National Education Policy (NEP) 2020

MURSHIDABAD MAHARAJA KRISHNANATH UNIVERSITY, BERHAMPORE

DEPARTMENT OF MATHEMATICS

UNDERGRADUATE PROGRAMME
(MAJOR)

(Courses effective from Academic Year 2025-26)

SYLLABUS OF COURSES TO BE OFFERED

DEPARTMENT OF MATHEMATICS, MURSHIDABAD MAHARAJA KRISHNANATH UNIVERSITY, BERHAMPORE

DETAILS OF COURSE UNDER B. Sc. MAJOR in MATHEMATICS

Course Code	Course Title	Course wise Class (L+T+P)	Credit	Marks
SEMESTER-I				
UG-MAT-M-101	Classical Algebra & Ordinary Differential Equations-I	3:1:0	4	60+20=80
UG-MAT-SEC-101	Analytical Geometry	2:1:0	3	40+20=60
UG-MAT-Mi-101	Algebra & Analytical Geometry	3:1:0	4	60+20=80
UG-MAT-MDC-101	Basic Mathematics	2:1:0	3	45+15=60
SEMESTER-II				
UG-MAT-M-201	Modern Algebra, Matrix Theory& Real Analysis	3:1:0	4	60+20=80
UG-MAT-SEC-201	Application of Calculus	2:1:0	3	40+20=60
UG-MAT-Mi-201	Algebra & Analytical Geometry	3:1:0	4	60+20=80
UG-MAT-MDC-201	Basic Mathematics	2:1:0	3	45+15=60
SEMESTER-III				
UG-MAT-M-301	Abstract Algebra-I & Linear Algebra-I	3:1:0	4	60+20=80
UG-MAT-M-302	Theory of Real and Vector Functions	3:1:0	4	60+20=80
UG-MAT-SEC-301	Programming in C (Theory &Practical)	1:0:2	3	40+20=60
UG-MAT-Mi-301	Calculus & Differential Equations	3:1:0	4	60+20=80
SEMESTER-IV				
UG-MAT-M-401	Abstract Algebra -II	3:1:0	4	60+20=80
UG-MAT-M-402	Linear Algebra-II	3:1:0	4	60+20=80
UG-MAT-M-403	Riemann Integrals & Series of Functions	3:1:0	4	60+20=80
UG-MAT-M-404	Multivariate Calculus	3:1:0	4	60+20=80
UG-MAT-Mi-401	Calculus & Differential Equations	3:1:0	4	60+20=80

Sushil Kr. Bhuiya

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Signature of the HOD/ Co-Ordinator

B.Sc. Mathematics (Major)
SEMESTER-I
Course Code: UG-MAT-M-101
Course title: Classical Algebra & Ordinary Differential Equations-I
Major Course; Credit-4; Full Marks-80
Course wise Class (L+T+P): 3:1:0

Classical Algebra

1. Complex numbers – definition and field structure, conjugate of a complex number, modulus of a complex number, triangle inequality, amplitude of a complex number, De Moivre's theorem, roots of a complex number, nth roots of unity, exponential and logarithm of a complex number, definition of a^z, a≠0.

2. Polynomials and polynomial equations, addition and multiplication of polynomials, statement of the division algorithm, remainder theorem, and factor theorem, fundamental theorem of classical algebra (statement only) and its consequences, polynomials with real co-efficient, Rolle's theorem (statement only) and its applications, multiple roots, Descartes rule of signs (statement only) and its consequences, Strum's function (emphasis on problems), relation between roots and coefficients, transformation of equation, reciprocal equation, binomial equation, special roots, Cardan's method for solving cubic equations, Ferrari's method for solving bi-quadratic equations.

3. Inequalities: A. M. $\geq$ G. M. $\geq$ H. M. and Cauchy's inequality – their simple and direct applications.

Ordinary Differential Equations-I

1. Significance of ordinary differential equations, geometrical and physical considerations, formation of differential equations by elimination of arbitrary constants, meaning of the solution of ordinary differential equations, concept of linear and non-linear differential equations.

2. Equations of first order and first degree: statement of existence and uniqueness theorem, separable, homogeneous, and exact equation, condition of exactness, integrating factor, rules of finding integrating factor, (statement of relevant results only).

3. First-order linear equations: integrating factor (Statement of relevant results only), equations reducible to first-order linear equations (Bernoulli's Equation), method of variation of parameters.

4. Equations of first order but not of first degree. Clairaut's equation, singular solution.

5. Applications: geometric applications, ω-trajectories, orthogonal trajectories.

6. Higher order linear equations with constant coefficients: complementary function, particular integral, Wronskian – its properties and applications, method of undetermined coefficients, symbolic operator D, method of variation of parameters, exact equation, Euler's homogeneous equation, and reduction to an equation of constant coefficients.

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REFERENCES:

1. Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser.
2. W. S. Burnstine and A.W. Panton, Theory of Equations, Nabu Press.
3. I. N. Herstein, Topics in Algebra, Wiley Eastern Limited, India.
4. K. B. Dutta, Matrix and Linear Algebra, Prentice-Hall of India Pvt. Ltd.
5. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India.
6. E.L. Ince, Ordinary Differential Equations, Dover Publications.
7. E. Rukmangadachari, Differential Equations, Pearson.
8. D. Murray, Introductory Course in Differential Equations, Longmans Green and Co.
9. G.F. Simmons, Differential Equations with Applications and Historical Notes, Tata Mcgraw Hill.
10. Belinda Barnes, Glenn R. Fulford, Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab, 2nd Ed., Taylor and Francis group, London and New York.
11. C.H. Edwards, D.E. Penny, Differential Equations and Boundary Value problems Computing and Modeling, Pearson Education India.
12. Martha L Abell, James P Braselton, Differential Equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press.

