Department of Mathematics
Faculty of Sciences, Jamia Millia Islamia

B. Sc. (Hons.) Mathematics
Course Structure and Syllabus (w. e. f. 2024-25)

Major Papers

Semester – I		
Code	**Title of Paper**	**Credits**
24MATC101	Calculus	4
24MATC102	Analytical Geometry	4
Semester – II		
Code	**Title of Paper**	**Credits**
24MATC151	Differential Equations	4
24MATC152	Probability and Statistics	4
Semester – III		
Code	**Title of Paper**	**Credits**
24MATC201	Real Analysis	4
24MATC202	Group Theory	4
Semester – IV		
Code	**Title of Paper**	**Credits**
24MATC251	Riemann Integration and Series of Functions	4
24MATC252	Ring Theory	4
24MATC253	Advanced Calculus	4
Semester – V		
Code	**Title of Paper**	**Credits**
24MATC301	Linear Algebra	4
24MATC302	Partial Differential Equations	4
24MATC303	Numerical Methods	4

24MATC101 Calculus

Unit-I Limit and Continuity by $\epsilon - \delta$ approach, Differentiability, Successive differentiation, Leibnitz Theorem, Rolle's Theorem, Mean Value Theorems, Taylor and Maclaurin series.

Unit-II Indeterminate forms, Curvature, Cartesian, polar and parametric formulae for radius of curvature, Partial derivatives, Euler's theorem on homogenous functions.

Unit-III Asymptotes, Test of concavity and convexity, Points of inflexion, Multiple points, Curve tracing in Cartesian coordinates, Tracing in polar coordinates of standard curves.

Unit-IV Derivations and illustrations of reduction formulae of the various types. Volumes by slicing; disks and washers methods, Volumes by cylindrical shells, Parametric equations, Arc length, Arc length of parametric curves. Surfaces of solids of revolution.

Books Recommended

1. J. Hass, C. Heil, P. Bogacki and M.D. Weir: Thomas' Calculus, 15th Ed., Pearson Education, Delhi, 2024
2. K. J. Smith, M.J. Strauss and M. D. Toda: Calculus, 6th Ed., Kendall/Hunt Publishing Co, U.S.,2013.
3. H. Anton, I. Bivens and S. Davis: Calculus, 10th Ed., Jhon Wiley and Sous (Asia) P. Ltd., Singapore, 2015.
4. Gorakh Prasad: Differential and Integral Calculus, Rashi Kansal (Pothishala), Reprint 2016
5. K. Ahmad and P. Sharma: Text Book of Calculus, New Age International Publishers, 2022.

24MATC102 Analytical Geometry

Unit-I General equation of second degree, Pair of lines, Parabola, Tangent, Normal, Pole and Polar and their properties, Ellipse, Hyperbola, Tangent, Normal, Pole and Polar, Conjugate diameters.

Unit-II Asymptotes, Conjugate hyperbola and Rectangular hyperbola, Polar equation of a conics, Polar equation of tangent, normal, polar and asymptotes, Tracing of parabola, Ellipse and hyperbola.

Unit-III Review of straight lines and planes, Equation of sphere, Tangent plane, Plane of contact and polar plane, Intersection of two spheres, radical plane, Coaxial spheres, Equation of a cone, Intersection of cone with a plane and a line, Enveloping cone, Right circular cone.

Unit-IV Equation of cylinder, Enveloping and right circular cylinders, Equations of central conicoids, Tangent plane, Normal, Plane of contact and polar plane, Enveloping cone and enveloping cylinder, Equations of paraboloids and its simple properties.

Books Recommended

1. Ram Ballabh: *Textbook of Coordinate Geometry*, Prakashan Kendra.
2. S. L. Loney: *The elements of Coordinate Geometry*, Michigan Historical Reprint Series.
3. P. K. Jain and Khalil Ahmad: *Textbook of Analytical Geometry*, New Age International (P) Ltd. Publishers, 1986.
4. R. J. T. Bell: *Elementary Treatise on Coordinate Geometry of Three Dimensions*, Macmillan India Ltd., 1994.
5. E. H. Askwith: *A Course of Pure Geometry*, Merchant Books, 2007.

