CURRICULUM
FOR
MASTER OF SCIENCE
IN
MATHEMATICS (SPECIALIZATION IN COMPUTING)

DEPARTMENT OF MATHEMATICS AND SCIENTIFIC COMPUTING
MADAN MOHAN MALAVIYA UNIVERSITY OF
TECHNOLOGY, GORAKHPUR-273010, UP

CREDIT STRUCTURE
for
M. Sc. Mathematics (Specialization in Computing)
(From Session 2019-2020)

Category **Semesters**	**I**	**II**	**III**	**IV**	**Total**
Programme Core (PC)	18	14	14	8	**54**
Programme Electives (PE)	-	6	3	3	**12**
Dissertation (D)			4	8	**12**
Audit					
Total	**18**	**20**	**21**	**19**	**78**

Junior Year, Semester I

S. N.	**Category**	**Paper Code**	**Subject Name**	**L**	**T**	**P**	**Credits**
1.	PC	MAC-101	Mathematical Analysis	3	1	0	**4**
2.	PC	MAC-102	Linear Algebra and Matrix Theory	3	1	0	**4**
3.	PC	MAC-103	Advanced Ordinary Differential Equations	3	1	0	**4**
4.	PC	MAC-104	Mathematical Programming	2	1	0	**3**
5.	PC	MAC-105	Data Analytics	2	1	0	**3**
6.	AC		Audit Subject				**-**
			Total	**13**	**5**	**0**	**18**

Junior Year, Semester II

S. N.	**Category**	**Paper Code**	**Subject Name**	**L**	**T**	**P**	**Credits**
1.	PC	MAC-201	Complex Analysis	3	1	0	**4**
2.	PC	MAC-202	Topology	3	1	0	**4**
3.	PC	MAC-203	Advanced Algebra	3	1	0	**4**
4.	PC	MAC-204	Seminar	0	0	4	**2**
5.	PE-1	MAE-20X	Program Elective-I	2	1	0	**3**
6.	PE-2	MAE-21X	Program Elective-II	2	1	0	**3**
7.	AC		Audit Subject				**-**
			Total	**13**	**5**	**4**	**20**

Senior Year, Semester III

S. N.	**Category**	**Paper Code**	**Subject Name**	**L**	**T**	**P**	**Credits**
1.	PC	MAC-301	Computational Functional Analysis	3	1	0	**4**
2.	PC	MAC-302	Theory of Computing	3	1	0	**4**
3.	PC	MAC-303	Numerical Methods for Scientific Computations	2	1	2	**4**
4.	PC	MAC-304	Computing Tools	0	0	4	**2**
5.	PE-3	MAE-30X	Program Elective-III	2	1	0	**3**
6.	D		Dissertation Part-I	0	0	8	**4**
			Total	**10**	**4**	**14**	**21**

Senior Year, Semester IV

S. N.	Category	Paper Code	Subject Name	L	T	P	Credits
1.	PC	MAC-401	Number Theory and Cryptography	3	1	0	**4**
2.	PC	MAC-402	Design and Analysis of Algorithms	2	1	2	**4**
3.	PE-4	MAE-40X	Program Elective-IV	2	1	0	**3**
4.	D		Dissertation Part-II	0	0	16	**8**
			Total	**7**	**3**	**18**	**19**

Programme Core: M. Sc. Mathematics (Specialization in Computing)

S. N.	Paper Code	Subject Name	L	T	P	Credits
1.	MAC-101	Mathematical Analysis	3	1	0	**4**
2.	MAC-102	Linear Algebra and Matrix Theory	3	1	0	**4**
3.	MAC-103	Advanced Ordinary Differential Equations	3	1	0	**4**
4.	MAC-104	Mathematical Programming	2	1	0	**3**
5.	MAC-105	Data Analytics	2	1	0	**3**
6.	MAC-201	Complex Analysis	3	1	0	**4**
7.	MAC-202	Topology	3	1	0	**4**
8.	MAC-203	Advanced Algebra	3	1	0	**4**
9.	MAC-204	Seminar	0	0	4	**2**
10.	MAC-301	Computational Functional Analysis	3	1	0	**4**
11.	MAC-302	Theory of Computing	3	1	0	**4**
12.	MAC-303	Numerical Methods for Scientific Computations	2	1	2	**4**
13	MAC-304	Computing Tools	0	0	4	**2**
14.	MAC-401	Number Theory and Cryptography	3	1	0	**4**
15.	MAC-402	Design and Analysis of Algorithms	2	1	2	**4**

Programme Electives-I (PE-I)

S. N.	Paper Code	Subject Name	L	T	P	Credits
1.	MAE-201	Game Theory	2	1	0	**3**
2.	MAE-202	Differential Geometry and Tensor Analysis	2	1	0	**3**
3.	MAE-203	Integral Equations and Partial Differential Equations	2	1	0	**3**
4.	MAE-204	Discrete Mathematical Structure	2	1	0	**3**
5.	MAE-205	Approximation Theory	2	1	0	**3**

