SYLLABUS
FOR
B.SC. HONOURS IN MATHEMATICS

Under

Choice Based Credit System

(CBCS)

Effective from the academic session 2019-2020

KAZI NAZRUL UNIVERSITY

ASANSOL-713 340, PASCHIM BARDHAMAN

WEST BENGAL

SEMESTER I

CORE COURSE-1

Course code: BSCHMTMC101
Calculus, Geometry & Differential Equations (Full Marks: 50)

Unit -1: Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to problems of type $e^{ax+b}sinx, e^{ax+b}cosx, (ax+b)^n sinx, (ax+b)^n cosx$, concavity and inflection points, envelopes, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule, applications in business, economics and life sciences.

Unit-2: Reduction formulae, derivations and illustrations of reduction formulae for the integration of sin $nx, cosnx, tan\, nx, sec\, nx, (log\, x)^n, \sin^n x \sin^m x$, parametric equations, parametrizing a curve, arc length, arc length of parametric curves, area of surface of revolution. Techniques of sketching conics.

Unit -3: Reflection properties of conics, translation and rotation of axes and second degree equations, classification of conics using the discriminant, polar equations of conics. Spheres. Cylindrical surfaces. Central conicoids, paraboloids, plane sections of conicoids, Generating lines, classification of quadrics, Illustrations of graphing standard quadric surfaces like cone, ellipsoid.

Unit -4: Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations.

Graphical Demonstration (Teaching Aid)

1. Plotting of graphs of function $\mathrm{e}^{\mathrm{ax+b}}, \log(\mathrm{ax+b}), 1/(\mathrm{ax+b}), \sin(\mathrm{ax+b}), \cos(\mathrm{ax+b}), |\mathrm{ax+b}|$ and to illustrate the effect of a and b on the graph
2. Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.
3. Sketching parametric curves (Eg. Trochoid, cycloid, epicycloids, hypocycloid).
4. Obtaining surface of revolution of curves.
5. Tracing of conics in Cartesian coordinates/polar coordinates.
6. Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic paraboloid, and hyperbolic paraboloid using Cartesian coordinates

References:

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.
3. H. Anton, I. Bivens and S. Davis, Calculus, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.
4. R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer-Verlag, New York, Inc., 1989.
5. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
6. Murray, D., Introductory Course in Differential Equations, Longmans Green and Co. 1897.
7. G.F.Simmons, Differential Equations, Tata Mcgraw Hill, 1991.

8. T. Apostol, Calculus, Volumes I and II. Vol-I, 1966, Vol-II, 1968.
9. S. Goldberg, Calculus and Mathematical analysis, 1989.

CORE COURSE-2

Course code: BSCHMTMC102
Algebra (Full Marks: 50)

Unit -1: Polar representation of complex numbers, n-th roots of unity, De Moivre's theorem for rational indices and its applications.
Theory of equations: Relation between roots and coefficients, Transformation of equation, Descartes rule of signs,
Cubic and biquadratic equations. Reciprocal equation, separation of the roots of equations, Strum's theorem.
Inequality: The inequality involving $AM \geq GM \geq HM,$ Cauchy-Schwartz inequality

Unit-2: 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 -3: 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.

Unit -4: Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Vector Spaces of R^n, Subspaces of R^n, dimension of subspaces of R^n, rank of a matrix, Eigen values, Eigen Vectors and Characteristic Equation of a matrix. Cayley-Hamilton theorem and its use in finding the inverse of a matrix.

References:

1. Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006.
2. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
3. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
4. K.B. Dutta, Matrix and linear algebra, 2004.
5. K. Hoffman, R. Kunze, Linear algebra, 1971.
6. W.S. Burnstine and A.W. Panton, Theory of equations, 2007.

SEMESTER II

CORE COURSE-3

Course code: BSCHMTMC201
Real Analysis (Full Marks: 50)

Unit-1: Review of Algebraic and Order Properties of ℝ, ε-neighbourhood of a point in ℝ .Idea of countable sets, uncountable sets and uncountability of ℝ.. Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets. Suprema and Infima. Completeness Property of ℝ and its equivalent properties. The Archimedean Property, Density of Rational (and Irrational) numbers in $\mathbb{R}$, Intervals. Limit points of a set, Isolated points, Open set, closed set, derived set, Illustrations of Bolzano-Weierstrass theorem for sets, compact sets in $\mathbb{R}$, Heine-Borel Theorem.

Unit-2: Sequences, Bounded sequence, Convergent sequence, Limit of a sequence, liminf, lim sup. Limit Theorems. Monotone Sequences, Monotone Convergence Theorem. Subsequences, Divergence Criteria.Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences.Cauchy sequence, Cauchy's Convergence Criterion.

Unit-3: Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's nth root test, Raabe's test, Gauss test, Cauchy condensation test, Integral test. Alternating series, Leibniz test. Absolute and Conditional convergence.

Graphical Demonstration (Teaching Aid)
1. Plotting of recursive sequences.
2. Study the convergence of sequences through plotting.
3. Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot.
4. Study the convergence/divergence of infinite series by plotting their sequences of partial sum.
5. Cauchy's root test by plotting nth roots.
6. Ratio test by plotting the ratio of n^{th} and $(n+1)^{th}$ term.

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. Tom M. Apostol, Mathematical Analysis, Narosa Publishing House, 1981.
6. Courant and John, Introduction to Calculus and Analysis, Vol I, Springer, 1999.
7. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill, 1953.
8. Terence Tao, Analysis I, Hindustan Book Agency, 2006
9. S. Goldberg, Calculus and mathematical analysis, 1989.

CORE COURSE-4

Course code: BSCHMTMC202
Differential Equations and Vector Calculus (Full Marks: 50)

Unit-1: Lipschitz condition and Picard's Theorem (Statement only). General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters.

Unit -2: 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: Two Equations in two unknown functions.

Unit-3: Equilibrium points, Interpretation of the phase plane. Power series solution of a differential equation about an ordinary point, solution about a regular singular point.

Unit- 4: Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions.

Graphical Demonstration (Teaching Aid) :
1. Plotting of family of curves which are solutions of second order differential equation.
2. Plotting of family of curves which are solutions of third order differential equation.

References:

1. Belinda Barnes and 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, 2009.
2. C.H. Edwards and D.E. Penny, Differential Equations and Boundary Value problems Computing and Modeling, Pearson Education India, 2005.
3. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
4. Martha L Abell, James P Braselton, Differential Equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press, 2004.
5. Murray, D., Introductory Course in Differential Equations, Longmans Green and Co, 1897.
6. Boyce and Diprima, Elementary Differential Equations and Boundary Value Problems, Wiley, 2012.
7. G.F.Simmons, Differential Equations, Tata McGraw Hill, 1991.
8. Marsden, J., and Tromba, Vector Calculus, McGraw Hill, 1987.
9. Maity, K.C. and Ghosh, R.K., Vector Analysis, New Central Book Agency (P) Ltd. Kolkata (India), 1999.
10. M. R. Speigel, Schaum's outline of Vector Analysis, McGraw Hill, 1980.