24MATC151 Differential Equations

Unit-I Method of separation of variables, Linear equations, Bernoulli equations, Exact differential equations, Integrating factors, Homogeneous equations. Equations of the first order and higher degree, Equations solvable for p, y and x, Clairaut's & Lagrange's equations.

Unit-II Linear differential equations of 2nd order with constant coefficient, Method of auxiliary equation, Complementary function and particular integral. Operator method for finding particular integral for functions of the form e^x, $\sin ax$, $\cos ax$, x^m and $e^{\alpha x}V(x)$, Euler-Cauchy equations.

Unit-III Linear differential equations of second order, Complete solution in terms of a known integral belonging to the complementary function, Normal form (removal of the first derivative), Simultaneous equations with constant coefficients, Simultaneous equations of form $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$

Unit-IV Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients, Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients.

Books Recommended

1. Dennis G. Zill: *A First Course in Differential Equations with Modelling Applications*, Cengage Learning; 11th Edition, 2019.
2. G.F. Simmons: Differential Equations with Applications and Historical Notes, 3rd edition, CRC press, Taylor & Francis, 2017.
3. S. L. Ross: *Differential equations*, John Wiley and Sons, 2004.
4. Zafar Ahsan: *Textbook of Differential Equations and their Applications*, 2nd Edition, Prentice Hall of India, 2012.
5. Khalil Ahmad: *Textbook of Differential Equations*, World Education Publishers, 2012.

24MATC152 Probability and Statistics

Unit-I Probability: Basic concepts and definitions, conditional probability, basic laws of total probability, Bayes' theorem, Discrete and continuous random variables, Probability mass/density functions, Cumulative distribution function, Mathematical expectation, Moments, Moment generating function, Characteristic function.

Unit-II Discrete distributions: Uniform, Bernoulli, Binomial, Negative binomial, Geometric and Poisson; Continuous distributions: Uniform, Gamma, Exponential, Chi-square, Beta and normal; Normal approximation to the binomial distribution.

Unit-III Two-dimensional random variables, Joint probability density function, joint distribution functions, marginal distributions, Expectation of function of two random variables, Joint moment generating function, Conditional distributions and expectations.

Unit-IV Covariance, the Correlation coefficient, Linear regression for two variables, Method of least squares, least square method of fitting regression lines, Strong law of large numbers, Central limit theorem and weak law of large numbers.

Books Recommended

1. Irwin Miller and Marylees Miller**,** *John E. Freund's: Mathematical Statistics with Applications*, Pearson Education, 2012
2. Robert V. Hogg, Allen Craig Deceased and Joseph W. McKean: *Introduction to Mathematical Statistics*, Pearson Education, 2012.
3. Sheldon M. Ross: *Introduction to Probability and Statistics for Engineers and Scientists*, Elsevier Academic Press, 2009.
4. S.C. Gupta and V. K. Kapoor: *Fundamentals of Mathematical Statistics*, S. Chand.

24MATC201 Real Analysis

Unit-I Bounded and unbounded sets, Infimum, supremum of a set and properties, Order completeness property of R, Archimedian property of R, Neighbourhoods, Open sets, Interior points, limit points of a set, Closed sets and related results. Derived sets, Closure of a set, Bolzano-Weierstrass theorem for sets

Unit-II Sequence of real numbers, Bounded sequences, Convergent and divergent sequences, Subsequences, limit points of a sequence, Bolzano Weierstrass theorem for sequences, Limit inferior and limit superior, Algebra of sequences, Monotone sequences, Monotone Convergence Theorem, Cauchy's sequence, Cauchy's general principal of convergence, Cauchy's first & second theorems on limits of sequences

Unit-III Infinite series: convergence and divergence, Cauchy's criterion for convergence of a series, Test for convergence of positive term series, Comparison tests, Ratio test, Cauchy's nth root test, Raabe's test, Alternating series, Leibnitz test, Absolute and conditional convergence

Unit-IV Continuous functions: $\epsilon - \delta$ approach, Sequential criterion for continuity, Theorems on continuity, Uniform continuity, Relation between continuity and uniform continuity, Derivative, Increasing and decreasing functions, Darboux theorem.