Programme Electives-II (PE-II)

S. N.	Paper Code	Subject Name	L	T	P	Credits
1.	MAE-211	Mathematical Methods	2	1	0	**3**
2.	MAE-212	Measure Theory	2	1	0	**3**
3.	MAE-213	Principles of Optimization Theory	2	1	0	**3**
4.	MAE-214	Graph Theory	2	1	0	**3**
5.	MAE-215	Computational Fluid Dynamics	2	1	0	**3**

Programme Electives III (PE-III)

S. N.	Paper Code	Subject Name	L	T	P	Credits
1.	MAE-301	Rings and Module	2	1	0	**3**
2.	MAE-302	Mathematical Modeling and Computer Simulations	2	1	0	**3**
3.	MAE-303	Mathematical Foundation of Artificial Intelligence	2	1	0	**3**
4.	MAE-304	Mathematical Theory of Coding	2	1	0	**3**
5.	MAE-305	Stochastic Processes and its Applications	2	1	0	**3**

Programme Electives IV (PE-IV)

S. N.	Paper Code	Subject Name	L	T	P	Credits
1.	MAE-401	Parallel Computing	2	1	0	**3**
2.	MAE-402	Operations Research	2	1	0	**3**
3.	MAE-403	Fuzzy Theory and its Application	2	1	0	**3**
4.	MAE-404	Theory of Mechanics	2	1	0	**3**
5.	MAE-405	Dynamical Systems	2	1	0	**3**

***Audit course for M. Sc. Mathematics (Specialization in Computing)**

S. N.	Paper Code	Subject Name	L	T	P	Credits
1.	BCS-01	Introduction to Computer Programming	3	1	2	**5**
2.	BCS-12	Principles of Data Structures through C/C++	3	1	2	**5**
3.	MAS-213	Mathematical Foundations of Computer Science	3	1	0	**4**
4.	MBA-109	Research Methodology	3	1	0	**4**

***The syllabus of audit courses BCS-01, BCS-12, MAS-213 and MBA-109 recommended for the M.Sc. Mathematics with Specialization in Computing during I^{st} and II^{nd} Semester will be same as recommended by different department and running as the part of different other courses of this university.

MAC-101 **Mathematical Analysis** **Credit 4 (3-1-0)**

UNIT- I

finite, countable and uncountable sets, Real number system as a complete ordered field, Archimedean property, limit point of a set, supremum, infimum, Bolzano Weierstrass theorem, Heine Borel theorem, Continuity, uniform continuity, differentiability, mean value theorems, Monotonic functions, types of discontinuity, functions of bounded variation, inverse and implicit function theorems. **9**

UNIT- II

Sequences and series of functions: Pointwise and uniform convergence of sequences and series of functions, uniform convergence and its consequences, space of continuous functions on a closed interval, equi-continuous families, Arzela-Ascoli theorem, Weierstrass approximation theorem, Power series. **9**

UNIT- III

Riemann-Stieltjes integral: Existence and properties of the integrals, Fundamental theorem of calculus, first and second mean value theorems, Riemann integrals, Definition and properties of Riemann-Stieltjes integral, differentiation of the integral, Fubini's theorem, Improper integrals. **9**

UNIT- IV

Metric Spaces: Review of complete metric spaces, connectedness, compact metric spaces, completeness, compactness and uniform continuity and connected metric spaces. **9**

Books/References

1. R. G. Bartle and D. R. Sherbert, "Introduction to real analysis", 4th edition, Wiley Publishing, 2011.
2. T. M. Apostol, "Mathematical Analysis", 2nd edition, Narosa Publishing, 1985.
3. W. C. Bauldry, "Introduction to real analysis", Wiley Publishing, 2009.
4. W. Rudin, "Principles of Mathematical Analysis", Mc-GrawHill Book Company, 1976.
5. C. D. Aliprantis and W. Burkinshaw, "Principles of Real Analysis", Elsevier, 2011.

MAC-102 **Linear Algebra and Matrix Theory** **Credit 4 (3-1-0)**

UNIT- I

Recall of vector space, basis, dimension and related properties, Algebra of Linear transformations, Dimension of space of linear transformations, Change of basis and transition matrices, Linear functional, Dual basis, Computing of a dual basis, Dual vector spaces, Annihilator, Second dual space, Dual transformations. **9**

UNIT- II

Inner-product spaces, Normed space, Cauchy-Schwartz inequality, Projections, Orthogonal Projections, Orthogonal complements, Orthonormality, Matrix Representation of Inner-products, Gram-Schmidt Orthonormalization Process, Bessel's Inequality, Riesz Representation theorem and orthogonal Transformation, Inner product space isomorphism. **9**

UNIT- III

Operators on Inner-product spaces, Adjoint operator, self-adjoint operator, normal operator and their properties, Matrix of adjoint operator, Algebra of Hom(V,V), Minimal Polynomial, Invertible Linear transformation, Characteristic Roots, Characteristic Polynomial and related results. **9**