SEMESTER III

CORE COURSE-5

Course code: BSCHMTMC301
Theory of Real Functions & Introduction to Metric Space (Full Marks: 50)

Unit -1: Limits of functions (ε-δ approach), sequential criterion for limits, divergence criteria. Limit theorems, one sided limits. 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, theorems on uniform continuity.

Unit -2: Differentiability of a function at a point and in an interval, Caratheodory's theorem, algebra of differentiable functions. Relative extrema, interior extremum, Rolle's theorem. Mean value theorem, intermediate value property of derivatives, Darboux's theorem. Applications of mean value theorem to inequalities and approximation of polynomials, Application of differential calculus: Curvature

Unit-3:Cauchy's mean value theorem. Taylor's theorem with Lagrange's form of remainder, Taylor's theorem with Cauchy's form of remainder, application of Taylor's theorem to convex functions, relative extrema. Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions, $ln(1 + x), 1/ax + b \; and \; (1 + x)^n$. Application of Taylor's theorem to inequalities.

Unit-4: Metric spaces: Definition and examples. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, subspaces, dense sets, separable spaces.

References:

1. R. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons, 2003.
2. K.A. Ross, Elementary Analysis: The Theory of Calculus, Springer, 2004.
3. A, Mattuck, Introduction to Analysis, Prentice Hall, 1999.
4. S.R. Ghorpade and B.V. Limaye, a Course in Calculus and Real Analysis, Springer, 2006.
5. Tom M. Apostol, Mathematical Analysis, Narosa Publishing House, 2002.
6. R. Courant and F. John, Introduction to Calculus and Analysis, Vol II, Springer, 1999.
7. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill, 2017.
8. Terence Tao, Analysis II, Hindustan Book Agency, 2006
9. Satish Shirali and Harikishan L. Vasudeva, Metric Spaces, Springer Verlag, London, 2006
10. S. Kumaresan, Topology of Metric Spaces, 2nd Ed., Narosa Publishing House, 2011.
11. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 2004.

CORE COURSE-6

Course code: BSCHMTMC302
Group Theory–I (Full Marks: 50)

Unit-1: Symmetries of a square, Dihedral groups, definition and examples of groups including permutation groups and quaternion groups (through matrices), elementary properties of groups.

Unit-2: Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups.

Unit-3: Properties of cyclic groups, classification of subgroups of cyclic groups, Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem.

Unit-4: External direct product of a finite number of groups, normal subgroups, factor groups, Cauchy's theorem for finite abelian groups.

Unit-5: Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms, First, Second and Third isomorphism theorems.

References:

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., 1999.
4. I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.
5. D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of Abstract Algebra, 1997

CORE COURSE-7

Course code: BSCHMTMC303
Numerical Methods & Numerical Methods Lab (Full Marks: 50)
(Theory: 30 Marks, Practical: 20 Marks)

Numerical Methods (30 marks)

Unit-1: Algorithms, Convergence, Errors: Relative, Absolute. Round off, Truncation.

Unit-2: Transcendental and Polynomial equations: Bisection method, Newton's method, Secant method, Regula-falsi method, fixed point iteration, Newton-Raphson method. Rate of convergence of these methods.

Unit -3: System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis, LU Decomposition.

Unit-4: Interpolation: Lagrange and Newton's methods, Error bounds, Finite difference operators. Gregory forward and backward difference interpolations.
Numerical differentiation: Methods based on interpolations, methods based on finite differences.

Unit–5: Numerical Integration: Newton Cotes formula, Trapezoidal rule, Simpson's $1/3^{rd}$ rule, Simpsons $3/8^{th}$ rule, Weddle's rule, Boole's rule. Midpoint rule, Composite Trapezoidal rule, Composite Simpson's $1/3^{rd}$ rule, Gauss quadrature formula.
The algebraic eigenvalue problem: Power method.

Unit -6: Ordinary Differential Equations: The method of successive approximations, Euler's method, the modified Euler method, Runge-Kutta methods of orders two and four.

Numerical Methods Lab (20 marks)
Lab notebook & Viva Voce: 5 marks
Numerical Problem: 15 marks (Working formula: 2, Algorithm: 3, Program: 8, Result: 2)

List of practical problems (using C programming)
1. Solution of transcendental and algebraic equations by
(a) Newton Raphson method.
(b) Regula Falsi method.

2. Solution of system of linear equations
(a) Gaussian elimination method
(b) Gauss-Seidel method

3. Interpolation: Lagrange Interpolation

4. Numerical Integration
(a) Trapezoidal Rule
(b) Simpson's one third rule

5. Solution of 1^{st} order ordinary differential equations: Fourth order Runge Kutta method

Reference:

1. Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering, 2012.
3. Nayak, P.K., Numerical Analysis: Theory & Applications, Asian Books Pvt. Ltd.
4. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.

5. Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed., PHI Learning Private
6. John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012.
7. Scarborough, James B., Numerical Mathematical Analysis, Oxford and IBH publishing co, 1966.
8. Atkinson, K. E., An Introduction to Numerical Analysis, John Wiley and Sons, 1978.
9. Yashavant Kanetkar, Let Us C, BPB Publications, 2016..

SKILL ENHANCEMENT COURSE-1

(Choose any one from the following)

Course code: BSCHMTMSE301
Logic and Sets (Full Marks: 50)

Unit -1: Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.

Unit -2: Sets, subsets, Set operations and 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 -3: Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections. Relation: Product set. Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation. Partial ordering relations, n- ary relations.

Reference:

1. R.P. Grimaldi, Discrete Mathematics and Combinatorial Mathematics, Pearson Education, 1998.
2. P.R. Halmos, Naive Set Theory, Springer, 1974.
3. E. Kamke, Theory of Sets, Dover Publishers, 1950.

Course code: BSCHMTMSE302
Programming Language in C (Full Marks: 50)

Unit-1: An overview of theoretical computers, history of computers, overview of architecture of computer, compiler, assembler, machine language, high level language, object oriented language, programming language and importance of C programming.

Unit-2: Constants, Variables and Data type of C-Program: Character set. Constants and variables data types, expression, assignment statements, declaration. Operation and Expressions: Arithmetic operators, relational operators, logical operators.

Unit-3: Decision Making and Branching: decision making with if statement, if-else statement, Nesting if statement, switch statement, break and continue statement. Control Statements: While statement, do-while statement, for statement.

