Draft Syllabus
for
Four-Year (Eight-Semester)
B.Sc. Degree Course
in
Mathematics

University of Gour Banga
Malda-732103
West Bengal

SEMESTER I

Duration: 6 Months (Including Examinations)
Total 22 credits (Marks: ***)
Total No. of Lectures: ** Hours per paper

Semester	Course Code	Course Name	Marks (Credits)
I	MC-1	Calculus & Geometry	** (4)
	MC-2	Algebra	** (4)
	MDC-1	********	** (3)
	MnC-1	Classical Algebra & Analytical Geometry	** (4)
	MIL-1	*******	** (2)
	SEC-1	Number Theory & Boolean Algebra	** (3)
	ENVS	*******	** (2)

MC-1
Calculus & Geometry
Full Marks: ** (Credit: 4)

Unit-1
Real-valued functions defined on an interval, limit of a function (Cauchy's definition). Algebra of limits. Continuity of a function at a point and in an interval. Acquaintance with the important properties of continuous functions no closed intervals. Hyperbolic functions, higher order derivatives, Leibnitz rule of successive differentiation and its applications to problems of type $e^{ax}+b\sin x$, $e^{ax}+b\cos x$, $(ax+b)^n\sin x$, $(ax+b)^n\cos x$, concavity and inflection points, envelopes, asymptotes.

Unit-2
Reduction formulae, derivations and illustrations of reduction formulae of the type integration of $\sin^n x$, $\cos^n x$, $\tan^n x$, $\sec^n x$, $(\log x)^n$, $\sin^n x \sin^m x$, evaluation of definite integrals, integration as the limit of a sum, concept of improper integration, use of Beta and Gamma functions. parametric equations, parametrizing a curve, arc length, arc length of parametric curves, area of surface of revolution.

Unit-3
Reflection properties of conics, translation and rotation of axes and second degree equations, reduction and classification of conics using the discriminant, Point of intersection of two intersecting straight lines. Angle between two lines, Equation of bisectors. Equation of two lines joining the origin to the points in which a line meets a conic. Equations of pair of tangents from an external point, chord of contact, Polar equations of straight lines and conics. Equation of chord joining two points. Equations of tangent and normal.

Unit-4
Aquaintance of plane and straight line in 3D may be assumed. Spheres. Cylindrical surfaces. Central conicoids, paraboloids, plane sections of conicoids, Generating lines, reduction and classification of quadrics.

References

[1] S.L. Loney, The Elements of Coordinate Geometry, Macmillan and Co., 1895.

[2] G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson, 2005.

[3] M.J. Strauss, G.L. Bradley and K.J. Smith, Calculus, 3rd Ed., Pearson Education, 2007.

[4] H. Anton, I. Bivens and S. Davis, Calculus, 10th Ed., John Wiley and Sons Inc., 2012.

[5] R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer, 1989.

[6] T.M. Apostol, Calculus (Volumes I & II), John Wiley & Sons, 1967.

[7] S. Goldberg, Calculus and mathematical analysis.

[8] S. Lang, A First Course in Calculus, Springer 1998.

[9] K.A. Ross, Elementary Analysis: The Theory of Calculus, Springer, 2nd ed., 2013.

[10] R.J.T. Bell, An Elementary Treatise on Coordinate Geometry of Three Dimensions, Macmillan Publishers India Limited, 2000.

MC-2
Algebra
Full Marks: 50 (Credit: 4)

Unit-1
Polar representation of complex numbers, n-th roots of unity, De Moivre's theorem for rational indices and its applications. Inequality: The inequality involving $AM \geq GM \geq HM$, m-th power theorem, Cauchy-Schwartz inequality. Maximum and minimum values of a polynomials.

Unit-2
General properties of equations, Fundamental theorem of classical algebra (statement only) and its application, Transformation of equation, Descarte's rule of signs positive and negative rule, Strum's theorem, Relation between the roots and the coefficients of equations. Symmetric functions. Applications of symmetric function of the roots. Solutions of reciprocal and binomial equations. Algebraic solutions of the cubic (Cardon's) and biquadratic (Ferrari's).

Unit-3
Equivalence relations and partitions, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set. Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm. Congruence relation between integers. Principles of Mathematical Induction, statement of Fundamental Theorem of Arithmetic.

Unit-4
Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation $Ax = b$, solution sets of linear systems, applications of linear systems, linear independence. Real Quadratic Form involving not more than three variables. Characteristic equation of square matrix of order not more than three determination of Eigen Values and Eigen Vectors. Cayley-Hamilton Theorem.