UNIT- IV

Diagonalization of Matrices, Invariant Subspaces, Cayley-Hamilton Theorem, Canonical form, Jordan Form. Forms on vector spaces, Bilinear Functionals, Symmetric Bilinear Forms, Skew Symmetric Bilinear Forms, Rank of Bilinear Forms, Quadratic Forms, Classification of Real Quadratic forms and related theorems. **9**

Books/References

1. K. Hoffman and Ray Kunje : Linear Algebra, Prentice - Hall of India private Ltd.
2. Vivek Sahai, Vikas Bist : Linear Algebra, Narosa Publishing House.
3. N.S. Gopalkrishanan, University algebra, Wiley Eastern Ltd.
4. S. Lang: Linear Algebra, Springer Undergraduate Texts in Mathematics, 1989.
5. G. Williams, Linear Algebra with Applications, Jones and Burlet Publishers, 2001.

MAC-103 Advanced Ordinary Differential Equation Credit 4 (3-1-0)

UNIT- I

Initial value problem, Boundary value problem, Linear dependence equations with constant as well as variable coefficient, Wronskian, Variation of parameter, Method of undetermined coefficients, Reduction of the order of equation, Method of Laplace's transform. **9**

UNIT- II

Lipchilz's condition and Gron Wall's inequality, Picards theorems, Dependence of solution on initial conditions and on function, Continuation of solutions, Nonlocal existence of solutions Systems as vector equations, Existence and uniqueness of solution for linear systems. **9**

UNIT- III

Strum-Liouvilles system, Green's function and its applications to boundary value problems, Some oscillation theorems such as Strum theorem, Strum comparison theorem and related results. **9**

UNIT- IV

System of first order equation, fundamental matrix, Nonhomogeneous linear system, Linear system's with constant as well as periodic coefficients. **9**

Books/References

1. P. Haitman, Ordinary Differential Equations, Wiley, New York, 1964.
2. E.A. Coddington and H. Davinson, Theory of Ordinary Differential Equations, McGraw Hill, NY, 1955.
3. George F.Simmons, 'Differential Equations with Applications and Historical Notes', Tata McGraw-Hill Publishing Company Ltd. (1972).
4. Boyce.W.E, Diprma.R.C, 'Elementary Differential Equations and Boundary Value Problems', John Wiley and Sons, NY.
5. S. G. Deo, V. Lakshmikantham, V. Raghvendra, Text book of ordinary Differential Equations. Second edition. Tata Mc-Graw Hill.

MAC-104 **Mathematical Programming** **Credit 3 (2-1-0)**

UNIT- I

Introduction to Linear Programming. Problem formulations. Linear independence and dependence of vectors. Convex sets. Extreme points. Hyperplanes and Halfspaces. Directions of a convex set. Convex cones. Polyhedral sets and cones. Theory of Simplex Method. Simplex Algorithm. Degeneracy. Bounded variable problem. **6**

UNIT- II

Revised Simplex method. Duality theory. Dual-simplex method, Unconstrained and constrained optimization problems. Types of extrema and their necessary and sufficient conditions. Convex functions and their properties. Fritz-John optimality conditions. Karush-Kuhn-Tucker optimality conditions. **6**

UNIT- III

Quadratic Programming: Wolfe's method. Complementary pivot algorithm, Duality in quadratic programming. Integer Linear Programming: Modeling using pure and mixed integer programming. Branch and Bound Technique. Gomory's Cutting Plane Algorithm, 0-1 programming problem, E-Bala's algorithm. **6**

UNIT- IV

Dynamic Programming: Additive and Multiplicative Separable returns for objective as well as constraints functions. Applications' of Integer and Quadratic Programming. **6**

Books/References

1. M. S. Bazara, H. D. Sherali, C. M. Shetty: Nonlinear Programming-Theory and Algorithms. Wiley, 3rd Edition. 2006.
2. Hamdy A. Taha: Operations Research-An Introduction, 'Prentice Hall, 8th Edition, 2007
3. Ravindran, D. T. Phillips and James J. Solberg: Operations Research- Principles and Practice, John Wiley & Sons, 2005.
4. G. Hadley: Nonlinear and Dynamic Programming, Addison-Wesley, 1964.
5. M. S. Bazara, J. J. Jarvis, H. D. Sherali: Linear Programming and Network Flows, Wiley, 3rd Edition, 2004.