Unit-4: Arrays: One-dimension, two-dimension and multidimensional arrays, declaration of arrays, initialization of one and multi-dimensional arrays.

Unit-5: User-defined Functions: Definition of functions, Scope of variables, return values and their types, function declaration, function call by value, Nesting of functions, passing of arrays to functions, Recurrence of function.

References:

1. B. W. Kernighan and D. M. Ritchi: The C-Programming Language, 2nd Edi. (ANSI Refresher), Prentice Hall, 1977.
2. E. Balagurnsamy: Programming in ANSI C, Tata McGraw Hill, 2004.
3. Y. Kanetkar: Let Us C; BPB Publication, 1999.
4. C. Xavier: C-Language and Numerical Methods, New Age International.
5. V. Rajaraman: Computer Oriented Numerical Methods, Prentice Hall of India, 1980.

SEMESTER IV

CORE COURSE-8

Course code: BSCHMTMC401
Riemann Integration and Series of Functions (Full Marks: 50)

Unit -1: Riemann integration: inequalities of upper and lower sums, Darbaux integration, Darbaux theorem, Riemann conditions of integrability, Riemann sum and definition of Riemann integral through Riemann sums, equivalence of two Definitions. Riemann integrability of monotone and continuous functions, Properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions.
Intermediate Value theorem for Integrals, Fundamental theorem of Integral Calculus.

Unit-2: Improper integrals, Convergence of Beta and Gamma functions.

Unit-3: Pointwise and uniform convergence of sequence of functions. Theorems on continuity, derivability and integrability of the limit function of a sequence of functions. Series of functions, Theorems on the continuity and derivability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M-Test.

Unit -4: Fourier series: Definition of Fourier coefficients and series, Riemann- Lebesgue lemma, Bessel's inequality, Parseval's identity, Dirichlet's condition. Examples of Fourier expansions and summation results for series.

Unit -5: Power series, radius of convergence, Cauchy Hadamard Theorem. Differentiation and integration of power series; Abel’s Theorem; Weierstrass Approximation Theorem.

References:

1. K.A. Ross, Elementary Analysis, The Theory of Calculus, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
2. R.G. Bartle and D.R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
3. Charles G. Denlinger, Elements of Real Analysis, Jones & Bartlett (Student Edition), 2011.
4. S. Goldberg, Calculus and Mathematical analysis.
5. Santi Narayan, Integral calculus, S Chand, 2005..
6. T. Apostol, Calculus I, II, Wiley, 2007.

CORE COURSE-9

Course code: BSCHMTMC402
Multivariate Calculus (Full Marks: 50)

Unit-1: Functions of several variables, limit and continuity of functions of n variables, Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, directional derivatives, the gradient, Jacobian, maximal and normal property of gradient, tangent planes, Implicit function theorem. Extrema of functions of n variables with necessary and sufficient conditions, method of Lagrange multipliers.

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

Unit-3: Vector operators, Gradient of a scalar function, directional derivatives, Definition of vector field, divergence and curl. Line integrals, Fundamental theorem for line integrals, conservative vector fields, Application of line integral to Workdone.

Unit-4: Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stoke's theorem, The Divergence theorem.

References:

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.
3. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer (SIE), Indian reprint, 2005.
4. James Stewart, Multivariable Calculus, Concepts and Contexts, 2nd Ed., Brooks Cole, Thomson Learning,USA, 2001
5. Tom M. Apostol, Mathematical Analysis, Narosa Publishing House, 2nd Ed.,2002
6. Courant and John, Introduction to Calculus and Analysis, Vol II, Springer New York, 2012
7. W. Rudin, Principles of Mathematical Analysis, Tata McGraw-Hill, 3rd Ed.,2013
8. Marsden, J., and Tromba, Vector Calculus, McGraw Hill,
9. Maity, K.C. and Ghosh, R.K. Vector Analysis, New Central Book Agency (P) Ltd. Kolkata (India).
10. Terence Tao, Analysis II, Hindustan Book Agency, 3rd Ed., 2015.
11. M.R. Speigel, Schaum's outline of Vector Analysis.

CORE COURSE-10

Course code: BSCHMTMC403

Ring Theory and Linear Algebra I (Full Marks: 50)

Unit -1: Definition and examples of rings, properties of rings, subrings, integral domains and fields, characteristic of a ring. Ideal, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals.

Unit-2: Ring homomorphisms, properties of ring homomorphisms. Isomorphism theorems I, II and III, field of quotients.

Unit -3: Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces, extension, deletion and replacement theorems.

Unit 4 : Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations, Isomorphisms, Isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix.

References:

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.
4. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999.
5. S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.
6. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.
7. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999
8. Kenneth Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
9. D.A.R. Wallace, Groups, Rings and Fields, Springer Verlag London Ltd., 1998.
10. D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of Abstract Algebra.s

SKILL ENHANCEMENT COURSE-2

(Choose any one from the following)

Course code: BSCHMTMSE401
Graph Theory (Full Marks: 50)

Unit -1: Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bipartite graphs isomorphism of graphs.

Unit -2: Eulerian circuits, Eulerian graph, semi-Eulerian graph and theorems, Hamiltonian cycles and theorems.
Representation of a graph by a matrix, the adjacency matrix, incidence matrix, weighted graph,

Unit -3: Travelling salesman's problem, shortest path, Tree and their properties, spanning tree, Dijkstra's algorithm, Warshall algorithm.

References:

1. J. Clark and D. A. Holton: A First Look at Graph Theory, Allied Publishers Ltd., 1995.
2. D. S. Malik, M. K. Sen and S. Ghosh: Introduction to Graph Theory, Cengage Learning Asia, 2014.
3. Nar Sing Deo : *Graph Theory*, Prentice-Hall, 1974.
4. J. A. Bondy and U.S.R. Murty: Graph Theory with Applications, Macmillan, 1976.
5. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 2nd Edition, Pearson Education (Singapore) P. Ltd., Indian Reprint 2003..

Course code: BSCHMTMSE402
Object Oriented Programming in C++ (Full Marks: 50)

Unit 1: Programming paradigms, characteristics of object oriented programming languages, brief history of C++, structure of C++ program, differences between C and C++, basic C++ operators, Comments, working with variables, enumeration, arrays and pointer.

Unit 2: Objects, classes, constructor and destructors, friend function, inline function, encapsulation, data abstraction, inheritance, polymorphism, dynamic binding, operator overloading, method overloading, overloading arithmetic operator and comparison operators.

Unit 3: Template class in C++, copy constructor, subscript and function call operator, concept of namespace and exception handling.