Books Recommended

1. R. G. Bartle and D. R. Sherbeer Introduction to Real Analysis (3rd Edition), John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2003
2. S. C. Malik and S. Arora Mathematical Analysis, New Age International (P) Ltd. Publishers, 2009
3. S. R. Ghorpade and B. V. Limaye: A course in Calculus and Real Analysis, Undergraduate Text in Maths. Springer (SIE), Indian reprint 2006
4. T. M. Apostol: Mathematica. Analysis, Addison-Wesley Series in Mathematics, 1974

24MATC202 Group Theory

Unit-I Sets, Relations, Functions, and binary operations (Review), Groups with examples and their properties, Subgroups, Cosets, Lagrange's theorem and its consequences, Order of an element of a group, Cyclic groups, Normal subgroups, Factor groups.

Unit-II Group homomorphism, Kernel of a homomorphism, The homomorphism theorems, Isomorphisms, The isomorphism theorems, Permutation groups, Even and odd permutations, Alternating groups, Cayley's theorem, and regular permutation group.

Unit-III Automorphism, Inner automorphism, Automorphism group of finite and infinite cyclic groups, Conjugacy relation, Normalizer and Centre, External direct products, and internal direct products.

Unit-IV Class equation of a finite group and its applications, Structure of finite Abelian groups, Cauchy's theorem, Sylow's theorems and its consequences, Simple groups, and non-simplicity tests.

Books Recommended

1. Surjeet Singh and Q. Zameeruddin: Modern Algebra, Vikas Publ. House, New Delhi, 2002.
2. I. N. Herstein, Topics in Algebra, John Wiley & Sons, New York, 2006.
3. J. A. Gallian, Contemporary Abstract Algebra, Narosa Publishing House, New Delhi,1998.
4. N. S. Gopalakrishan: University Algebra, New Age Int. Publishers, New Delhi, 2015.
5. N. Jacobson: Basic Algebra Vol. I & II, W. H. Freeman and Company, New York 1974.
6. J. B. Fraleigh, A first Course in Abstract Algebra, Pearson Education Inc. Essex, 2002.

24MATC251 Riemann Integration and Series of Functions

Unit-I Definition of Riemann integral of a bounded function, Darboux theorem, Condition of integrability, Riemann integrability for continuous functions, monotonic functions, Riemann integral as a Riemann sum, Equivalence of two definitions, Fundamental theorem of calculus, First and Second Mean Value theorems.

Unit-II Definition of improper integrals, Convergence of improper integrals, Test for convergence of improper integrals, Comparison test, Cauchy's test for convergence, Absolute convergence, Abel's test, Dirichlet's test, Convergence of Beta and Gamma functions.

Unit-III Pointwise and uniform convergence of sequences and series of functions, Cauchy's criterion for uniform convergence of sequence and series, Weierstrass M-test, Uniform convergence and continuity, Uniform convergence and differentiation, Uniform convergence and integration.

Unit-IV Fourier Series, Fourier Series for even and odd functions, Half Range Series, Power Series, Radius of Convergence, Cauchy's Hadamard theorem, Uniform and Absolute convergence, Abel's theorem.

Books Recommended

1. A. Mattuck: Introduction to Analysis, Prentice Hall, 1990
2. R. G. Bartle and D. R. Sherbert: Introduction to Real Analysis (3rd Edition), John Wiley and Sons (Asia) Pvt. Ltd., Singapore,
3. S. C. Malik and S. Arora: Mathematical Analysis, New Age International (P) Ltd. Publishers, 2009
4. K. A. Ross, Elementary Analysis: The Theory of Calculus, Under graduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004
5. D. Chatterjee: Real Analysis, 2nd ed., PHI Learning Pvt. Ltd., 2015.

