vector space, linear transformations, canonical forms and bilinear transformations.

UNIT	Contents	Hours Allotted
1	Direct sum of a vector space, Dual Spaces, Annihilator of a subspace, Quotient Spaces, Algebra of Linear transformations.	15
2	Adjoint of a linear transformation, Inner product spaces, Eigen values and eigenvectors of a linear transformation, Diagonalization, Invariant subspaces.	15
3	Canonical forms, Similarity of linear transformations, Reduction to triangular forms, Nilpotent transformations, Primary decomposition theorem, Jordan blocks and Jordan forms, Invariants of linear transformations**.**	15
4	Hermitian, Self adjoint, Unitary and normal linear transformation, Symmetric bilinear forms, skew symmetric bilinear forms, Group preserving bilinear forms.	15

Recommended Books:

1. Herstein I. N. : Topics in Algebra, 2nd Edition, Willey eastern Limited
2. Hoffman, Kenneth and Kunze R: Linear Algebra, Prentice Hill of India Private Limited, 1984.

Reference Books:

1. Rao A. R. and Bhimashankaran P., Linear Algebra, Hidustan Book Agency (200)
2. Singh Surjit, Linear Algebra, Vikas publishing House (1997)

M. Sc. Part – I Semester -II MATHEMATICS

DSC -VI: DSC13MAT22: General Toplology

Theory: 60 hrs.

Marks-100 (Credits: 04)

Course Outcomes (COs)

On completion of the course, the students will be able to:

CO1. build foundation for future study in analysis, in geometry and in algebraic topology.
CO2. introduce the fundamental concepts in topological spaces.
CO3. identify compact and connected sets in topological spaces.
CO4.use separation and countability axioms, Urysohn lemma, Urysohn metrization theorem and Tychonoff theorem.

UNIT	Contents	Hours Allotted
1	Topological spaces, Examples, Limit points, Closed sets and closure, Interior, exterior, Neighborhoods, Different ways of defining topologies, Bases, Subbases, Subspaces of topological space. Hereditary properties	15
2	Connected Spaces, Components, Connected subspaces of real lines, Compact Spaces, One point compactification, Continuous Functions, Homeomorphisms, Topological properties.	15
3	Separation axioms: To, T1, T2-spaces, First and second axioms spaces, Separable Spaces, Lindelof spaces, Regular and T3 - Spaces, Normal and T4-Spaces.	15
4	Completely Regular and T3 1/2-Spaces, Completely Normal and T5 -Spaces, Product Spaces (For To, T1, T2, -compact, and connected spaces), Urysohn lemma and Urysohn metrization theorem.	15

Recommended Books:

1. Pervin W. J., Foundations of General Topology, Academic Press, New York, 3rd edition, 1970.

Reference Books:

1. Munkers J. R., Topology: A First Course, Prentice Hall of India Pvt. Ltd.
2. Simmons G. F., Introduction to Topology and Modern Analysis, Mc Graw Hill Book Company, New Delhi, 1963.
3. Joshi K. D., General Topology.
4. Willard, Topology, Academic press.

M. Sc. Part – I Semester -II MATHEMATICS

DSC -VII: DSC13MAT23: Advanced Calculus

Theory: 60 hrs.

Marks-100 (Credits: 04)

Course Outcomes (COs)

On completion of the course, the students will be able to:

CO1. Analyze convergence of sequences and series, double sequences and double series
CO2. Analyze convergence of sequences and series of functions
CO3. Check differentiability of functions of several variables
CO4. Apply inverse and implicit function theorems for functions of several variables

UNIT	Contents	Hours Allotted
1	Sequences and series of functions: Pointwise convergence of sequences of functions, Examples of sequences of real valued functions, Definition of uniform convergence, Uniform convergence and continuity, Cauchy condition for uniform convergence, Uniform convergence and Riemann integration, Uniform convergence and differentiation	15
2	Rearrangement of series, subseries, Double sequences, Double series, rearrangement of double series, sufficient condition for equality of iterated series, multiplication of series, Cesaro summability, sufficient conditions for uniform convergence of series, uniform convergence and double sequences, mean convergence, Taylor series generated by a function, Bernstein's theorem, binomial series.	15
3	Multivariable differential Calculus: The Directional derivatives, directional derivatives and continuity, total derivative, total derivatives expressed in terms of partial derivatives, The matrix of linear function, mean value theorem for differentiable functions, A sufficient condition for differentiability, sufficient condition for equality of mixed partial derivatives, Taylor's formula for functions from $R^n \; to \; R^1$.	15
4	Implicit functions: Functions of several variables, Linear transformations, Differentiation, Contraction principle, The inverse function theorem, The implicit function theorem and their applications.	15

Recommended Book:

1. Apostal, Mathematical Analysis, Second Edition, Narosa Publishing House.1974

Reference Books:

1. Walter Rudin, Principles of mathematical Analysis, third Edition, McGraw Hill book company
2. Tom M. Apostol, Calculus Vol. I , Vol II, Second EditionWiley India Pvt. Ltd.
3. W.Fleming, Functions of several Variables,2nd Edition ,Springer Verlag, 1977.