References:

1. A. R. Venugopal, Rajkumar, and T. Ravishanker, Mastering C++, TMH, 1997.
2. S. B. Lippman and J. Lajoie, C++ Primer, 3rd Ed., Addison Wesley, 2000.
3. Bruce Eckel, Thinking in C++, 2nd Ed., President, Mindview Inc., Prentice Hall, 2000.
4. D. Parasons, Object Oriented Programming with C++, BPB Publication, 2008.
5. Bjarne Stroustrup, The C++ Programming Language, 3rd Ed., Addison Welsley, 1997.
6. E. Balaguruswami, Object Oriented Programming In C++, Tata McGrawHill, 2011.
7. Herbert Scildt, C++, The Complete Reference, Tata McGrawHill, 2003.

SEMESTER V

CORE COURSE-11

Course code: BSCHMTMC501
Partial Differential Equations and Applications (Full Marks: 50)

Unit -1: Partial Differential Equations – Basic concepts and Definitions. Mathematical Problems. First- Order Equations: Classification, Construction and Geometrical Interpretation. Method of Characteristics for obtaining General Solution of Quasi Linear Equations. Canonical Forms of First-order Linear Equations. Solution of first order partial differential equations by Charpit's method and Jacobi's method. Method of Separation of Variables for solving first order partial differential equations.

Unit -2: Derivation of Heat equation, Wave equation and Laplace equation. Classification of second order linear equations as hyperbolic, parabolic, elliptic. Reduction of second order Linear Equations to canonical forms.

Unit -3: The Cauchy problem of 2^{nd} order partial differential equation, Cauchy-Kowalewskaya theorem, Cauchy problem of an infinite string, Initial and Boundary Value Problems. Semi-Infinite String with a fixed end, Semi-Infinite String with a Free end. Equations with non-homogeneous boundary conditions. Non-Homogeneous Wave Equation. Method of separation of variables: Solving the Vibrating String Problem. Solving the Heat Conduction
problem.

Graphical Demonstration

1. Solution of Cauchy problem for first order PDE.
2. Finding the characteristics for the first order PDE.
3. Plot the integral surfaces of a given first order PDE with initial data.
4. Solution of the equation $\frac{\partial^2 u}{\partial t^2} - \frac{\partial^2 u}{\partial x^2} = 0$ for the following associated conditions:

a) $u(x,0) = \emptyset(x), u_t\ (x,0) = \psi(x), x \in R, t > 0.$
b) $u(x,0) = \emptyset(x), u_t\ (x,0) = \psi(x), u(0,t) = 0\ x \in (0,\infty), t > 0$

5. Solution of the equation $\frac{\partial^2 u}{\partial t^2} - c^2 \frac{\partial^2 u}{\partial x^2} = 0$ for the following associated conditions:

a) $u(x,0) = \emptyset(x), u_t\ (0,t) = a, u\ (l,t) = b, 0 < x < l,\ t > 0.$
b) $u(x,0) = \emptyset(x), x \in R, 0 < t < T.$

References:

1. Tyn Myint-U and Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers, 4^{th} Edition, Springer, Indian reprint, 2006.
2. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
3. Martha L Abell, James P Braselton, Differential equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press, 2004.
4. Sneddon, I. N., Elements of Partial Differential Equations, McGraw Hill,2013.
5. Miller, F. H., Partial Differential Equations, John Wiley and Sons,2013.
6. Loney, S. L., An Elementary Treatise on the Dynamics of particle and of Rigid Bodies, Loney Press,2007

CORE COURSE-12

Course code: BSCHMTMC502
Ring Theory and Linear Algebra II (Full Marks: 50)

Unit -1: Polynomial rings over commutative rings, division algorithm and consequences, principal ideal domains,factorization of polynomials, reducibility tests, irreducibility tests, Eisenstein criterion, and unique factorization in $Z[x]$. Divisibility in integral domains, irreducible, primes, unique factorization domains, Euclidean domains.

Unit- 2: Dual spaces, dual basis, double dual, transpose of a linear transformation and its matrix in the dual basis, annihilators. Eigen spaces of a linear operator, diagonalizability, invariant subspaces and Cayley-Hamilton theorem, the minimal polynomial for a linear operator, canonical forms.

Unit -3: Inner product spaces and norms, Gram-Schmidt orthogonalisation process, orthogonal complements, Bessel's inequality, the adjoint of a linear operator, Least Squares Approximation, minimal solutions to systems of linear equations, Normal and self-adjoint operators, Orthogonal projections and Spectral theorem.

References:

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, 1999.
4. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th Ed., Prentice- Hall of IndiaPvt. Ltd., New Delhi, 2004.
5. S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.
6. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.
7. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.
8. Kenneth Hoffman and Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
9. S.H. Friedberg, A.L. Insel and L.E. Spence, Linear Algebra, Prentice Hall of India Pvt. Ltd.

DESCIPLINE SPECIFIC ELECTIVE (DSE-1)

(Choose any one from the following)

Course code: BSCHMTMDSE501
Linear Programming and Game Theory (Full Marks: 50)

Unit -1: Introduction to linear programming problem. Theory of simplex method, graphical solution, convex sets, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method. Big-M method and their comparison.

Unit -2: Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual, Dual Simplex method.

Unit -3: Transportation problem and its mathematical formulation, northwest corner method, least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, assignment problem and its mathematical formulation, Hungarian method for solving assignment problem, Travelling salesman problem.

Unit -4: Game theory: Formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure, linear programming solution of games.

References:

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flows, 2nd Ed., John Wiley and Sons, India, 2004.
2. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009.

3. Hamdy A. Taha, Operations Research, An Introduction, 8th Ed., Prentice- Hall India, 2006.
4. G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.

Course code: BSCHMTMDSE502
Group Theory II (Full Marks: 50)

Unit -1: Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups, Characteristic subgroups, Commutator subgroup and its properties.

Unit -2: Properties of external direct products, the group of units modulo n as an external direct product, internal direct products, Fundamental Theorem of finite abelian groups.

Unit -3: Group actions, stabilizers and kernels, permutation representation associated with a given group action. Applications of group actions. Generalized Cayley's theorem. Index theorem.

Unit -4: Groups acting on themselves by conjugation, class equation and consequences, conjugacy in S_n, p-groups, Sylow's theorems and consequences, Cauchy's theorem, Simplicity of An for $n \geq 5$, non-simplicity tests.

References:

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., 1999.
4. David S. Dummit and Richard M. Foote, Abstract Algebra, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2004.
5. J.R. Durbin, Modern Algebra, John Wiley & Sons, New York Inc., 2000.
6. D. A. R. Wallace, Groups, Rings and Fields, Springer Verlag London Ltd., 1998
7. D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of Abstract Algebra, Tata McGrawHill,1997.
8. I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.