B.Sc. Mathematics (Major)
SEMESTER-I
Course Code: UG-MAT-SEC-101
Course title: Analytical Geometry
Skill Enhancement Course; Credit-3; Full Marks-60
Course wise Class (L+T+P): 2:1:0

Analytic Geometry (2D)

1. Transformations of rectangular Axes: Translation, Rotation, and their combinations. Theory of Invariants.

2. General Equations of Second Degree in two variables: Reduction to canonical form.

3. Pairs of straight lines: The Condition that the general equation of the second degree in two variables may represent two straight lines. The point of intersection of two intersecting straight lines. The angle between two lines given by $ax^2 + 2hxy + by^2 = 0$. Angle bisectors. Equation of two lines joining the origin to the points where a line meets a conic.

4. Circle, parabola, ellipse, and hyperbola: Equations of a pair of tangents from an external point, chord of contact, Poles, and Polars. Conjugate point and conjugate line.

5. Polar Equations: Polar equations of straight lines and circles. Polar equation of a conic refers to a focus as a pole. Equations of tangent, normal, and chord of contact.

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Analytical Geometry (3D)

1. Plane; Straight lines.

2. Sphere: General Equation, Circle, Sphere through circle, Tangent, Normal.
3. Cone: General homogeneous second-degree equation, Enveloping cone, Section of cone by a plane, Tangent and normal, Condition for three perpendicular generators, Reciprocal cone, Right circular cone, Cylinder, Enveloping cylinder, Right circular Cylinder.

4. Conicoid: Ellipsoid, Hyperboloid, Paraboloid: Canonical equations only. Plane sections of it.

5. Transformation of coordinates, Reduction of general second-degree equations.

References:

1. P. R. Vittal, Analytical Geometry 2D and 3D, Pearson.
2. S. L. Loney, Co-ordinate Geometry, Arihant Publications.
3. R.M. Khan, Analytical Geometry of Two and Three Dimensions and Vector Analysis, New Central Book Agency, 2010.
4. E.H. Askwith, The Analytical Geometry of the Conic Sections, Adam and Charles Black
5. London, 1908.
6. S. Karmakar & S. Karmakar, Analytic Geometry: Two Dimensions, CRC Press (Taylor & Francis Group)/Levant Books (India), London, 2022.
7. Robert J. T. Bell, An Elementary Treatise On Coordinate Geometry, Macmillan and Company Limited. 8. B.K. Kar, Advanced Analytical Geometry and Vector Analysis, Books & Allied Pvt. Ltd., Kolkata, 2000.

B.Sc. Mathematics (Major)
SEMESTER-I
Course Code: UG-MAT-Mi-101
Course title: Algebra & Analytical Geometry
Minor Course; Credit-4; Full Marks-80
Course wise Class (L+T+P): 3:1:0

1. Integers, well ordering principle, principle of mathematical induction. Division algorithm ($a = bq + r$, $b \neq 0$, $0 \leq r < b$), greatest common divisor(g.c.d.) of two integers and its simple properties, co-prime integers, Euler's φ-function. Prime numbers, Euclid's theorem, fundamental theorem of arithmetic.

2. Complex Numbers: De Moivre's Theorem and its applications. Exponential, Sine, Cosine and Logarithm of a complex number. Definition of $a^z (a \neq 0)$.

3. Polynomials with real coefficients, Fundamental Theorem of Algebra (Statement only): The n-th degree polynomial equation has exactly n roots. Nature of roots of an equation (surd or complex roots occur in pairs). Existence of real roots, Descarte's rule of sign and application of intermediate value theorem. Relation between roots and coefficients, symmetric functions of roots. Cardan's method of solution of a cubic equation.

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4. Matrices with real and complex entries. Inverse of a matrix. Elementary row operations and row reduced Echelon matrix. Rank of a matrix. System of linear equation, consistency and inconsistency of system of linear equation, solution of system of linear equations. Symmetric, skew symmetric, Hermitian, Skew-Hermitian, Unitary and orthogonal matrices.

5. Determinant and its basic properties. Laplace expansion of determinant. Singular and non singular matrix, rank of a matrix in terms of determinants.

6. Transformations of Rectangular axes: Translation, Rotation and their combinations. Invariants.

7. General equation of second degree in x and y: Reduction to canonical forms. Classification of conic.

8. Pair of straight lines: Condition that the general equation of second degree in x and y may represent two straight lines. Point of intersection of two intersecting straight lines. Angle between two lines given by $ax^2 + 2hxy + by^2 = 0$. Equation of bisectors. Equation of two lines joining the origin to the points in which a line meets a conic.

9. Equations of pair of tangents from an external point, chord of contact, poles and polers in case of General conic: Particular cases for Parabola, Ellipse, Circle, Hyperbola. Polar equation of straight lines and circles. Polar equation of a conic referred to a focus as pole. Equation of chord joining two points. Equations of tangent and normal.