MAC-105 **Data Analytics** **Credit 3 (2-1-0)**

UNIT- I

Descriptive Statistics, Probability Distributions: Binomial, Poisson, Negative binomial, Geometric, Hyper-geometric, Normal, Exponential, Gamma, Beta and Weibull. **6**

UNIT- II

Theory of estimation: Basic concepts of estimation, Interval estimation, point estimation, methods of estimation, method of moments, method of maximum likelihood, unbiasedness, minimum variance estimation, interval estimation, Cramer-Rao, inequality. **6**

UNIT- III

Testing of hypothesis: Null and alternative hypothesis, type I and II errors, power function, method of finding tests, likelihood ratio test, UMP Test, Neyman, Pearson lemma, uniformly most powerful tests .ANOVA. **6**

UNIT- IV

Machine Learning: Introduction and Concepts: Differentiating algorithmic and model based frameworks, Regression: Ordinary Least Squares, Ridge Regression, Lasso Regression, K Nearest Neighbours Regression & Classification. **6**

Books/References

1. Montgomery, Douglas C., and George C. Runger. Applied statistics and probability for engineers. John Wiley & Sons, 2010
2. Hastie, Trevor, et al. The elements of statistical learning. Vol. 2. No. 1. New York: springer, 2009.
3. Hogg, R. V. and Craig, A., "Introduction to Mathematical Statistics", Pearson Education, 6th Ed. 2006
4. Rohatgi, V. K. and Md. Ehsanes Saleh, A. K., "An Introduction to Probability and Statistics", John Wiley and Sons, 2nd edition. 2000
5. Papoulis, A., Pillai, S.U., Probability, "Random Variables and Stochastic Processes", Tata McGraw-Hill, 4th Ed. 2002

MAC-201 **Complex Analysis** **Credit 4 (3-1-0)**

UNIT- I

Extended complex plane and stereographic projection, Complex differentiability, Cauchy-Riemann equations, Analytic functions, Harmonic functions, Harmonic conjugates, Analyticity of functions defined by power series, The exponential function and its properties. **9**

UNIT- II

Branch of logarithm, Power of a complex number, Pasic properties of contour integration, M-L inequality, fundamental theorem of contour integration, Cauchy's integral theorem, Cauchy-Goursat theorem (statement only), Cauchy's integral formula, Cauchy's integral formula for higher derivatives, Morera's theorem. Maximum modulus theorem, Schwarz lemma, Taylor's theorem, Laurent's theorem. **9**

UNIT- III

Zeros of an analytic functions, The identity theorem for analytic functions, Liouville's theorem, The fundamental theorem of algebra, Singularities of functions, Removable singularity, Poles and essential singularities, Residues, Cauchy's residue theorem. **9**

UNIT- IV

Evaluation of definite and Improper integrals using contour integration, Meromorphic functions, argument principle, Rouche's theorem. Conformality, Möbius transformations, The group of Möbius transformations, Cross ratio, Invariance of circles, Symmetry and orientation principles (statement only). **9**

Books/References

1. J. B. Conway, Functions of One Complex Variable, Narosa Publishing House, New Delhi, 2002.
2. Dennis G. Zill, Complex Analysis,Jones and Bartlett Publishers, 3ed
3. V. Ahlfors, Complex Analysis (Third Edition), McGraw-Hill, 1979.
4. M. Spiegel, J. Schiller, S. Lipschutz, Schaum's Outline of Complex Variables, 2ed (Schaum's Outlines)
5. James W. Brown & R. V. Churchill: Complex variables and applications, Mcgraw-Hill Asia

MAC-202 **Topology** **Credit: 4 (3-1-0)**

UNIT- I

Definitions and examples of topological spaces, Topology induced by a metric, closed sets, Closure, Dense subsets, Neighbourhoods, Interior, Exterior and boundary accumulation points and derived sets, Bases and subbases. **9**

UNIT- II

Topology generated by the subbases, subspaces and relative topology.Alternative methods of defining a topology in terms of Kuratowski closure operator and neighbourhood systems. Continuous functions and homeomorphism. First and second countable space. Lindelöf spaces. Separable spaces. **9**

UNIT- III

The separation axioms T0, T1, T2, T3½, T4; their characterizations and basic properties. Urysohn's lemma. Tietz extension theorem. Compactness. Basic properties of compactness. Compactness and finite intersection property. Sequential, countable, and B-W compactness. Local compactness. **9**

UNIT- IV

Connected spaces and their basic properties. Connectedness of the real line. Components. Locally connected spaces. Tychonoff product topology in terms of standard sub-base and its characterizations. Product topology and separation axioms, connected-ness, and compactness, Tychonoff's theorem, countability and product spaces. **9**

Books/References

1. GF Simmons: Introduction to Topology and Modern Analysis, Mc Graw Hill, 1963
2. James R Munkres: Topology, A first course, Prentice Hall, New Delhi, 2000
3. JL Kelly: Topology, Von Nostrand Reinhold Co. New York, 1995.
4. K.D. Joshi : Introduction to General Topology, Wiley Eastern Ltd.
5. J. V. Deshpande: Introduction to Topology, Tata McGraw Hill, 1988.