Course code: BSCHMTMDSE503
Point Set Topology (Full Marks: 50)

Unit -1: Countable and Uncountable Sets, Schröeder-Bernstein Theorem, Cantor's Theorem, Cardinal Numbers and Cardinal Arithmetic, Continuum Hypothesis. Zorn's Lemma, Axiom of Choice,Well-Ordered Sets, Hausdorff's Maximality Principle. Ordinal Numbers.

Unit -2: Topological spaces, Basis and Subbasis for a topology, subspace Topology, Interior Points, Limit Points, Derived Set, Boundary of a set, Closed Sets, Closure and Interior of a set. Continuous Functions, Open maps, closed maps and Homeomorphisms, Product Topology, Quotient Topology, Metric Topology, Baire Category Theorem.

Unit-3: Connected and Path Connected Spaces, Connected Sets in R, Components and Path Components, Local Connectedness, Compact Spaces, Compact Sets in R, Compactness in Metric Spaces, Totally Bounded Spaces, Ascoli-Arzela Theorem, The Lebesgue Number Lemma, Local Compactness.

References:

1. Munkres, J.R., Topology, A First Course, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
2. Dugundji, J., Topology, Allyn and Bacon, 1966.
3. Simmons, G.F., Introduction to Topol**ogy** and Modern Analysis, McGraw Hill, 1963.
4. Kelley, J.L., General Topology, Van Nostrand Reinhold Co., New York, 1995.
5. Hocking, J., Young, G., Topology, Addison-Wesley Reading, 1961.
6. Steen, L., Seebach, J., Counter Examples in Topology, Holt, Reinhart and Winston, New York, 1970.
7. Abhijit Dasgupta, Set Theory, Birkhäuser, 2013.

DESCIPLINE SPECIFIC ELECTIVE (DSE-2)

(Choose any one from the following)

Course code: BSCHMTMDSE504
Probability and Statistics (Full Marks: 50)

Unit- 1: Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function, discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, continuous distributions: uniform, normal, exponential.

Unit -2: Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, expectation of function of two random variables, conditional expectations, independent random variables, bivariate normal distribution, correlation coefficient, joint moment generating function (jmgf) and calculation of covariance (from jmgf), linear regression for two variables.

Unit -3: Chebyshev's inequality, statement and interpretation of (weak) law of large numbers and strong law of large numbers. Central Limit theorem for independent and identically distributed random variables with finite variance, Markov Chains, Chapman-Kolmogorov equations, classification of states.

Unit-4: Random Samples, Sampling Distributions, Estimation of parameters, Testing of hypothesis.

References:

1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007.
2. Irwin Miller and Marylees Miller and John E. Freund, Mathematical Statistics with Applications, 7th Ed. Pearson Education, Asia, 2006.
3. Sheldon Ross, Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint, 2007.
4. Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, Introduction to the Theory of Statistics, 3^{rd} Ed., Tata McGraw- Hill, Reprint 2007
5. A. Gupta, Ground work of Mathematical Probability and Statistics, Academic publishers, 1983.

Course code: BSCHMTMDSE505
Portfolio Optimization (Full Marks: 50)

Unit -1: Financial markets. Investment objectives. Measures of return and risk. Types of risks. Risk free assets. Mutual funds. Portfolio of assets. Expected risk and return of portfolio. Diversification.

Unit -2: Mean-variance portfolio optimization- the Markowitz model and the two-fund theorem, risk-free assets and one fund theorem, efficient frontier. Portfolios with short sales. Capital market theory.

Unit -3: Capital assets pricing model- the capital market line, beta of an asset, beta of a portfolio, security market line. Index tracking optimization models. Portfolio performance evaluation measures.

References:

1. F. K. Reilly, Keith C. Brown, Investment Analysis and Portfolio Management, 10th Ed., South-Western Publishers, 2011.
2. H.M. Markowitz, Mean-Variance Analysis in Portfolio Choice and Capital Markets, Blackwell, New York, 1987.
3. M.J. Best, Portfolio Optimization, Chapman and Hall, CRC Press, 2010.
4. D.G. Luenberger, Investment Science, 2nd Ed., Oxford University Press, 2013.

Course code: BSCHMTMDSE506
Boolean Algebra and Automata Theory (Full Marks: 50)

Unit -1: 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 -2: 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.

Unit -3: Introduction: Alphabets, strings, and languages. Finite Automata and Regular Languages: deterministic and non-deterministic finite automata, regular expressions, regular languages and their relationship with finite automata, pumping lemma and closure properties of regular languages.

Unit -4: Context Free Grammars and Pushdown Automata: Context free grammars (CFG), parse trees, ambiguities in grammars and languages, pushdown automaton (PDA) and the language accepted by PDA, deterministic PDA, Non- deterministic PDA, properties of context free languages; normal forms, pumping lemma, closure properties,
decision properties.

Unit -5: Turing Machines: Turing machine as a model of computation, programming with a Turing machine, variants of Turing machine and their equivalence.

Unit -6: Undecidability: Recursively enumerable and recursive languages, undecidable problems about Turing machines: halting problem. Post Correspondence Problem, and undecidability problems about CFGs.

References:

1. B A. Davey and H. A. Priestley, Introduction to Lattices and Order, Cambridge University Press,Cambridge, 1990.
2. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, (2nd Ed.), Pearson Education (Singapore) P.Ltd., Indian Reprint 2003.
3. Rudolf Lidl and Günter Pilz, Applied Abstract Algebra, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
4. J. E. Hopcroft, R. Motwani and J. D. Ullman, Introduction to Automata Theory, Languages, and Computation, 2nd Ed., Addison-Wesley, 2001.
5. H.R. Lewis, C.H. Papadimitriou and C. Papadimitriou, Elements of the Theory of Computation, 2nd Ed., Prentice-Hall, NJ, 1997.
6. J.A. Anderson, Automata Theory with Modern Applications, Cambridge University Press, 2006.

SEMESTER VI

CORE COURSE-13

Course code: BSCHMTMC601
Metric Spaces and Complex Analysis (Full Marks: 50)

Unit -1: Metric spaces: Sequences in Metric Spaces, Cauchy sequences. Complete Metric Spaces, Cantor's theorem.

Unit -2: Continuous mappings, sequential criterion and other characterizations of continuity, Uniform continuity, Connectedness, connected subsets of R.
Compactness: Sequential compactness, Heine-Borel theorem, Totally bounded spaces, finite intersection property, and continuous functions on compact sets.
Homeomorphism, Contraction mappings, Banach Fixed point Theorem and its application to ordinary differential equation.

Unit -3: Limits, Limits involving the point at infinity, continuity. Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings, Conformal mapping, bilinear transformations.
Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability.