10. Three-dimensional coordinate system. Straight line, direction cosine, problems on straight lines. Equation of plane and elementary properties. Sphere and its tangent plane. Right circular cone.

Reference Books

1. S. L. Loney, The Elements of Coordinate Geometry, Macmillan and Co., 1895.
2. S. Bernard and J.M. Child, Higher Algebra, Macmillan and Co., 1952.
3. T. Andreescu and D. Andrica, Complex Numbers from A to...Z, Birkhauser, 2006.
4. D.C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
5. K.B. Dutta, Matrix and Linear algebra, Prentice-Hall of India Pvt.Ltd., 2004.
6. W.S. Burnside and A.W. Panton, The Theory of equations, Dublin University Press, 1954.
7. R.J.T. Bell, An elementary treatise on coordinate geometry of three dimensions, Macmillan and Co.

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Signature of the HOD/ Co-Ordinator

B.Sc. Mathematics (Major)
SEMESTER-I
Course Code: UG-MAT-MDC-101
Course title: Basic Mathematics
Multidisciplinary Course; Credit-3; Full Marks-60
Course wise Class (L+T+P): 2:1:0

Set Theory

Introduction to sets and their representations. The empty set, finite and infinite sets, equal sets, subsets, power set, and Universal set.
Venn Diagrams, operations on sets, complement of a set, problems on union and intersection of sets.

Complex Numbers

Polar representation of complex numbers.

De Moivre's theorem (without proof) for rational indices and their applications.

Matrix & Determinant

Definition of a Matrix. Types of Matrices.
Determinant of a square matrix (up to third order). Properties of determinants. Cofactors and minor of a determinant.

Reference:

1. A. Kumar, S. Kumaresan, B.K. Sarma, A Foundation Course in Mathematics, Narosa Publishing House.

2. Bernard and Child: Higher Algebra, Arihant Publications.

3. I. Stewart, D. Tall, The Foundations of Mathematics. Oxford University Press.

4. M.K. Sen, S. Ghosh and P. Mukhopadhyay, Topics in Abstract Algebra, University Press.

5. K.B. Dutta, Matrix and Linear Algebra, Prentice-Hall of India Pvt. Ltd.

6. Shanti Narayan: A Textbook of Matrices, S Chand.

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Signature of the HOD/ Co-Ordinator

B.Sc. Mathematics (Major)
SEMESTER-II
Course Code: UG-MAT-M-201
Course title: Modern Algebra, Matrix Theory & Real Analysis
Major Course; Credit-4; Full Marks-80
Course wise Class (L+T+P): 3:1:0

Modern Algebra

1. Recapitulation**:** Sets, subsets, equality of sets, operations on sets – Union, Intersection, Complements, and Symmetric difference. Properties including De Morgan's laws.

2. Cartesian products, Binary relation from a set to a set (domain, range, Examples from R × R). Equivalence relation. Fundamental theorem on Equivalence relation. Partition, Relation of partial order. The congruence relation modulo n is an equivalence relation—congruence classes.

3. Mapping**:** different types of mappings, the composition of mapping, restriction, and extension of mapping.

Matrix Theory

1. Matrices of Real and Complex Numbers: Definition, examples, equality, addition, multiplication of matrices, Transpose of a matrix, Symmetric and Skew-symmetric matrices.

2. Determinants: Definition of a determinant of a square matrix, Basic properties, Minors and Cofactors, equations by Cramer's rule. Problems of determinants up to order 3.

3. Rank of a Matrix: Adjoint of a square matrix. Singular, non-singular, and invertible matrices. Elementary operations. Rank of a matrix and its determination. Normal forms: Elementary matrices; The normal form equivalence of matrices. Congruence of Matrices.

Real Analysis

1. Finite and infinite sets, countable and uncountable sets, cardinality of R, Q, and intervals.
2. Natural numbers, well ordering principle for N, mathematical induction – simple applications, rational numbers – examples, algebraic property, order property and density property of rational numbers, real Numbers – algebraic property and order property, point set in one-dimension, bounded set, least upper bound axiom or completeness axiom, Archimedean property and density property of real numbers.

3. Point set theory in one dimension**:** neighborhood of a point, interior, accumulation points, and isolated points. Bolzano – Weierstrass theorem for accumulation point. Union, intersection, complement of open and closed sets in R, derived set, closure of a set, deduction of basic properties of the interior of a set, and closure of a set.
4. Sequence of real numbers**:** bounds, limits, convergence and non-convergence of a sequence, operations on limits. Sandwich rule. monotone sequences and their convergence, the theorem on nested intervals. Cauchy's general principle of convergence, Cauchy sequence. Cauchy's first and second limit theorems, subsequence, Bolzano–Weierstrass theorem for sequences, subsequential limits. upper limit and lower limit of a sequence, results on upper and lower limits.

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5. Infinite Series of Real Numbers**:** Convergence, Cauchy's criterion of convergence.

   Series of non-negative real numbers**:** tests of convergence – comparison test, Cauchy's condensation test, ratio test.

   Statements and applications of: Cauchy root test, Abel–Pringsheim's test, Kummer's test, Raabe's test, Bertrand's test, logarithmic test, and Gauss's test.

   Series of arbitrary terms**:** absolute and conditional convergence.

   Alternating series**:** Leibniz test.