MAC-203 **Advanced Algebra** **Credit: 4 (3-1-0)**

UNIT- I

Relation of conjugacy, conjugate classes of a group, number of elements in a conjugate class of an element of a finite group, class equation in a finite group and related results, partition of a positive integer, conjugate classes in Sn, Sylow's theorems, external and internal direct products and related results. **9**

UNIT- II

subnormal series of a group, refinement of a subnormal series, length of a subnormal series, solvable groups and related results, n-th derived subgroup, upper central and lower central series of a group, nilpotent groups, relation between solvable and nilpotent groups, composition series of a group, Zassenhaus theorem, Schreier refinement theorem, Jordan-Holder theorem for finite groups, Insolvability of S_n for n>5. **9**

UNIT- III

Field extensions: Finite extension, Finitely generated extension, Algebraic extension, algebraic closure, Simple extension, Transcendental Extension, Finite Field, Splitting field, Algebraically closed field. **9**

UNIT- IV

Normal extension, Separable extension, Primitive Element Theorem, Automorphism of fields, Galois field, Galois extension, Fundamental Theorem of Galois theory, primitive elements, Solution of polynomial equations by radicals. **9**

Books/References

1. I. N. Herstein, Topic in Algebra, Wiley, New York, 1975.
2. D. S. Dummit and R.M. Foote, Abstract Algebra, John Wiley, N.Y., 2003.
3. V.Sahai&V.Bist: Algebra, Second edition, Narosa.
4. N. Jacobson, Basic Algebra, Vol. I, Hindustan Publishing Co., New Delhi, 1984.
5. P.M. Cohn, **Basic Algebra,** Springer (India) Pvt. Ltd., New Delhi, **2003.**

MAE-201 **Game Theory** **Credit 3 (2-1-0)**

UNIT- I

Game Theory Introduction: Overview, Examples and applications of Game Theory, Normal forms, Payoffs, Nash Equilibrium, Dominate Strategies, Perfect Information Games, Games in Extensive Form Game Trees, Choice Functions and Strategies, Choice Subtrees, Two-Person Matrix Games, Mixed strategies, Best Response Strategies. **6**

UNIT- II

Equilibrium in Games: Nash equilibrium, The von Neumann Minimax Theorem, Fixed point theorems, Computational aspects of Nash equilibrium.
Solution Methods for Matrix Games: Linear Programming, Simplex Algorithm, DualSimplex Algorithm. **6**

UNIT- III

Two Person Non-Zero-Sum Games: 2x2 Bimatrix Games, Nonlinear Programming Methods for Non-zero Sum Two-Person Games.
N-Person Cooperative Games: Coalitions and Characteristic Functions, Imputations 5 and their Dominance, The Core, Strategic Equivalence. **6**

UNIT- IV

Continuum Strategies: N-Person Non-Zero-Sum Games with continuum of strategies, Duels, Auctions, Nash Model with Security Point, Threats.
Evolutionary Strategies: Evolution, Stable Strategies. **6**

Books/References

1. M.J.Osborne, An Introduction to Game Theory, Oxford University Press, 2004
2. Peter Morris, Introduction to Game Theory, Springer-Verlag, 1994.
3. Gibbons, Robert, Game Theory for applied economists, Princeton University Press.
4. Leyton Brown & Y. Shoham, Essential Game Theory, K., Morgan &Clayful, 2008.
5. Martin, J. Osborne and Ariel Rubinstein, A course in game theory , , MIT Press.

MAE-202 Differential Geometry and Tensor Analysis Credit 3 (2-1-0)

UNIT- I

Plane curves, tangent and normal and binormal, Osculating plane, normal plane and rectifying plane, Helices, SerretFrenet apparatus, contact between curve and surfaces, tangent surfaces, Intrinsic equations, fundamental existence theorem for space curves, Local theory of surfaces- Parametric patches on surface curve of a surface, surfaces of revolutions, metric-first fundamental form and arc length. **6**

UNIT- II

Direction coefficients, families of curves, intrinsic properties, geodesics, canonical geodesic equations, normal properties of geodesics, geodesics curvature, geodesics polars, Gauss-Bonnet theorem, Gaussian curvature, normal curvature, Meusneir's theorem, mean curvature, Gaussian curvature, umbilic points, lines of curvature, Rodrigue's formula, Euler's theorem. The fundamental equation of surface theory – The equation of Gauss, the (vi) equation of Weingarten, the Mainardi-Codazzi equation.. **6**

UNIT- III

Differential Manifold-examples, tangent vectors, connexions, covariant differentiation. Elements of general Riemannian geometry-Riemannian metric, the fundamental theorem of local Riemannian Geometry, Differential parameters, curvature tensor, Geodesics, geodesics curvature, geometrical interpretation of the curvature tensor and special Riemannian spaces. **6**

UNIT- IV

Contravariant and covariant vectors and tensors, Mixed tensors, Symmetric and skew-symmetric tensors, Algebra of tensors, Contraction and inner product, Quotient theorem, Reciprocal tensors, Christoffel's symbols, Covariant differentiation, Gradient, divergence and curl in tensor notation. **6**

Books/References

1. K. Yano, The Theory of Lie Derivatives and its Applications, North-Holland Publishing Company, 1957.
2. C. E. Weatherburn, An Introduction to Riemannian Geometry and the Tensor Calculus, Cambridge University Press.
3. T. J. Willmore, An Introduction to Differential Geometry (Dover Books on Mathematics) Kindle Edition.
4. Struik, D.T. Lectures on Classical Differential Geometry, Addison - Wesley, Mass. 1950.
5. R. S. Mishra, A Course in Tensors with Applications to Riemannian Geometry, Pothishala Pvt. Ltd., Allahabad, 1965.