References

[1] T. Andreescu and D. Andrica, Complex Numbers from A to . . . Z, Birkhauser Boston, 2008.

[2] D.C. Lay, S.R. Lay and J.J. McDonald, Linear Algebra and its Applications, 5rd Ed., Pearson, 2014.

[3] K.B. Dutta, Matrix and linear algebra, Prentice Hall, 2004.

[4] K. Hoffman and R. Kunze, Linear algebra, Prentice Hall, 1971.

[5] W.S. Burnstine and A.W. Panton, Theory of equations, Nabu Press, 2011.

[6] S.H. Friedberg, A.J. Insel and L.E. Spence, Linear Algebra, 4th Ed., PHI, 2004.

[7] S. Bernard and J.M. Child, Higher Algebra, Macmillan and Co. 1952.

MnC-1
Classical Algebra & Analytical Geometry
Full Marks: ** (Credit: 4)

Algebra

Unit-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.

Congruence relation, linear congruence and simple problems related to linear congruence, congruence class, Chinese Remainder Theorem and simple problems.

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

Unit-2

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.

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.

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

Analytical Geometry

Unit-3

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

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

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.

Unit-4

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.

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.

References

[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.

SEC-1
Number Theory & Boolean Algebra
Full Marks: ** (Credit: 3)

Number Theory

Unit-1

Integers: Principle of Mathematical Induction. Division Algorithm. Representation of integer in an arbitrary base. Prime Integers. Fundamental theorem of Arithmetic. Euclid's Theorem. Linear Diophantine equations.

Congruences: Congruence relation on integers, Basic properties of this relation. Linear Congruence. Chinese Remainder Theorem, System of Linear Congruences.

Unit-2

Application of Congruences: Divisibility test. Computer file, Starage and Hashing functions. Round-Robin Tournaments. Check-digit in an ISBN, in Universal Product code, in Major Credit Cards. Error detecting capability.
Congruence Classes: Addition and Multiplication of Congruence Classes. Fermat's little Theorem. Euler's Theorem. Wilson's Theorem. Some simple applications.

Boolean Algebra

Unit-3

Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, lattices as ordered sets, lattices as algebraic structures, sublattices, products and homomorphisms.

Unit-4

Definition, examples and properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal and maximal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, Logic Gates, switching circuits and applications of switching circuits.

References

[1] B.A. Davey and H.A. Priestley, Introduction to Lattices and Order, Cambridge University Press, 1990.

[2] E.G. Goodaire and M.M. Parmenter, Discrete Mathematics with Graph Theory, (2nd Ed.), Pearson Education (Singapore) P.Ltd., Indian Reprint 2003.

[3] R. Lidl and G. Pilz, Applied Abstract Algebra, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.

[4] D.M. Burton, Elementary Number Theory, 6th Ed., Tata McGraw Hill, Indian reprint, 2007.

[5] N. Robinns, Beginning Number Theory, 2nd Ed., Narosa Publishing House Pvt. Ltd., Delhi, 2007

[6] G.A. Jones and J.M. Jones, Elementary Number Theory, Springer International Edition.

[7] N. Koblitz, A course in number theory and cryptography, Springer-Verlag, 2nd edition.

[8] K.H. Rosen, Elementary Number Theory & Its Applications, AT&T Bell Laboratories, Addition-Wesley Publishing Company, 3rd Edition.

[9] K. Ireland and M. Rosen, A Classical Introduction to Modern Number Theory, 2nd edition, Springer-verlag.

[10] R.A. Mollin, Advanced Number Theory with Applications, CRC Press, A Chapman & Hall Book.

SEMESTER II

Duration: 6 Months (Including Examinations)
Total 22 credits (Marks: ***)
Total No. of Lectures: ** Hours per paper

Semester	Course Code	Course Name	Marks (Credits)
II	MC-3	Real Analysis I	** (4)
	MC-4	Abstract Algebra	** (4)
	MDC-2	********	** (3)
	MnC-2	Calculus & Differential Equations	** (4)
	MIL-2	*******	** (2)
	SEC-2	Set Theory	** (3)
	*****	*******	** (2)

MC-3
Real Analysis I
Full Marks: ** (Credit: 4)

Unit-1

Development of real numbers. The algebraic properties of $\mathbb{R}$, rational and irrational numbers, the order properties of $\mathbb{R}$. Absolute value and the real line, bounded and unbounded sets in $\mathbb{R}$, supremum and infimum, neighbourhood of a point. The completeness property of $\mathbb{R}$, the Archimedean property, density of rational numbers in $\mathbb{R}$, nested intervals property, binary representation of real numbers, uncountability of $\mathbb{R}$. Closed set, open set, closure and interior of a subset of the real line.