   Non-absolute convergence**:** Abel's and Dirichlet's test (statements and applications).

   Riemann's rearrangement theorem and rearrangement of absolutely convergent series.

References:

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. Gerald G. Bilodeau , Paul R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones & Bartlett, 2010.
3. Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, Elementary Real Analysis,Prentice Hall, 2001.
4. S.K. Berberian, a First Course in Real Analysis, Springer Verlag, New York, 1994.
5. T. Apostol, Mathematical Analysis, Narosa Publishing House
6. Courant and John, Introduction to Calculus and Analysis, Vol I, Springer
7. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill
8. C. C. Pugh, Real Mathematical Analysis, Springer, 2002.
9. Terence Tao, Analysis I, Hindustan Book Agency, 2006.
10. S. Goldberg, Calculus and mathematical analysis.
11. Horst R. Beyer, Calculus and Analysis, Wiley, 2010.
12. K.B. Dutta, Matrix and Linear Algebra, Prentice-Hall of India Pvt. Ltd.
13. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint.
14. K. Hoffman, R. Kunze, Linear Algebra, Pearson.

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Signature of the HOD/ Co-Ordinator

B.Sc. Mathematics (Major)
SEMESTER-II
Course Code: UG-MAT-SEC-201
Course title: Application of Calculus
Skill Enhancement Course; Credit-3; Full Marks-60
Course wise Class (L+T+P):2:1:0

Application of Calculus

1. Differential Calculus: Higher order derivatives, Leibnitz rule of successive differentiation and its applications; Indeterminate forms, L'Hospital's rule; Basic ideas of Partial derivatives, Chain Rules, Jacobian, Euler's theorem and its converse; Tangents and Normals, Sub-tangent and sub-normals, Derivatives of arc lengths, Pedal equation of a curve; Curvature and radius of curvature; Asymptotes; Envelopes; Concavity, convexity and point of inflexion and Classification of singular points.

2. Integral Calculus: Reduction formulae; Rectification & quadrature of plane curves, length of a curve; Arc length as a parameter; Volume and surface area of revolution.

3. Familiarity with common figures, including cycloid, catenary, lemniscate of Bernoulli, astroid, cardioid, folium of Descartes, equiangular spiral.

REFERENCES:

1. G. B. Thomas and R.L.Finney, Calculus, 9 thEd.,Pearson Education, Delhi, 2005.
2. M. J. Strauss, G. L. Bradley and K. J. Smith, Calculus, 3 rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.
3. H. Anton, I. Bivens and S. Davis, Calculus, 7thEd., John Wiley and Sons(Asia) P.Ltd.,Singapore,2002.
4. R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), SpringerVerlag, NewYork, Inc., 1989.
5. T. Apostol, Calculus, Volumes I and II.
6. S. Goldberg, Calculus and Mathematical Analysis.

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Signature of the HOD/ Co-Ordinator

B.Sc. Mathematics (Major)
SEMESTER-II
Course Code: UG-MAT-Mi-201
Course title: Algebra & Analytical Geometry
Minor Course; Credit-4; Full Marks-80
Course wise Class (L+T+P): 3:1:0

1. Integers, well ordering principle, principle of mathematical induction. Division algorithm ($a = bq + r$, $b \neq 0$, $0 \leq r < b$), greatest common divisor(g.c.d.) of two integers and its simple properties, co-prime integers, Euler's φ-function. Prime numbers, Euclid's theorem, fundamental theorem of arithmetic.

2. Complex Numbers: De Moivre's Theorem and its applications. Exponential, Sine, Cosine and Logarithm of a complex number. Definition of $a^z (a \neq 0)$.

3. Polynomials with real coefficients, Fundamental Theorem of Algebra (Statement only): The n-th degree polynomial equation has exactly n roots. Nature of roots of an equation (surd or complex roots occur in pairs). Existence of real roots, Descarte's rule of sign and application of intermediate value theorem. Relation between roots and coefficients, symmetric functions of roots. Cardan's method of solution of a cubic equation.

4. Matrices with real and complex entries. Inverse of a matrix. Elementary row operations and row reduced Echelon matrix. Rank of a matrix. System of linear equation, consistency and inconsistency of system of linear equation, solution of system of linear equations. Symmetric, skew symmetric, Hermitian, Skew-Hermitian, Unitary and orthogonal matrices.

5. Determinant and its basic properties. Laplace expansion of determinant. Singular and non singular matrix, rank of a matrix in terms of determinants.

6. Transformations of Rectangular axes: Translation, Rotation and their combinations. Invariants.

7. General equation of second degree in x and y: Reduction to canonical forms. Classification of conic.

8. Pair of straight lines: Condition that the general equation of second degree in x and y may represent two straight lines. Point of intersection of two intersecting straight lines. Angle between two lines given by $ax^2 + 2hxy + by^2 = 0$. Equation of bisectors. Equation of two lines joining the origin to the points in which a line meets a conic.

9. Equations of pair of tangents from an external point, chord of contact, poles and polers in case of General conic: Particular cases for Parabola, Ellipse, Circle, Hyperbola. Polar equation of straight lines and circles. Polar equation of a conic referred to a focus as pole. Equation of chord joining two points. Equations of tangent and normal.

10. Three-dimensional coordinate system. Straight line, direction cosine, problems on straight lines. Equation of plane and elementary properties. Sphere and its tangent plane. Right circular cone.