Unit -4: Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions, and definite integrals of functions. Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. Cauchy-Goursat theorem, Cauchy integral formula.

Unit -5: Liouville's theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples.

Unit -6: Laurent series and its examples, absolute and uniform convergence of power series.
.

References:

1. Satish Shirali and Harikishan L. Vasudeva, Metric Spaces, Springer Verlag, London, 2006.
2. S. Kumaresan, Topology of Metric Spaces, 2nd Ed., Narosa Publishing House, 2011.

3. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 2004.
4. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 8th Ed., McGraw – Hill International Edition, 2009.
5. Joseph Bak and Donald J. Newman, Complex Analysis, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., NewYork, 1997.
6. Nayak P.K. and Seikh M. R., A Textbook of Complex Analysis, Universities Press.
7. S. Ponnusamy, Foundations of omplex Analysis, Alpha Science International, 2005.
8. E.M.Stein and R. Shakrachi, Complex Analysis, Princeton University Press, 2010.

CORE COURSE-14

Course code: BSCHMTMC602
Mechanics (Full Marks: 50)

Unit-1: Coplanar forces in general: Resultant force and resultant couple, Special cases, Varignon's theorem, Necessary and sufficient conditions of equilibrium. Astatic equilibrium. Friction. Equilibrium of a particle on a rough curve. Virtual work. Forces in three dimensions. General conditions of equilibrium. Centre of gravity for different bodies. Stable and unstable equilibrium.

Unit 2: Simple harmonic motion, Damped and forced vibrations, Components of velocity and acceleration, Equations of motion referred to a set of rotating axes. Motion of a projectile in a resisting medium. Motion of a particle under central force, Keplar's laws of motion, Motion under the inverse square law, Stability of nearly circular orbits, Slightly disturbed orbits, Motion of artificial satellites. Varying mass, constrained Motion of a particle in three dimensions. Motion on a smooth sphere, cone, and on any surface of revolution.

Unit-3: Degrees of freedom, Moments and products of inertia, Momental Ellipsoid, Principal axes, D'Alembert's Principle, Motion about a fixed axis, Compound pendulum, Motion of a system of particles, Motion of a rigid body in two dimensions under finite and impulsive forces, Conservation of momentum and energy.

References:

1. Gregory I.H. Shames and G. Krishna Mohan Rao, Engineering Mechanics: Statics and Dynamics, 2006. Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2009.
2. R.C. Hibbeler and Ashok Gupta, Engineering Mechanics: Statics and Dynamics, 11th Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2010.
3. Chorlton, F., Textbook of Dynamics CBS Publishers & Distributors, 2005.
4. Loney, S. L., An Elementary Treatise on the Dynamics of particle and of Rigid Bodies, 2017
5. Loney, S. L., Elements of Statics and Dynamics I and II, 2004
6. Nayak, P.K., A Text Book of Mechanics, Alpha-Science.
7. Ghosh, M. C, Analytical Statics.
8. Matiur Rahman, Md., Statics, New Central Book Agancy (P) Ltd, 2004.
9. Verma, R. S., A Textbook on Statics, Pothishala, 1962
10. Ramsey, A. S., Dynamics (Part I & II).

DESCIPLINE SPECIFIC ELECTIVE (DSE-3)

(Choose any one from the following)

Course code: BSCHMTMDSE601

Number Theory (Full Marks: 50)

Unit -1: Linear Diophantine equation, prime counting function, statement of prime number theorem, Goldbach conjecture, linear congruences, complete set of residues, Chinese Remainder theorem, Fermat's Little theorem, Wilson's theorem.

Unit -2: Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius Inversion formula, the greatest integer function, Euler's phi-function, Euler's theorem, reduced set of residues. some properties of Euler's phi-function.

Unit -3: Order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots, Euler's criterion, the Legendre symbol and its properties, quadratic reciprocity, quadratic congruences with composite moduli, Public key encryption, RSA encryption and decryption, the equation $x^2 + y^2 = z^2$ Fermat's Last theorem (Statement only).

References:

1. David M. Burton, Elementary Number Theory, 6th Ed., Tata McGraw- Hill, Indian reprint, 2007.
2. Neville Robinns, Beginning Number Theory, 2nd Ed., Narosa Publishing House Pvt. Ltd., Delhi, 2007.

Course code: BSCHMTMDSE602
Industrial Mathematics (Full Marks: 50)

Unit -1: Medical Imaging and Inverse Problems. The content is based on Mathematics of X-ray and CT scan based on the knowledge of calculus, elementary differential equations, complex numbers and matrices.

Unit -2: Introduction to Inverse problems: Why should we teach Inverse Problems? Illustration of Inverse problems through problems taught in Pre-Calculus, Calculus, Matrices and differential equations. Geological anomalies in Earth's interior from measurements at its surface (Inverse problems for Natural disaster) and Tomography.

Unit -3: X-ray: Introduction, X-ray behavior and Beers Law (The fundamental question of image construction) Lines in the place.

Unit -4: Radon Transform: Definition and Examples, Linearity, Phantom (Shepp - Logan Phantom – Mathematical phantoms).

Unit -5: Back Projection: Definition, properties and examples.

Unit -6: CT Scan: Revision of properties of Fourier and inverse Fourier transforms and applications of their properties in image reconstruction. Algorithms of CT scan machine. Algebraic reconstruction techniques abbreviated as ART with application to CT scan.

References:

1. Timothy G. Feeman, The Mathematics of Medical Imaging, A Beginners Guide, Springer Under graduate Text in Mathematics and Technology, Springer, 2010.
2. C.W. Groetsch, Inverse Problems, Activities for Undergraduates, The Mathematical Association of America, 1999.

3. Andreas Kirsch, An Introduction to the Mathematical Theory of Inverse Problems, 2nd Ed., Springer, 2011.

Course code: BSCHMTMDSE603
Mathematical Modelling (Full Marks: 50)

Unit-1: The modeling process. Arguments from scales: Dimensional analysis
Arguments from data: Least squares, parameter estimation.

Unit-2: Linear models: Generalized least squares estimators.

Unit-3: Mathematical models in biology: Population models, predator-prey systems.

Unit-4: Stability analysis: Equilibria, oscillations, growth and decay.

Unit-5: Difference equations: Modeling of traffic flows.
Poisson process and single server queueing models.