M. Sc. Part – I Semester -II MATHEMATICS

DSC -VIII: DSC13MAT24: Numerical Analysis-II

Theory: 30 hrs.

Marks-50 (Credits: 02)

Course Outcomes (COs)

On completion of the course, the students will be able to:

CO1. Apply the methods to solve linear and nonlinear equations.
CO2. Find numerical integration and analyze error in computation.
CO3. Solve differential equations using various numerical methods.
CO4. To Check convergence and stability of numerical methods.

UNIT	Contents	Hours Allotted
1	Interpolation, differentiation and integration: Lagrange and Newton interpolations, Truncation error bounds, Newtons divided difference interpolation, finite difference operators, numerical differentiation, methods based on interpolation, numerical integration, methods based on interpolation, error analysis, Newton-Cotes methods, Error estimates for trapezoidal and Simpson's rule.	15
2	Numerical solution of differential equations: Euler method, analysis of Euler method, Backward Euler method, mid-point method, order of a method, Taylor series method, Explicit Runge-Kutta methods of order two and four, convergence and stability of numerical methods, Truncation error, error analysis.	15

Recommended Books:

1) M. K. Jain, S. R. K. Iyengar, R. K. Jain, Numerical methods for scientific and Engineering Computation (Fifth Edition), New Age International Publishers 2007.

Reference Books: -

1. S. S. Sastry, Introductory methods of Numerical Analysis (Fifth Edition), PHI learning Private Limited, New Delhi 2012.
2. D. Kincaid, W. Cheney, Numerical Analysis Mathematics of Scientific Computing (Third Edition), American Mathematical Society.
3. J.C. Butcher, Numerical methods for ordinary differential equations (Second Edition), John Wiley & Sons Ltd, 2008.
4. Kendall E. Atkinson, An Introduction to Numerical Analysis (Second Edition), John Wiley & Sons 1988.

M. Sc. Part – I Semester -II MATHEMATICS
DSE -II: DSE13MAT21: Number Theory
Theory: 60 hrs.
Marks-100 (Credits: 04)

Course Outcomes (COs)

On completion of the course, the students will be able to:

CO1. Learn more advanced properties of primes and pseudo primes.
CO2. Able to apply Mobius Inversion formula to number theoretic functions.
CO3. Able to explore basic idea of cryptography.
CO4. Understand concept of primitive roots and index of an integer relative to a given primitive root.

UNIT	Contents	Hours Allotted
1	Review of Divisibility: The division algorithm, G.C.D., Euclidean algorithm, Diophantine equation $ax + by = c$, Primes and their distribution: Fundamental theorem of arithmetic, The Goldbach Conjecture.	15
2	Congruences: Properties of congruences, Linear congruences, Chinese Remainder Theorem, Special divisibility tests, Fermat's theorem, Wilsons's theorem and applications.	15
3	Number Theoretic Functions: Euler's phi function, Euler's theorem, Greatest integer function, the functions $\tau$and σ, Mobius function and Mobius inversion formula, Properties of these functions and their inter relations.	15
4	Primitive roots: The order of an integer modulo n, Primitive roots of primes, composite numbers having primitive roots, The theory of indices, The quadratic reciprocity law: Eulerian criteria, The Legendre symbol and its properties, quadratic reciprocity, quadratic reciprocity with composite moduli.	15

Recommended Book:

1 D. M. Burton: Elementary Number Theory, Universal book stall, New Delhi.

Reference Books:

1 S. B. Malik: Basic Number theory Vikas publishing House.
2 George E. Andrews: Number theory, Hindustan Pub. Corp. (1972)
3 Niven, Zuckerman: An Introduction to theory of numbers. John Wiley & Sons
4 S. G. Telang, Number Theory, Tata Mc. Graw-Hill Publishing Co., New Delhi

M. Sc. Part – I Semester -II MATHEMATICS

DSE -II: DSE13MAT22: Fuzzy Mathematics-I

Theory: 60 hrs.