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Reference Books

1. S. L. Loney, The Elements of Coordinate Geometry, Macmillan and Co., 1895.
2. S. Bernard and J.M. Child, Higher Algebra, Macmillan and Co., 1952.
3. T. Andreescu and D. Andrica, Complex Numbers from A to...Z, Birkhauser, 2006.
4. D.C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
5. K.B. Dutta, Matrix and Linear algebra, Prentice-Hall of India Pvt.Ltd., 2004.
6. W.S. Burnside and A.W. Panton, The Theory of equations, Dublin University Press, 1954.
7. R.J.T. Bell, An elementary treatise on coordinate geometry of three dimensions, Macmillan and Co.

B.Sc. Mathematics (Major)
SEMESTER-II
Course Code: UG-MAT-MDC-201
Course title: Basic Mathematics
Multidisciplinary Course; Credit-3; Full Marks-60
Course wise Class (L+T+P): 2:1:0

Set Theory

Introduction to sets and their representations. The empty set, finite and infinite sets, equal sets, subsets, power set, and Universal set.
Venn Diagrams, operations on sets, complement of a set, problems on union and intersection of sets.

Complex Numbers

Polar representation of complex numbers.

De Moivre's theorem (without proof) for rational indices and their applications.

Matrix & Determinant

Definition of a Matrix. Types of Matrices.
Determinant of a square matrix (up to third order). Properties of determinants. Cofactors and minor of a determinant.

Reference:

1. A. Kumar, S. Kumaresan, B.K. Sarma, A Foundation Course in Mathematics, Narosa Publishing House.
2. Bernard and Child: Higher Algebra, Arihant Publications.
3. I. Stewart, D. Tall, The Foundations of Mathematics. Oxford University Press.
4. M.K. Sen, S. Ghosh and P. Mukhopadhyay, Topics in Abstract Algebra, University Press.
5. K.B. Dutta, Matrix and Linear Algebra, Prentice-Hall of India Pvt. Ltd.
6. Shanti Narayan: A Textbook of Matrices, S Chand.

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Signature of the HOD/ Co-Ordinator

B.Sc. Mathematics (Major)
SEMESTER-III
Course Code: UG-MAT-M-301
Course title: Abstract Algebra-I & Linear Algebra-I
Major Course; Credit-4; Full Marks-80
Course wise Class (L+T+P): 3:1:0

Abstract Algebra 1

1. Group, elementary properties of groups. semi-group, integral power (multiple) of an element of a group, order of an element of a group, order of a group, subgroups, centre of a group, centraliser of an element of a group, cyclic group.

2. Permutation, order of a permutation, cycle and transposition, even and odd permutations, symmetric group and alternating group.

3. Coset and Lagrange's theorem – applications.

4. Normal subgroup. Quotient group, homomorphism and its properties, kernel of a homomorphism, first. second and third Isomorphism theorems, Cayley's Theorem. Automorphism, inner automorphism.

Linear Algebra-I

1. Vector space**:** definitions and examples, subspace, union and intersection of subspaces, linear combination, independence and dependence, linear span, linear sum of two subspaces, generators of vector space, dimension of a vector space, examples of infinite dimensional vector space, every vector space has a basis- statement and notion, replacement theorem, extension theorem, contraction theorem, quotient spaces.

2. Row space and column space of a matrix, row rank and column rank of a matrix, equality of row rank and column rank, nullity of a matrix, sum of rank and nullity of a matrix equals the number of columns of the matrix, linear homogeneous system of equations: Solution space, necessary and sufficient condition for consistency of a linear non-homogeneous system of equations.

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References:

1. D. S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of Abstract Algebra, McGraw-Hill.
2. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson.
3. M. Artin, Abstract Algebra, 2nd Ed., Pearson.
4. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi.
5. Joseph J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer Verlag.
6. R. K. Sharma, S. K. Shah and A. G. Shankar, Algebra-I, Pearson.
7. U. M. Swamy, A.R.S.N. Murthy, Algebra, Pearson.
8. I. N. Herstein, Topics in Algebra, Wiley Eastern Limited, India.
9. D.C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
10. K.B. Dutta, Matrix and Linear Algebra. Prentice Hall India Pvt., Ltd., 2004.
11. K. Hoffman and R. Kunze, Linear Algebra. 2nd Ed., Prentice Hall India Pvt., Ltd., 2015

B.Sc. Mathematics (Major)
SEMESTER-III
Course Code: UG-MAT-M-302
Course title: Theory of Real and Vector Functions
Major Course; Credit-4; Full Marks-80
Course wise Class (L+T+P): 3:1:0

Theory of Real Functions

1. Limits of functions (ε - δ approach). Sequential criterion for limits. Divergence criteria. Limit theorems, one-sided limits. Infinite limits and limits at infinity.

2. Continuous functions, neighbourhood property. Sequential criterion for continuity and discontinuity. Algebra of continuous functions. Continuous functions on an interval. Bolzano's Theorem, the intermediate value theorem. Location of roots theorem, preservation of intervals theorem. Uniform continuity, non-uniform continuity criteria, uniform continuity theorem.

3. Differentiability of a function at a point and in an interval. Caratheodory's theorem. Algebra of differentiable functions. Darboux's theorem.