24MATC252 Ring Theory

Unit-I Rings, Types of rings and their properties, Boolean ring, Integral domain, Division ring and Field, Subrings, Ideals and their properties, Operations on ideals, Ideal generated by a subset of a ring, Quotient rings.

Unit-II Homomorphism of rings, Natural homomorphism, Kernel of a homomorphism, The homomorphism theorems, Isomorphisms, The isomorphism theorems, Field of quotients.

Unit-III Polynomial rings, Properties of polynomial rings, Division algorithm in polynomial rings and its consequences, Gauss' s theorem, Irreducibility test, Eisenstein's criterion for irreducibility.

Unit-IV The greatest common divisor and least common multiple of any two non-zero elements of a ring, prime and irreducible element, Principal ideal domain, Euclidean domain, Unique factorization domain and their properties.

Books Recommended

1. I. N. Herstein, Topics in Algebra, John Wiley & Sons, New York, 2006.
2. Surjeet Singh and Q. Zameeruddin: Modern Algebra, Vikas Publ. House, New Delhi, 2002.
3. I. S. Luthar and I.B.S. Passi, Algebra, Vol. 2: Rings, Narosa Pub. House, New Delhi, 1999.
4. Anderson and Fuller: Rings and Categories of Modules. Springer-Verlag, New York, 1992.
5. N. H. McCoy: The Theory of Rings, Macmillan, New York, 1964.

24MATC253 Advanced Calculus

Unit-I Functions of several variables. Level curves and level surfaces. Limits and Continuity. Partial derivatives. Differentiability. Differential of functions of n variables. The general chain rules. Partial derivatives of higher order. Maxima and minima of functions of several variables.

Unit-II Double integrals, triple integrals and multiple integrals in general. The Jacobian matrix. Change of variables in multiple integrals. Change of order in multiple integrals. Arc length and surface area.

Unit-III Vector fields and scalar fields. The directional derivatives. The gradient field. The divergence of a vector field. The curl of a vector field. Combined operations. Vector Identities involving differential operators. Irrotational fields and Solenoidal fields.

Unit-IV Line integrals in the plane. Basic properties of line integrals. Line integrals as integrals of vectors. Green's Theorem in plane. Line Integrals in space. Surfaces in space. Surface integrals. Stokes's theorem. The divergence theorem. Integrals independent of path.

Books Recommended

1. Wilfred Kaplan: *Advanced Calculus*, Adisson-Wasley Publishing Company,1973.
2. E.Swokowski: *Calculus with Analytical Geometry*, Prindle, Weber & Schmidt, 1994.
3. E. Kreyzig: *Advanced Engineering Mathematics*, John Wiley and Sons, 1999.
4. David Widder: *Advanced Calculus*, Prentice Hall of India, 1999.
5. S. C Malik and Savita Arora: *Mathematical Analysis*, New Age International(P) 2009

24MATC301 Linear Algebra

Unit-I Vector Space and Subspace: Definition examples and properties; Linear Combination; Linear independence and Linear independence; Basis; Dimension; Coordinates; Change of basis; Sum and Direct sum of subspaces.

Unit-II Linear Transformation: Definition examples and properties; The algebra of linear transformations; Isomorphism; Matrix representation of Linear transformations; The rank and nullity of a linear transformation; Rank-Nullity Theorem; Linear functionals; Dual Space.

Unit-III Inner Product Space: Definition examples and properties; Norm and Normed Linear Space; Schwarz Inequality; Orthogonal and Orthonormal Sets; Gram-Schmidt Orthogonalization process; Orthogonal Complement; Orthogonal Projection; Bessel's Inequality.

Unit-IV Eigenvalues and eigenvectors; Characteristic equation and polynomial; Eigenvectors and eigenvalues of linear transformations and matrices; The Cayley-Hamilton Theorem; Similar matrices and Diagonalization; Eigenvalues and eigenvectors of symmetric and Hermitian matrices; Orthogonal Diagonalization; Quadratic forms and conic sections.