References:

1. R. Illner et al., Mathematical Modelling: A Case Studies Approach. AMS, 2005.
2. E. Bender, Introduction to Mathematical Modelling. Dover, 2000.
3. J. Kapur, Maximum-entropy Models in Science and Engineering. Wiley, 1989.
4. P. Brockwell and R. Davis, Introduction to Time Series and Forecasting, Springer, 2010.
5. D. Higham, Modeling and Simulating Chemical Reactions. In: SIAM Review, 347-368, 2008

DESCIPLINE SPECIFIC ELECTIVE (DSE-4)

(Choose any one from the following)

Course code: BSCHMTMDSE604
Differential Geometry (Full Marks: 50)

Unit -1: Tensor: Different transformation laws, Properties of tensors, Metric tensor, Riemannian space, Covariant Differentiation, Einstein space.

Theory of Space Curves: Space curves, Planer curves, Curvature, torsion and Serret-Frenet formula. Osculating circles, Osculating circles and spheres, Existence of space curves. Evolutes and involutes of curves.

Unit -2: Theory of Surfaces: Parametric curves on surfaces, Direction coefficients, First and second Fundamental forms, Principal and Gaussian curvatures, Lines of curvature, Euler’s theorem. Rodrigue’s formula, Conjugate and Asymptotic lines.

Unit -3: Developables: Developable associated with space curves and curves on surfaces, Minimal surfaces. Geodesics: Canonical geodesic equations, Nature of geodesics on a surface of revolution. Clairaut’s theorem, Normal property of geodesics, Torsion of a geodesic, Geodesic curvature. Gauss-Bonnet theorem.

References:

1. T.J. Willmore, An Introduction to Differential Geometry, Dover Publications, 2012.
2. B. O'Neill, Elementary Differential Geometry, 2nd Ed., Academic Press, 2006.
3. C.E. Weatherburn, Differential Geometry of Three Dimensions, Cambridge University Press 2003.
4. D.J. Struik, Lectures on Classical Differential Geometry, Dover Publications, 1988.
5. S. Lang, Fundamentals of Differential Geometry, Springer, 1999.
6. B. Spain, Tensor Calculus: A Concise Course, Dover Publications, 2003
7. P. K. Nayak, Textbook of Tensor Calculus and Differential Geometry, PHI Learning Private Limited, 2012.

Course code: BSCHMTMDSE605
Bio Mathematics (Full Marks: 50)

Unit -1: Mathematical Biology and the modeling process: an overview. Continuous models: Malthus model, logistic growth, Allee effect, Gompertz growth, Michaelis-Menten Kinetics, Holling type growth, Bacterial growth in a Chemostat, Harvesting a single natural population, Prey predator systems and Lotka Volterra equations, Populations in competitions, Epidemic Models (SI, SIR, SIRS, SIC)

Unit -2: Activator-Inhibitor system, Insect Outbreak Model: Spruce Budworm, Numerical solution of the models and its graphical representation. Qualitative analysis of continuous models: Steady state solutions, stability and linearization, multiple species communities and Routh-Hurwitz Criteria, Phase plane methods and qualitative solutions, bifurcations and limit cycles with examples in the context of biological scenario Spatial Models: One species model with diffusion, Two species model with diffusion. Conditions for diffusive instability, Spreading colonies of microorganisms, Blood flow in circulatory system, Travelling wave solutions, Spread of genes in a population.

Unit -3: Discrete Models: Overview of difference equations, steady state solution and linear stability analysis. Introduction to Discrete Models, Linear Models, Growth models, Decay models, Drug Delivery Problem, Discrete Prey-Predator models, Density dependent growth models with harvesting, Host-Parasitoid systems (Nicholson- Bailey model), Numerical solution of the models and its graphical representation. Case Studies: Optimal Exploitation models, Models in Genetics, Stage Structure Models, Age Structure Models.

Graphical Demonstration (Teaching Aid)

1. Growth model (exponential case only).
2. Decay model (exponential case only).
3. Lake pollution model (with constant/seasonal flow and pollution concentration).
4. Case of single cold pill and a course of cold pills.
5. Limited growth of population (with and without harvesting).
6. Predatory-prey model (basic volterra model, with density dependence, effect of DDT, two prey one predator).
7. Epidemic model of infuenza (basic epidemic model, contagious for life, disease with carriers).
8. Battle model (basic battle model, jungle warfare, long range weapons).

References:

1. L.E. Keshet, Mathematical Models in Biology, SIAM, 1988.
2. J. D. Murray, Mathematical Biology, Springer, 1993.
3. Y.C. Fung, Biomechanics, Springer-Verlag, 1990.
4. F. Brauer, P.V.D. Driessche and J. Wu, Mathematical Epidemiology, Springer, 2008
5. M. Kot, Elements of Mathematical Ecology, Cambridge University Press, 2001.

Course code: BSCHMTMDSE606
Astronomy (Full Marks: 50)

Unit-1: Celestial Sphere, various Coordinate Systems, transformation formulae among various coordinate systems, formulae of spherical triangle : cosine formula, sine formula, four parts formula , analogous cosine formula, hour angle, sidereal day, sidereal time, equation of time. Exercises.

Unit-2: Light and its properties, Optical , absorption, emission and continuous spectra, radio and Hubble Space Telescopes (HST), Photometry, Spectrometry, Spectrophotometry, magnification, resolution, f/a ratio , refractors and reflectors. Exercises.

Unit-3: Various magnitudes of stars: apparent, absolute, photovisual, photographic, bolometric etc. Distance measurements of stars: Parallax method, Statistical Palallax Method, Moving Cluster Method. Radial and proper motion. Exercises.

Unit-4: Morphological structure of Sun, solar cycles, sunspots, solar corona, solar wind, solar neutrino puzzle (Merely descriptive models). Solar system.

Unit-5: Interstellar matter, elastic collisions and kinetic equilibrium, Jeans Mass for gravitational collapse, radiative process (statement only).

Unit-6: Morphological classification of galaxies, rotation curves and mass modelling, missing mass and dark matter, distance determination by various methods. Our Galaxy. Exercises.

References:

1. T. Padmanabhan, Theoretical Astrophysics, vols. 1-3, Cambridge University Press, 2002.
2. S. Weinberg, Gravitation and Cosmology, Wiley, 2001.
3. J.V. Narlikar, Introduction to Cosmology, Cambridge University Press, 2002.
4. J.V. Narlikar, An Introduction to Relativity, Cambridge University Press, 2010.
5. B. Basu, T.Chattopadhyay and S.N.Biswas, An Introduction to Astrophysics, Prentice Hall of India, 2010.
6. Physical Processes in the Interstellar Medium, Lyman Spitzer, Jr. Wiley, 1998.
7. Astrophysics for Physicists, Arnab Rai Choudhuri, Cambridge University Press, 2010.
8. Extragalactic Astronomy and Cosmology: An Introduction, Peter Scineider, Springer, 2006.
9. Textbook on Spherical Astronomy, W.M. Smart , Cambridge University Press.
10. A Text Book on Astronomy, K.K. De, Books Syndicate (P) Ltd. 2013

Pool of Generic elective Calculus

[Students of a Particular Honours department will choose one Generic Elective Paper of any other existing Honours Department except his/her Department from the pool provided below]

Semester I

GENERIC ELECTIVES [GE-1(1)]

Course code: BSCHMTMGE101
Differential Calculus (Full Marks: 50)

Limit of functions, Algebra of limits, Continuous functions, Properties of continuous functions, Monotone functions, Inverse function. Differentiability of functions, Successive differentiation, Leibnitz's theorem, Rolle's theorem, Mean value theorem of Lagrange and of Cauchy with geometrical interpretations. Taylor's theorem and Maclaurin's theorem with remainder in Lagrange's and Cauchy's form and application of mean value theorem, Darboux's theorem. Series expansion of $\sin x$, $\cos x$, $\log(1+x)$, $(1+x)^n$, a^x with domain of convergence.