4. Rolle's theorem. Lagrange's and Cauchy's mean value theorems. Taylor's theorem with Lagrange's and Cauchy's forms of remainder. Application of Taylor's theorem to convex functions. Applications of the mean value theorem to inequalities and approximation of polynomials. Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions. Application of Taylor's theorem to inequalities.

5. Relative extrema, interior extremum theorem, sufficient condition for the existence of a local extremum of a function at a point, problems on local maxima and minima.

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Theory of Vector Functions

1. Vector products. Introduction to vector functions, operations with vector-valued functions.

2. Limits and continuity of vector functions. Differentiation and integration of vector functions of one variable.

3. Gradient, divergence, and curl of vector functions

References:

1. R. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons.
2. K. A. Ross, Elementary Analysis: The Theory of Calculus, Springer. 15
3. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill.
4. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill.
5. T. Apostol, Mathematical Analysis, Narosa Publishing House.
6. A. Mattuck, Introduction to Analysis, Prentice Hall.
7. S. R. Ghorpade and B.V. Limaye, a Course in Calculus and Real Analysis, Springer.
8. V. Karunakaran, Real Analysis, Pearson.
9. Courant and John, Introduction to Calculus and Analysis, Vol II, Springer.
10. Terence Tao, Analysis II, Hindustan Book Agency.
11. S. Goldberg, Methods of Real Analysis, Oxford & IBH Publishing.
12. M. S. Speizel, Vector Analysis, McGraw Hill Education.

B.Sc. Mathematics (Major)
SEMESTER-III
Course Code: UG-MAT-SEC-301
Course title: Programming in C (Theory & Practical)
Skill Enhancement Course; Credit-3; Full Marks-60
Course wise Class (L+T+P): 1:0:2

Programming in C (Theory &Practical)

1. Brief historical development. Computer generation. Basic structure and elementary ideas of computer systems, operating systems, hardware and software. Positional number systems: Binary, octal, decimal, hexadecimal systems. Binary arithmetic. BIT, BYTE, WORD. Algorithms and flow chart: Important features, ideas about the complexities of algorithms. Application in simple problems.

2. Programming language and importance of 'C' programming. C Character set, keywords, identifiers, constants, variables and data types. Declaration of variables and assigning values to variables. Operations and expressions: Arithmetic operators, relational operators, logical operators, conditional operator, increment and decrement operator. Managing input and output operations. Decision making and branching: Decision making with if statement, if-else statement, nesting if-else statement, else-if ladder, switch statement, break, and continue statement. Decision making and looping: While statement, do-while statement, and for statement. Arrays: One-dimensional, two-dimensional and multidimensional arrays; declaration of arrays; initialization of one and multi-dimensional arrays.

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3. Application to simple problems : Sum of first n natural number, factorial of a given positive integer n, sum of square and cubes of first n natural numbers, sum of some divisibility-restricted integers, sum of digits of a positive integers, testing an integer for primality, H.C.F. and L.C.M. of two given positive integers, sum of square numbers from a set of given positive integers, sum of n arbitrary numbers, first n terms of a sequence and the sums of their terms, squares, and cubes, the perimeter and area of a triangle, solution of quadratic equations with real coefficients, largest and smallest number among a set of given numbers.

References:

1. Yashvant Kanetkar, Let us C, BPB Publications.
2. V. Krishnamoorthy, K.R. Radhakrishnan, Programming in C, Tata McGraw Hilll.
3. Noel Kalicharan, C by Example, Cambridge Low price edition.
4. E. Balagurusamy, Programming in ANSI C, Tata McGraw Hill.
5. C. Xavier, C-Language and Numerical Methods, New Age International.
6. Byron S. Gottfried, Programming with C, McGraw Hill Education.
7. A. N. Kamthane, Programming in C, Pearson.

B.Sc. Mathematics (Major)
SEMESTER-III
Course Code: UG-MAT-Mi-301
Course title: Calculus & Differential Equations
Minor Course; Credit-4; Full Marks-80
Course-wise Class (L+T+P): 3:1:0

1. Prerequisite (Definition, Statement & Applications): Real-valued functions defined on an interval, limit and continuity of a function, algebra of limits, and differentiability of a function. Rolle's Theorem: statement and geometrical interpretation; Mean Value Theorems of Lagrange and Cauchy. Taylor's and Maclaurin's theorems with Lagrange's and Cauchy's forms of remainders. Applications of the principle of maxima and minima for a function of a single variable.

2. Differential Calculus: Higher order derivatives, Leibnitz rule of successive differentiation and its applications; Indeterminate forms, L'Hospital's rule; Basic ideas of Partial derivatives, Chain Rules, Jacobian, Euler's theorem and its converse; Tangents and Normals, Sub-tangent and sub-normals, Derivatives of arc lengths, Pedal equation of a curve; Curvature and radius of curvature; Asymptotes; Envelopes; Concavity, convexity and point of inflexion and Classification of singular points.

3. Integral Calculus: Reduction formulae; Rectification & quadrature of plane curves, length of a curve; Arc length as a parameter; Volume and surface area of revolution.

4. Familiarity with common figures, including cycloid, catenary, lemniscate of Bernoulli, astroid, cardioid, folium of Descartes, equiangular spiral.

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5. Reduction formulae: derivations and illustrations of reduction formulae.