MAE-203 Integral Equations and Partial Differential Equations Credit 3 (2-1-0)

UNIT- I

Fredholm equations of second kind with separable kernels, Fredholm alternative theorem, Eigen values and eigen functions, Method of successive approximation for Fredholm and Volterra equations, Resolvent kernel. **6**

UNIT- II

Formation of Partial Differential Equations, First order P.D.E.'s, Classification of first order P.D.E.'s, Complete, general and singular integrals, Lagrange's or quasi-linear equations, Integral surfaces through a given curve, Orthogonal surfaces to a given system of surfaces, Characteristic curves. **6**

UNIT- III

Pfaffian differential equations, Compatible systems, Charpit's method, Jacobi's Method, Linear equations with constant coefficients, Reduction to canonical forms, Classification of second order P.D.E.'s. **6**

UNIT- IV

Method of separation of variables: Laplace, Diffusion and Wave equations in Cartesian, cylindrical and spherical polar coordinates, Boundary value problems for transverse vibrations in a string of finite length and heat diffusion in a finite rod, Classification of linear integral equations, Relation between differential and integral equations. **6**

Books/References

1. John F., Partial Differential Equations, 2nd Edition, Springer-Verlag. 1981.
2. I. N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, 1957
3. T. Amaranath, An Elementary Course in Partial Differential Equations, Narosa Publishing House, New Delhi, 2005
4. R. P. Kanwal, Linear Integral Equations, Birkhäuser, Inc., Boston, MA, 1997.
5. E. C. Zachmanoglou and D. W. Thoe, Introduction to Partial Differential Equations with Applications, Dover Publication, Inc., New York, 1986.

MAE-204 **Discrete Mathematical Structure** **Credit 3 (2-1-0)**

UNIT- I

Fundamental – Sets and Subsets, operations on sets, sequence, Division in the integer, Matrices, Mathematics Structures. Logic-Proposition and Logical Operation Conditional Statements, Methods of Proof, Mathematical Induction, Mathematics Logic- Statements and Notation, Connectives,Normal Forms, The Theory of Interface for the statement Calculus, Inference Theory of the Predicate Calculus **6**

UNIT- II

Counting- Permutation, Combination, The pigeonhole Principle, Recurrence Relations. Relational and Digraphs- Product sets and Partitions, Relations and Digraphs, Paths in Relations and Digraphs Properties of Relations, Equivalence Relations, Computer Representation of Relations and Digraph, Manipulation of Relations, Transitive Closure and Warshall's Algorithms. Functions-Definition and Introduction, Function for Computer Science, Permutation Functions, Growth of Functions. **6**

UNIT- III

Boolean Algebra as Lattices, Various Boolean Identities Join-irreducible elements, Atoms and Minterms, Boolean Forms and their Equivalence,Minterm Boolean Forms, Sum of Products Canonical Forms, Minimization of Boolean Functions, Applications of Boolean Algebra to Switching Theory (using AND, OR and NOT gates), The Karnaugh Map method. **6**

UNIT- IV

Finite State Machines and Their Transition Table Diagrams, Equivalence of Finite State Machines, Reduced Machines, Homomorphism, Finite Automata, Acceptors, Non-Deterministic Finite Automata and Equivalence of Its Power to that of Deterministic Finite Automata, Moore and Mealy Machines. **6**

Books/References

1. Bernard Kolma, Discrete Mathematical Structures, Busby & Sharon Ross [PHI].
2. J.P.Tremblay&R.Manohar, Discrete Mathematical Structures with Application to computer science, Tata McGraw –Hill.
3. C. J. Liu, Combinational Mathematics, Tata McGraw –Hill
4. Seymour Lipschutz, Discrete Mathematics, Marc Lipson (TMH).
5. Rajendra Akerkar, Discrete Mathematics, Pearson.

MAE-205 **Approximation Theory** **Credit 3 (2-1-0)**

UNIT- I

Different types of Approximations, Least squares polynomial approximation Weierstrass Approximation Theorem, Monotone operators, Markoff inequality, Bernstein inequality, Fejers theorem for HF interpolation. **6**

UNIT- II

Erdos- Turan Theorem, Jackson's Theorems (I to V), Dini-Lipschitz theorem, Inverse of Jackson's Theorem, Bernstein Theorems (I,II, III), Zygmund theorem. **6**

UNIT- III

Lobetto and Radau Quadrature, Hermite and HF interpolation, (0,2)-interpolation on the nodes of $\pi(x)$, existence, uniqueness, explicit representation and convergence. **6**

UNIT- IV

Spline interpolation, existence, uniqueness, explicit representation of cubic spline, certain external properties and uniform approximation. **6**

Books/References

1. T.J. Rivlin, An Introduction to the Approximation of functions, Dover Publications.
2. E.W. Cheney: Introduction to Approximation Theory, McGraw-Hill Book Company.
3. A. Ralston, A First Course in Numerical Analysis, MacGraw –Hill Book Company.
4. Hrushikesh N. Mhaskar and Devidas V. Pai., "Fundamentals of approximation theory", Narosa Publishing House, New Delhi, 2000
5. Singer I.," Best Approximation in Normed Linear Spaces by element of linear subspaces", Springer-Verlag, Berlin ,1970.