Partial differentiation, Euler's theorem on homogeneous functions.

Determination of maxima and minima, Indeterminate forms.

Tangents and normals, Curvature, Asymptotes, Singular points, Tracing of curves. Parametric representation of curves and tracing of parametric curves, Polar coordinates and tracing of curves in polar coordinates.

References:

1. H. Anton, I. Birens and S. Davis, *Calculus*, John Wiley and Sons, Inc., 2002.
2. G.B. Thomas and R.L. Finney, *Calculus*, Pearson Education, 2007.
3. Richard R.Goldberg, *Methods of Real Analysis*, Oxford and IBH, 2012.
4. Shanti Naryayn and P. K. Mittal, *Differential Calculus*, S Chand.
5. K.C.Maity and R.K.Ghosh, *Differential Calculus*, Books and Allied (P) Ltd.

Semester II

GENERIC ELECTIVES [GE-1(2)]

Course code: BSCHMTMGE201
Differential Equations and Vector Calculus (Full Marks: 50)

First order exact differential equations. Integrating factors, rules to find an integrating factor. First order higher degree equations solvable for x, y, p. Methods for solving higher-order differential equations. Basic theory of linear differential equations, Wronskian, and its properties. Solving a differential equation by reducing its order.

Linear homogenous equations with constant coefficients, Linear non-homogenous equations, The method of variation of parameters, The Cauchy-Euler equation, Simultaneous differential equations, Total differential equations.

Definition of vector, Resolution of vectors into components along three directions. Scalar and vector products of two and three vectors. Applications to geometry and mechanics**.**

Continuity and differentiability of vector-valued function of one variable. Velocity and acceleration. Vector-valued functions of two and three variables, Gradient of scalar function, Divergence, Curl and their properties.

References:

1. S. L. Ross, *Differential Equations*, 3rd Ed., John Wiley and Sons, 1984.
2. B. Spain, *Vector Analysis*, D.Van Nostrand Company Ltd.
3. L. Brand, *Vector Analysis*, Dover Publications Inc.
4. Shanti Narayan**,** *A Text Book of Vector Analysis*, 19th Edn, S.Chand publishing.
5. M. Spiegel, S.Lipschutz , D. Spellman, *Vector Analysis*, McGraw-Hill.

Semester III

GENERIC ELECTIVES [GE-1(3)]

Course code: BSCHMTMGE301
Algebra (Full Marks: 50)

Definition and examples of groups, examples of abelian and non-abelian groups, the group Zn of integers under addition modulo n and the group U(n) of units under multiplication modulo n. Cyclic groups from number systems, complex roots of unity, circle group, the general linear group GLn(n,R), groups of symmetries of (i) an isosceles triangle, (ii) an equilateral triangle, (iii) a rectangle, and (iv) a square, the permutation group Sym (n), Group of quaternions. group of permutation, Normal subgroups: their definition, examples, and characterizations, Quotient groups. Divisor of zeros, Rings, Integral domain, fields.

Solution of non-homogeneous system of three linear equations by matrix inversion method. Elementary row and column operations, rank of a matrix, row reduced echelon form and fully reduced normal form.

Vector spaces over reals, simple examples, linear dependence and independence of a finite set of vectors, sub-spaces, definition and examples.

References:

1. John B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002**.**

2. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson, 2011.
3. Joseph A Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa, 1999.
4. George E Andrews, *Number Theory*, Hindustan Publishing Corporation, 1984.
5. S. K. Mapa, *Higher Algebra (Abstract and Linear),* Sarat Book House.
6. Promode Kumar Saikia, *Linear Algebra With Applications*, Pearson.
7. U. M. Swamy & A. V. S. N. Murthy, *Algebra: Abstract and Modern*, Pearson.
8. Ghosh & Chakravorty, *Higher Algebra (Classical & Modern),* U. N. Dhur & Sons Pvt. Ltd.

Semester IV

GENERIC ELECTIVES [GE-1(4)]

Course code: BSCHMTMGE401
Real Analysis (Full Marks: 50)

Finite and infinite sets, examples of countable and uncountable sets. Real line, bounded sets, suprema and infima, completeness property of R, Archimedean property of R, intervals. Concept of cluster points and statement of Bolzano-Weierstrass theorem.

Real Sequence, Bounded sequence, Cauchy convergence criterion for sequences. Cauchy's theorem on limits, order preservation and squeeze theorem, monotone sequences and their convergence (monotone convergence theorem without proof).
Infinite series. Cauchy convergence criterion for series, positive term series, geometric series, comparison test, convergence of p-series, Root test, Ratio test, alternating series, Leibnitz's test(Tests of Convergence without proof). Definition and examples of absolute and
conditional convergence.

Sequences and series of functions, Pointwise and uniform convergence. Mn-test, M-test, Statements of the results about uniform convergence and integrability and differentiability of functions, Power series and radius of convergence.

References:

1. T. M. Apostol, *Calculus* (Vol. I), John Wiley and Sons (Asia) P. Ltd., 2002.
2. R.G. Bartle and D. R Sherbert, *Introduction to Real Analysis,* John Wiley and Sons (Asia) P.Ltd.,2000.
3. E. Fischer, *Intermediate Real Analysis*, Springer Verlag, 1983.
4. K.A. Ross, *Elementary Analysis- The Theory of Calculus Series*- Undergraduate Texts In Mathematics, Springer Verlag, 2003.
5. Richard R.Goldberg, *Methods of Real Analysis*, Oxford and IBH , 2012.
6. S. N. Mukhopadhyay and A. Layek – *Mathematical Analysis – Vol-I* , U. N. Dhar & Sons Pvt. Ltd.
7. S. N. Mukhopadhyay and S. Mitra – *Mathematical Analysis – Vol-II,* (U. N. Dhar & Sons. Pvt. Ltd.

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