6. First-order differential equations: exact equations and equations reducible to exact equations; Euler's and Bernoulli's equations (linear); Clairaut's equations—general and singular solutions.

7. Second-order differential equations: method of variation of parameters and method of undetermined coefficients.

8. Linear homogeneous differential equations with constant coefficients, method of variation of parameters, and simultaneous differential equations.

REFERENCES:

1. R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore.
2. T. Apostol, Mathematical Analysis, Narosa Publishing House.
3. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill
4. Anton, I. Birens and S. Davis, Calculus, John Wiley and Sons, Inc.
5. G. B. Thomas and R.L. Finney, Calculus, Pearson Education.
6. Santi Narayan, Integral Calculus, S. Chand.
7. S. L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India
8. E. L. Ince, Ordinary Differential Equations, Dover Publications.
9. E. Rukmangadachari, Differential Equations, Pearson.
10. D. Murray, Introductory Course in Differential Equations, Longmans Green and Co.
11. G. F. Simmons, Differential Equations with Applications and Historical Notes, Tata McGraw Hill.

B.Sc. Mathematics (Major)
SEMESTER-IV
Course Code: UG-MAT-M-401
Course title: Abstract Algebra-II
Major Course; Credit-4; Full Marks-80
Course wise Class (L+T+P): 3:1:0

Abstract Algebra -II

1. External and internal direct product of two groups and applications.

2. Class equation, Cauchy's Theorem on finite groups, converse of Lagrange's theorem for finite commutative group, group action, p-group. Sylow's theorems and their applications, simplicity of A_n, for n>=5.

3. Rings- elementary properties, units, characteristic of a ring, subring integral domains, skew fields, fields, subfields properties. every finite integral domain is a field. Wedderburn's theorem (statement only).

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4. Ideals of a commutative ring, quotient ring, ring homomorphism and its properties, first, second and third Isomorphism theorems, ring embedding every integral domain can be embedded in a field.
5. Maximal and prime ideals and the corresponding quotient rings.

References:

1. D. S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of Abstract Algebra, McGraw-Hill.
2. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson.
3. M. Artin, Abstract Algebra, 2nd Ed., Pearson.
4. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi.
5. Joseph J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer Verlag.
6. R. K. Sharma, S. K. Shah and A. G. Shankar, Algebra-I, Pearson.
7. U. M. Swamy, A.R.S.N. Murthy, Algebra, Pearson.
8. I. N. Herstein, Topics in Algebra, Wiley Eastern Limited, India.
9. D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of abstract algebra.
10. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
11. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
12. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, 1999.

B.Sc. Mathematics (Major)
SEMESTER-IV
Course Code: UG-MAT-M-402
Course title: Linear Algebra-II
Major Course; Credit-4; Full Marks-80
Course wise Class (L+T+P): 3:1:0

Linear Algebra-II

1. Linear Transformation: Linear transformation on vector spaces: definition of linear transformation, null space, range space of an linear transformation, rank and nullity, rank-nullity theorem and related problems, isomorphisms, non-singular linear transformation, inverse of linear transformation, matrix of a linear transformation relative to ordered bases of finite-dimensional vector spaces, linear transformation is non-singular iff its representative matrix is non-singular, rank of L.T. = rank of the corresponding matrix.

2. Inner Product Spaces: Euclidean plane and dot product, real and complex inner product spaces, norm, orthogonality, Pythagorean Theorem, Cauchy-Schwarz's inequality, triangle inequality, parallelogram equality, orthonormal basis, Besssel's inequality, Gram-Schmidt's orthogonalization process, linear functionals, Riesz representation theorem, orthogonal complement, direct sum of subspace and its orthogonal complement, orthogonal projection and its properties, orthogonal transformations: reflection, rotation.

3. Diagonalization: invariant subspaces, eigenvalues and eigenvectors and their relevant theorems, diagonalizability criterion, Cayley–Hamilton theorem for square matrices, diagonalization of symmetric matrices. Real quadratic form involving three variables. Reduction to Normal form.

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REFERENCES:

1. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th Ed., Prentice- Hall of India Pvt. Ltd., New Delhi, 2004.
2. S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.
3. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.
4. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.
5. Kenneth Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
6. S.H. Friedberg, A.L. Insel and L.E. Spence, Linear Algebra, Prentice Hall of India Pvt. Ltd., 2004.

B.Sc. Mathematics (Major)
SEMESTER-IV
Course Code: UG-MAT-M-403
Course title: Riemann Integrals & Series of Functions
Major Course; Credit-4; Full Marks-80
Course-wise Class (L+T+P): 3:1:0

1. Partition and refinement of partition of a closed and bounded interval, upper Darboux sum U(P,f) and lower Darboux sum L(P,f) and associated results, upper integral and lower integral, Darboux's theorem, Darboux's definition of integration over a closed and bounded interval.
2. Riemann's definition of integrability, equivalence with Darboux definition of integrability, derivation of results of Darboux integration using Riemann sum.
3. Integrability of sum, scalar multiple, product, quotient, modulus of Riemann integrable functions, properties of Riemann integrable functions arising from the above results.
4. Function defined by definite integral $\int_a^x f(t)\,dt$ and its properties, anti-derivative (primitive or indefinite integral).
5. Fundamental theorem of integral calculus, first mean value theorem of integral calculus, second mean value theorem of integral calculus (both Bonnet's and Weierstrass' form).
6. Integrability of the limit function of sequence of integrable functions and integrability of the sum function of a series of integrable functions, in case of uniform convergence.
7. Pointwise and uniform convergence of a sequence of functions, Cauchy criterion, consequences of uniform convergence (excluding integrability).
8. Pointwise and uniform convergence of a series of functions, Cauchy's principle, Weierstrass' M-test, consequences of uniform convergence (excluding integrability).
9. Power series, radius of convergence, Ratio test, Cauchy – Hadamard theorem. Weierstrass' approximation theorem.