Unit-2

Sequences, the limit of a sequence and the notion of convergence, bounded sequences, limit theorems, squeeze theorem, monotone sequences, monotone convergence theorem. Subsequences, monotone subsequence theorem and the Bolzano-Weierstrass theorem, the divergence criterion, limit superior and limit inferior of a sequence, Cauchy sequences, Cauchy's convergence criterion. Infinite series, convergence and divergence of infinite series. Tests for Convergence: Comparison test, root test, ratio test, integral test. Alternating series, absolute and conditional convergence.

Unit-3

Sequential criterion for limits, divergence criteria. Limit theorems, infinite limits and limits at infinity. Continuous functions, sequential criterion for continuity and discontinuity. Algebra of continuous functions. Continuous functions on an interval, intermediate value theorem, location of roots theorem, preservation of intervals theorem. Uniform continuity, non-uniform continuity criteria, uniform continuity theorems.

Unit-4

Differentiability of a function at a point and in an interval, Caratheodory's theorem, chain rule, derivative of inverse functions, algebra of differentiable functions. Mean value theorems, Rolle's Theorem, Lagrange's mean value theorem. Applications of mean value theorem to inequalities, relative extremum. The intermediate value property of derivatives, Darboux's theorem. L'Hospital's rule. Taylor's theorem and its application. Expansion of functions.

References

[1] R.G. Bartle and D.R. Sherbert, Introduction to Real Analysis, 3rd Ed., Wiley, 2000.

[2] G.G. Bilodeau , P.R. Thie and G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones & Bartlett, 2009.

[3] B.S. Thomson, A.M. Bruckner and J.B. Bruckner, Elementary Real Analysis, Prentice Hall, 2001.

[4] S.K. Berberian, A First Course in Real Analysis, Springer, 1998.

[5] T.M. Apostol, Mathematical Analysis, Narosa, 2002.

[6] R. Courant and F. John, Introduction to Calculus and Analysis, Vol I, Springer, 1999.

[7] W. Rudin, Principles of Mathematical Analysis, McGraw Hill, 2017.

[8] C.C. Pugh, Real Mathematical Analysis, Springer, 2002.

[9] T. Tao, Analysis I, Hindustan Book Agency, 2006

[10] S. Goldberg, Calculus and mathematical analysis.

[11] H.R. Beyer, Calculus and Analysis, Wiley, 2010.

[12] S. Lang, Undergraduate Analysis, Springer, 2nd Ed., 1997.

[13] A. Kumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2014.

MC-4
Abstract Algebra
Full Marks: ** (Credit: 4)

Unit-1
Definition and examples of groups, elementary properties of groups. Subgroups and examples of subgroups, centralizer, normalizer, center of a group. Properties of cyclic groups, classification of subgroups of cyclic groups. Permutation group, cycle notation for permutations, properties of permutations, even and odd permutations, alternating group. Cosets, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem. Normal subgroup and quotient group.

Unit-2
Group homomorphisms, properties of homomorphisms, properties of isomorphisms. First, Second and Third isomorphism theorems. External direct product of a finite number of groups, Cauchy's theorem for finite abelian groups. Cayley's theorem,

Unit-3
Definition and examples of rings, elementary properties of rings, subrings, integral domains and fields, characteristic of a ring. Ring homomorphisms, properties of ring homomorphisms.

Unit-4
Ideal, First Isomorphism theorem. Isomorphism theorems II and III, field of quotients. Elementary properties of field. Introduction to polynomial ring.

References

[1] J.B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.

[2] M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.

[3] J.A. Gallian, Contemporary Abstract Algebra, 8th Ed., Houghton Mifflin, 2012.

[4] J.J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer, 1995.

[5] I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, 1975.

[6] D.S. Malik, J.M. Mordeson and M.K. Sen, Fundamentals of Abstract Algebra, McGraw Hill, 1996.

[7] D.S. Dummit and R.M. Foote, Fundamentals of Abstract Algebra, 3rd Ed., Wiley, 2003.

[8] M.K. Sen, S. Ghosh, P. Mukhopadhyay and S.K. Maiti, Topics in Abstract Algebra, 3rd Ed., Universities Press, 2019.