Marks-100 (Credits: 04)

Course Outcomes (COs)

On completion of the course, the students will be able to:

CO1. Acquire the knowledge of notion of crisp sets and fuzzy sets
CO2. Understand the basic concepts of crisp set and fuzzy sets
CO3. Develop the skill of operation on fuzzy sets and fuzzy arithmetic's
CO4. Demonstrate the technologies of fuzzy sets and fuzzy numbers

UNIT	Contents	Hours Allotted
1	Fuzzy sets and crisp sets, examples of fuzzy sets, types of fuzzy sets, standard operations, cardinality, degree of subset hood, level cuts and its properties, representation of fuzzy sets, decomposition theorems, extension principle, properties of direct and inverse images of fuzzy sets	15
2	Operations on fuzzy sets, types of operations, fuzzy complement, equilibrium and dual point Increasing and decreasing generators, fuzzy intersection: t-norms	15
3	Fuzzy union t-conorms, characterization theorem of t-conorm, combination of operators, aggregation operations, ordered weighted averaging operations.	15
4	Fuzzy numbers, characterization theorem, linguistic variables, arithmetic operations on intervals, arithmetic operations on fuzzy numbers, lattice of fuzzy numbers, fuzzy equations.	15

Recommended Books:

1. George J. Klir, Bo Yuan, Fuzzy sets and Fuzzy Logic. Theory and Applications, PHI, Ltd.2000

Reference Books: -

1. M. Grabish, Sugeno, and Murofushi Fuzzy Measures and Integrals: Theory and Applications, PHI,1999.
2. H.J.Zimmerermann, Fuzzy Set Theory and its Applications, Kluwer, 1984.
3. M. Hanss, Applied Fuzzy Arithmetic, An Introduction with Engineering Applications, Springer-Verlag Berlin Heidelberg 2005.
4. M. Ganesh, Introduction to Fuzzy Sets & Fuzzy Logic; PHI Learning Private Limited, New Delhi 2011.

M. Sc. Part – I Semester -II MATHEMATICS

DSE -II: DSE13MAT23: Dynamical System-II

Theory: 60 hrs.

Marks-100 (Credits: 04)

Course Outcomes (COs)

On completion of the course, the students will be able to:

CO1. Relate the stability of the system with its linearization.
CO2. Distinguish between stable and unstable sets corresponding to the given system.
CO3. Construct the local stable manifolds for the nonlinear system.
CO4. Identify the chaotic behavior in the system by using Lyapunov exponents.

UNIT	Contents	Hours Allotted
1	Basic concepts of nonlinear dynamics: Introduction, Historical developments, Autonomous system of nonlinear ODEs: fundamental existence and uniqueness of solution, dependence of solution on initial conditions and parameters, The maximal interval of existence.	15
2	Stability analysis: The flow defined by a differential equation, Linearization, Stable manifold theorem, Hartman Grobman theorm, Stability and Lyapunov functions, Bifurcation.	15
3	II Chaos: Concept, properties, Limit sets and attractors, Poincare-Bendixson theorem, The Poincare map, Lyapunov exponents in flows, Numerical computation of Lyapunov exponents, Examples: Lorenz system, Chua circuit, Rossler attractor, Forced oscillators, Chaos synchronization.	15
4	Applications and computer experiments: Application of chaos to secure communication, Introduction to fractals, Use of computer softwares to solve problems in Dynamical Systems: Solving linear and nonlinear systems, data visualization-2D and 3D plots, vector field plots, chaotic phase portraits, solving discrete systems- cobweb plots.	15

Recommended Book(s):

1. Perko, Differential Equations and Dynamical Systems, Springer, New York.
2. Alligood, Sauer and Yorke, Chaos - an introduction to dynamical systems, Springer, New York.

Reference Books:

1. M. Hirsch, S. Smale and R. L. Devaney, Differential equations, dynamical systems, and an introduction to chaos, Elsevier Academic Press, USA, 2004.
2. Strogatz, Nonlinear dynamics and chaos, Perseus Books, New York.
3. Wiggins, Introduction to applied nonlinear dynamics and chaos, Springer, New York. (Algorithms)
4. Arrowsmith and Place, Dynamical systems: differential equations, maps and chaotic behaviour, Chapman and Hall, London. (Applications)

M. Sc. Part – I Semester -II MATHEMATICS

FP: FPR13MAT21: Field Project.
Marks-100 (Credits: 04)

Nature of Question Paper
(CREDIT:4)

***Instructions*:** *1) Questions **No. 1** is **compulsory**.*

*2) Attempt any **four** questions from que. no. 2 to que. no. 7.*

3) All questions carry equal marks.

4) Figures to right indicates full marks.

5) Use of log table/calculator is allowed.

Time: 3 hours **Total Marks: 80**

Q.1. A) Choose correct alternative. (2 Marks each) **08**

i)

A) B) C) D)

ii)

A) B) C) D)

iii)

A) B) C) D)

iv)

A) B) C) D)

A) Fill in the blanks/True or False (2 Marks each) 08

Q.2) A)
B)
C)

OR

A)
B)

Q.3) A)
B)
C)

OR

A)
B)

Q.4) A)
B)
C)

OR

A)
B)

Q.5) A)
B)
C)

OR

A)
B)

Q.6) A)
B)
C)

OR

A)
B)

Q.7) A)
B)
C)

OR

A)
B)

REMARK:

Note that the distribution of marks for A, B, C or A, B (Q.N.2 to Q.N.-7) may vary according to the nature of questions