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References:

1. Principles of Mathematical Analysis – Walter Rudin.
2. Mathematical Analysis – T. M. Apostol.
3. Real Analysis – S. K. Mapa.
4. Introduction to Real Analysis – Donald R. Sherbert and Robert G. Bartle

B.Sc. Mathematics (Major)
SEMESTER-IV
Course Code: UG-MAT-M-403
Course title: Multivariate Calculus
Major Course; Credit-4; Full Marks-80
Course wise Class (L+T+P): 3:1:0

Multivariate Calculus

1. Functions of several variables, limit and continuity of functions of two or more variables. Differentiability and total differentiability. Partial differentiation: Sufficient condition for differentiability. Schwarz's theorem, Young's theorem. Chain rule for one and two independent parameters. Homogeneous function and Euler's theorem on homogeneous functions and its converse. Jacobians and functional dependence. Extrema of functions of two variables, method of Lagrange multipliers, and constrained optimization problems.

2. Double integration over a rectangular region. Double integration over non-rectangular regions. Double integrals in polar coordinates, Triple integrals. Triple integral over parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical coordinates. Change of variables in double integrals and triple integrals.

3. Line integrals, applications of line integrals: Mass and work. Fundamental theorem for line integrals, conservative vector fields, and independence of path. Green's theorem, surface integrals, and integrals over parametrically defined surfaces. Stoke's theorem, the divergence theorem. Applications of Green's, Stokes and divergence theorems.

References:

1. M. Spivak, *Calculus on Manifolds*.
2. J. Stewart, *Multivariable Calculus*.
3. T. M. Apostol, *Calculus 2*.
4. W. Rudin, *Principles of Mathematical Analysis*.
5. S. Kumaresan, *A Course in Multivariable Calculus and Analysis*.
6. Theodore Shifrin, *Multivariable Mathematics: Linear Algebra, Multivariable Calculus, and Manifolds*.
7. Anant R Shastri, Elements of Differential Topology

Sushil Kr. Bhuiya

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B.Sc. Mathematics (Major)
SEMESTER-III
Course Code: UG-MAT-Mi-401
Course title: Calculus & Differential Equations
Minor Course; Credit-4; Full Marks-80
Course-wise Class (L+T+P): 3:1:0

1. Prerequisite (Definition, Statement & Applications): Real-valued functions defined on an interval, limit and continuity of a function, algebra of limits, and differentiability of a function. Rolle's Theorem: statement and geometrical interpretation; Mean Value Theorems of Lagrange and Cauchy. Taylor's and Maclaurin's theorems with Lagrange's and Cauchy's forms of remainders. Applications of the principle of maxima and minima for a function of a single variable.

2. Differential Calculus: Higher order derivatives, Leibnitz rule of successive differentiation and its applications; Indeterminate forms, L'Hospital's rule; Basic ideas of Partial derivatives, Chain Rules, Jacobian, Euler's theorem and its converse; Tangents and Normals, Sub-tangent and sub-normals, Derivatives of arc lengths, Pedal equation of a curve; Curvature and radius of curvature; Asymptotes; Envelopes; Concavity, convexity and point of inflexion and Classification of singular points.

3. Integral Calculus: Reduction formulae; Rectification & quadrature of plane curves, length of a curve; Arc length as a parameter; Volume and surface area of revolution.

4. Familiarity with common figures, including cycloid, catenary, lemniscate of Bernoulli, astroid, cardioid, folium of Descartes, equiangular spiral.

5. Reduction formulae: derivations and illustrations of reduction formulae.

6. First-order differential equations: exact equations and equations reducible to exact equations; Euler's and Bernoulli's equations (linear); Clairaut's equations—general and singular solutions.

7. Second-order differential equations: method of variation of parameters and method of undetermined coefficients.

8. Linear homogeneous differential equations with constant coefficients, method of variation of parameters, and simultaneous differential equations.

Sushil Kr. Bhuya

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REFERENCES:

1. R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore.
2. T. Apostol, Mathematical Analysis, Narosa Publishing House.
3. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill
4. Anton, I. Birens and S. Davis, Calculus, John Wiley and Sons, Inc.
5. G. B. Thomas and R.L. Finney, Calculus, Pearson Education.
6. Santi Narayan, Integral Calculus, S. Chand.
7. S. L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India
8. E. L. Ince, Ordinary Differential Equations, Dover Publications.
9. E. Rukmangadachari, Differential Equations, Pearson.
10. D. Murray, Introductory Course in Differential Equations, Longmans Green and Co.
11. G. F. Simmons, Differential Equations with Applications and Historical Notes, Tata McGraw Hill.

Sushil Kr. Bhuya

Signature of the HOD/ Co-Ordinator
Department of Mathematics
Murshidabad Maharaja Krishnanath University, Berhampore