MnC-2
Calculus & Differential Equations
Full Marks: ** (Credit: 4)

Calculus

Unit-1

Set, relation, mapping. Real number system, the algebraic and order properties of $\mathbb{R}$. The least upper bound property of real numbers, the Archimedean property.

Sequence of real numbers: Definition of bounds of a sequence and monotone sequence. Limit of a sequence. Statements of limit theorems. Concept of convergence and divergence of monotone sequences-applications of the theorems, in particular, definition of e. Statement of Cauchy's general principle of convergence and its application.

Infinite series of constant terms, Convergence and Divergence (definitions). Cauchy's principle as applied to infinite series (application only). Series of positive terms: Statements of comparison test. D.Alembert's Ratio test. Cauchy's n-th root test and Raabe's test and their applications. Alternating series. Statement of Leibnitz test and its applications.

Unit-2

Real function, the limit of a function, basic limit theorems. Definition of continuity, composite function and continuity, intermediate value property, the process of inversion, the extreme value theorem for continuous function.

Derivative of a function, algebra of derivatives, geometric interpretation of derivative as a slope, chain rule. Successive differentiation.

Mean value theorems for derivatives, Rolle's theorem and Lagrange's mean value theorem. Statements of Taylor's and Maclaurin's Theorems with Lagrange's and Cauchy's from of remainders. Taylor's and Maclaurin's Infinite series of functions like e^x, $\sin x$, $\cos x$, $(1+x)^n$, $\log(1+x)$ with restrictions wherever necessary. Indeterminate Forms: L'Hospital's Rule: Statement and Problems only. Application of the principle of local extrema for a function of single variable in geometrical, physical and to other problems.

Unit -3

Evaluation of definite integrals.Integration as the limit of a sum (with equally spaced as well as unequal intervals), Riemann's definition for definite integrals. Fundamental theorem of calculus and its applications.

Reduction formulae of $\int \sin^n x \cos^m x\, dx$, $\int \frac{\sin^n x}{\cos^m x}\, dx$, $\int \tan^n x\, dx$ and associated problems (m and n are non-negative integers).

Definition of Improper Integrals: Statements of (i) μ-test (ii) Comparison test (Limit from excluded) - Simple problems only. Use of Beta and Gamma functions (convergence and important relations being assumed).

Differential Equations
Unit-4
Order, degree and solution of an ordinary differential equation (ODE) in presence of arbitrary constants. Formation of ODE. Solution of first order ODE, exact and non exact equations.

First order linear equations, Euler's and Bernoulli's equations. Nonlinear equations: Clairaut's equations, general and singular solutions.

Second order linear equations: Linear homogeneous equations with constant coefficients, Linear non-homogeneous equations, The method of variation of parameters, The Cauchy-Euler equation, Simultaneous differential equations.

References

[1] G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.

[2] G.F. Simmons, Differential Equations with Applications and Historical Notes, Tata McGraw Hill.

[3] M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.

[4] H. Anton, I. Bivens and S. Davis, Calculus, 7th Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.

[5] R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer-Verlag, New York, Inc., 1989.

[6] T.M. Apostol, Calculus, Volume I and II, Wiley.

[7] R.R. Goldberg, Methods of Real Analysis, Oxford and Ibh, 2012.

[8] K.A. Ross, Elementary Analysis: The Theory of Calculus, Springer, 2nd ed., 2013.

[9] D. Murray, Introductory Course in Differential Equations, Longmans Green and Co.

[10] S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.

[11] S. Lang, A First Course in Calculus, Springer.

SEC-2
Set Theory
Full Marks: ** (Credit: 3)

Unit-1

Sets, subsets, Set operations, The laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. Empty set, properties of empty set. Standard set operations. Classes of sets. Power set of a set.

Unit-2

Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections. Cardinality of a set, Concept of Countable and Uncountable set.

Unit-3

Relation: Cartesian Product of sets. Composition of relations, Types of relations, Partitions, Equivalence Relations, Examples of congruence modulo relation and examples in $\mathbb{Z}$. Binary operations on set, Functions.

Unit-4

Partial ordering relations, n-ary relations, Hasse diagram, greatest and least element in a poset. Lattice, distributive lattice, boolean algebra.

References

[1] R.P. Grimaldi, Discrete and combinatorial mathematics: An Applied Introduction, Pearson Education, 2004.

[2] P.R. Halmos, Naive Set Theory, Springer, 1974.

[3] E. Kamke, Theory of Sets, Dover Publishers, 1950.