MAE – 211 Mathematical Methods Credits 3 (2-1-0)

UNIT- I

Calculus of Variations: Functionals, Euler's equations for one and several variables, higher order derivatives, isoperimetric problems, Variational problem in parametric form, Variational problems with moving boundaries, Weierstrass – Erdmann conditions, sufficient conditions for weak and strong maxima and minima, applications. **6**

UNIT- II

Laplace Transform: Laplace of some functions, Existence conditions for the Laplace Transform, Shifting theorems, Laplace transform of derivatives and integrals, Inverse Laplace transform and their properties, Convolution theorem, Initial and final value theorem, Laplace transform of periodic functions, error functions, Heaviside unit step function and Dirac delta function, Applications of Laplace transform to solve ODEs, PDEs and integral equations. **6**

UNIT- III

Z-Transform: Z–transform and inverse Z-transform of elementary functions, Shifting theorems, Convolution theorem, Initial and final value theorem, Application of Z-transforms to solve difference equations.
Hankel Transform: Basic properties of Hankel Transform, Hankel Transform of derivatives, Application of Hankel transform to PDE. **6**

UNIT- IV

Fourier series: Trigonometric Fourier series and its convergence. Fourier series of even and odd functions, Gibbs phenomenon, Fourier half-range series, Parseval's identity.
Fourier Transforms: Fourier integrals, Fourier sine and cosine integrals, Complex form of Fourier integral representation, Fourier transform of derivatives and integrals, Fourier sine and cosine transforms and their properties, Convolution theorem, Application of Fourier transforms to Boundary Value Problems. **6**

Books/References

1. McLachlan N. W., Laplace Transforms and Their Applications to Differential Equations, Dover Publication, 2014.
2. Sneddon I. N. Fourier Transforms, Dover Publication, 2010.
3. Debanth L. and Bhatta D., "Integral Transforms and Their Applications", 2nd edition, Taylor and Francis Group, 2007.
4. I. M. Gelfand and S. V. Fomin, "Calculus of variations", Prentice Hall, INC, Englewood Cliffs, New Jersey.
5. Dean G. Duffy, "Advanced Engineering Mathematics", CRC Press, 1998.

MAE – 212 **Measure Theory** **Credits 3 (2-1-0)**

UNIT- I

Set functions, Algebra and σ -algebra of sets, Borel sets, F_σ -sets and G_δ -sets, Intuitive idea of measure, Elementary properties of measure, Measurable sets and their fundamental properties, Algebra of measurable sets, The Lebesgue measure and its properties, Non measurable sets. **6**

UNIT- II

Measurable functions, Simple functions, Littlewood's three principles, Convergence of sequence of measurable functions, Egoroff's theorem. **6**

UNIT- III

Lebesgue integral of simple and bounded functions, Bounded convergence theorem, Lebesgue integral of nonnegative measurable functions, Fatou's lemma, Monotone convergence theorem, Integral of a Lebesgue measurable functions, Lebesgue convergence theorem, Convergence in measure. **6**

UNIT- IV

Vitali covering lemma, Differentiation of monotonic functions, Function of bounded variation and its representation as difference of monotonic functions, Differentiation of indefinite integral, Fundamental theorem of calculus, Absolutely continuous functions and their properties. **6**

Books/References

1. H. L., Royden, Real Analysis, 4 th Edition, Macmillan, 1993.
2. P. R. Halmos, Measure Theory, Van Nostrand, New York 1950.
3. G. De Barra, Measure Theory and Integration, Wiley Eastern.
4. R.R. Goldberg, Methods of Real Analysis, Oxford & IBH Pub. Co. Pvt. Ltd, 1976.
5. P. K. Jain and V. P. Gupta, Lebesgue Measure and Integration, New Age International (P) Limited Published, New Delhi, 1986

MAE – 213 Principles of Optimization Theory Credits 3 (2-1-0)

UNIT- I

Convex sets and Convex functions, their properties, Multivariable Optimization with no Constraints and Equality Constraints, Kuhn –Tucker Theory, **1-D Unconstrained Minimization Methods:** Fibonnacci Method, Golden Section, Univariate Method, Steepest Descent Method, Newton's Methods. **6**