Books Recommended

1. K. Hoffman and R. Kunze: Linear Algebra, Prentice Hall of India (2006).
2. Seymour Lipschutz: Theory and Problems of Linear Algebra, Tata McGraw Hill.
3. Gilbert Strang: Linear Algebra and its Applications, Cengage Learning, India Edition.
4. G. Schay: Introduction to Linear Algebra, Narosa (1997).
5. G. C. Cullen: Linear Algebra with Applications, 2nd Edition, Addison Wesley.
6. S. Axler: Linear Algebra Done Right, 2nd Edition, UTM, Springer (1997).
7. K. Janich: Linear Algebra, UTM, Springer (1994).
8. David C. Lang: Linear Algebra and its Applications, 3rd Edition, Pearson.

24MATC302 Partial Differential Equations

Unit-I Introduction, Classification, Construction and geometrical interpretation of first order partial differential equations (PDE), Solution of quasilinear partial differential equation of first order by Lagrange's method, Charpit's method, Method of characteristic and general solution of first order PDE, Method of separation of variables for first order PDE.

Unit-II Classification of second order PDE, Reduction to canonical forms, Equations with constant coefficients, General solution, Partial differential equations reducible to equations with constant coefficients.

Unit-III Mathematical modeling of vibrating string and vibrating membrane, Cauchy problem for second order PDE, Homogeneous wave equation, Initial and boundary value problems, Nonhomogeneous boundary conditions, Finite strings with fixed ends, non-homogeneous wave equation, Goursat problem.

Unit-IV Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients, Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients.

Books Recommended

1. Dennis G. Zill: *A First Course in Differential Equations with Modeling Applications,* Cengage Learning; 10th edition, 2012.
2. Tyn Myint-U and Lokenath Debnath: *Linear Partial Differential Equations for Scientists and Engineers,* Birkhäuser; 4th ed. 2007.
3. D.A. Murray: *Introductory Course on Differential Equations,* Orient Longman (India), 1967.
4. I.N. Sneddon*: Elements of Partial Differential Equations*, McGraw Hill Book Company, 1988.
5. Zafar Ahsan: *Differential Equations and their Applications*, Prentice Hall of India, 2nd Edition, 2012.

24MATC303 Numerical Methods

Unit-I Methods for Solving Algebraic and Transcendental Equations: Bisection method, Method of false position, Fixed-point iteration method, Newton-Raphson method, and Secant method, their convergence analysis; Solution of system of non-linear equations by Newton's method.

Unit-II LU decomposition and its applications; Direct methods to solve linear systems: Gauss elimination method, Gauss Jordan method; Iterative methods: Gauss−Jacobi, Gauss−Seidel methods; The algebraic Eigen value problems by power method.

Unit-III Finite difference operators and finite differences; Interpolation and interpolating polynomials: Newton's forward and backward difference formulae, Central differences: Sterling's and Bessel's formula; Lagrange and Newton interpolation; Piecewise linear interpolation.

Unit-IV First and higher order approximation for the first derivative; Numerical integration using Gauss quadrature formulae: Trapezoidal rule, Simpson's rules and their error estimation; Numerical solution of ordinary differential equations by Picard's method, Euler's method and Runge-Kutta methods.

Books Recommended

1. B. Bradie: *A Friendly Introduction to Numerical Analysis*, Pearson Education, India, 2011.
2. M. K. Jain, S. R. K. Iyengar and R. K. Jain: *Numerical Methods for Scientific and Engineering Computation*, New age International Publisher, India, 6th edition, 2016.
3. C. F. Gerald and P. O. Wheatley: *Applied Numerical Analysis*, Pearson Education, India,7th edition, 2008.
4. S. S. Sastry: *Introductory Methods of Numerical Analysis (Fifth Ed.)*, Prentice Hall of India (Ltd.) 2012.