UNIT- II

Conjugate Gradient (Fletcher–Reeves) Methods, Hookes and Jeeves Method, Powell Method, Quadratic Interpolation method, Cubic Interpolation method, Broyden–Fletcher–Goldfarb–Shanno method, **Penalty function methods:** Exterior penalty function method, Interior penalty function method. **6**

UNIT- III

Separable Programming, **Geometric Programming**: Unconstrained and Constrained Minimization Geometric Programming, Geometric Programming with mixed Inequality Constraints, Generalized method for problems with positive and negative coefficients, Complementary Geometric Programming. **6**

UNIT- IV

Multi-Objective and Concept of Goal Programming, Graphical solution method, **Nature Inspired Algorithms:** Random walks and Levy Flights, Simulated Annealing, Genetic Algorithm, Differential evaluation, Ant and Bee algorithm, swarm optimization, Harmony search, Firefly Algorithm, Bat Algorithm, Cuckoo search. **6**

Books/References

1. Mohan C. and Deep K., "Optimization Techniques", New Age India Pvt. Pvt. 2009
2. Bazaraa, M.S., Sherali, H. D. and Shetty, C. M. "Non linear Programming Theory and Algorithms", 3rd Edition, John Wiley and Sons, 2006.
3. Deb K., "Optimization for Engineering Design: Algorithms and Examples" Prentice Hall of India, 2004.
4. Singiresu S. Rao, "Engineering Optimization", Fourth Edition, John Wiley & Sons, INC, 2009.
5. Hamdy A. Taha, "Operations Research" Eighth Edition, Pearson, 2007.

MAE-214 **Graph Theory** **Credits 3 (2-1-0)**

UNIT- I

Connectivity :- Cut- vertex, Bridge, Blocks, Vertex-connectivity, Edge-connectivity and some external problems, Mengers theorems, Properties of n-connected graphs with respect to vertices and edges. **6**

UNIT- II

Planarity:- Plane and Planar graphs, Euler Identity, Non planar graphs, Maximal planar graph Outer planar graphs, Maximal outer planar graphs, Characterization of planar graphs , Geometric dual, Crossing number. **6**

UNIT- III

Colorability :-Vertex Coloring, Chromatic index of a graph, Chromatic number of standard graphs, Bichromatic graphs, Colorings in critical graphs, Relation between chromatic number and clique number/independence number/maximum degree, Edge coloring, Edge chromatic number of standard graphs Coloring of a plane map, Four color problem, Five color theorem, Uniquely colorable graph. Chromatic polynomial. **6**

UNIT- IV

Directed Graphs:- Preliminaries of digraph, Oriented graph, indegree and outdegree, Elementary theorems in digraph, Types of digraph, Tournament, Cyclic and transitive tournament, Spanning path in a tournament, Tournament with a Hamiltonian path, strongly connected tournaments. **6**

Books/References

1. J.A.Bondy and V.S.R.Murthy: Graph Theory with Applications, Macmillan, London, (2004).
2. G.Chartrand and Ping Zhang: Introduction to Graph Theory. McGrawHill, International edition (2005).
3. F. Harary Graph Theory, Addition Wesley Reading Mass, 1969.
4. N. Deo: Graph Theory: Prentice Hall of India Pvt. Ltd. New Delhi – 1990
5. Norman Biggs: Algebraic Graph Theory, Cambridge University Press (2ndEd.)1996.

MAE – 215 Computational Fluid Dynamics Credits 3 (2-1-0)

UNIT- I

Introduction to fluid, Lagrangian and Eulerian descriptions, Continuity of mass flow, circulation, rotational and irrotational flows, boundary surface, streamlines, path lines, streak lines, vorticity. **6**

UNIT- II

General equations of motion: Bernoulli's theorem, compressible and incompressible flows, Kelvin's theorem, constancy of circulation, Stream function, Complex-potential, source, sink and doublets, circle theorem, method of images, Theorem of Blasius, Strokes stream function. **6**

UNIT- III

Helmholtz's vorticity equation, vortex filaments, vortex pair, Navier-Stokes equations, dissipation of energy, diffusion of vorticity, Steady flow between two infinite parallel plates through a circular pipe (Hagen-Poiseuille flow), Flow between two coaxial cylinders. **6**

UNIT- IV

Dimensional analysis, large Reynold's numbers; Laminar boundary layer equations, Similar solutions; Flow past a flat plate, Momentum integral equations, Solution by KarmanPohlhausen methods, impulsive flow, Reyleigh problem, dynamical similarity, Thermal boundary layer equation for incompressible flow. **6**

Books/References

1. Batechelor, G.K., "An Introduction to Fluid Dynamics", Cambridge Press, 2002.
2. Schliting, H., Gersten K., "Boundary Layer Theory", Springer, 8th edition, 2004.
3. Rosenhead, L., "Laminar Boundary Layers", Dover Publications, 1963.
4. Drazin, P.G., Reid W. H., "Hydrodynamic Stability", Cambridge Press 2004.
5. Raisinghania, M. D.," Fluid Dynamics", S. Chand, sixth edition, 2005.