University of Dhaka

7 Affiliated Colleges

(Effective from 2017 – 2018 to 2020 -2021)

4th Year Detailed Syllabus

MAT 401: Theory of Numbers 4 Credits

1. Divisibility: Definition; properties; division algorithm; greatest integer function.
2. Primes: Definition, Euclid's Theorem; Prime Number Theorem (statement only); Goldbach and Twin Primes conjectures; Fermat primes; Fermat's Theorem; Mersenne primes.
3. Fundamental Theorem of Arithmetic: Definition and properties of greatest common divisor (GCD) and least common multiple (LCM); Euclid's algorithm; Linear combinations; Linear Diophantine equations; Continued Fractions; Euclid's Lemma; Canonical prime factorization; divisibility; GCD; and LCM in terms of prime factorizations; Pseudoprimes and Carmichael.
4. Congruences: Definitions and basic properties; residue classes; complete residue systems; reduced residue systems; Linear congruences in one variable; Euclid's algorithm; Simultaneous linear congruences; Chinese Remainder Theorem; Wilson's Theorem; Euler's Theorem; Application of congruence(Round robin tournaments).
5. Arithmetic Functions: Arithmetic function and Multiplicative functions (definitions and basic examples); Dirichlet convolution. The Möbius function; The Euler phi function; Carmichael conjecture; Number of divisors and sum of divisors functions; Perfect numbers; Characterization of even perfect numbers; Euclid’s theorem.
6. Representation by sum of two, four squares and sum of squares. Quadratic field.
7. Arithmetic of quadratic fields. Euclidean quadratic Fields.

Evaluation : Incourse Assessment 30 Marks. Final examination (Theory, 3 hours): 70 Marks
Eight questions of equal value will be set, of which any **five** are to be answered.

References

1. S. G Telang, Number Theory.
2. James Strayer, Elementary Number Theory.
3. G H. Hardy and E. M. Wright, An Introduction to Theory of Number.
4. Kenneth Rosen, Elementary Number Theory and its Applications.
5. I. Niven, H. Zuckerman, H. Montgomery, An Introduction to the Theory of Numbers.

MAT 402: Hydrodynamics 4 Credits

1. Velocity and acceleration of fluid particles; relation between local and individual rates; steady and unsteady flows; uniform and nonuniform flows; stream lines; path lines; vortex lines; velocity potential. Bernoulli's equations and its application.
2. Rotational and irrotational flows; equations of continuity; equations of continuity in spherical and cylindrical polar coordintes; boundary surfaces.
3. Euler's equation of motion, conservative field of force ; Lamb's hydrodynamical equations of motion; motion under conservative body force; vorticity equations (Helmholtz's vorticity equation)
4. Motion in two-dimensions; stream function, physical meaning of stream function; velocity in polar-coordinates; relation between stream function and velocity.
5. Circulation and vorticity; relation between circulation and vorticity; Kelvin's circulation theorem, Kelvin's minimum energy theorem. Generalized Joukowki's transformation, Elliptic coordinates and its application.
6. The circle's theorem, motion of a circular cylinder; pressure at points on a circular cylinder; application of circle theorem. Blasius theorem.
7. Sources, sinks and doublets, complex potential and complex velocity, stagnation points; complex potential due to a source and a doublet, image in two and three dimensions; Stoke's stream function.
8. Vortex motion; vortex tube; strength of a vortex; vortex pair; complex potential due to vortex motion; vortex rows; Free vortex, Forced vortex, spireal vortex.
9. Wave motion, mathematical representation of wave, surface wave, Canal wave, long wave.

Evaluation: Incourse Assessment 30 Marks. Final exam (Theory, 3 hours): 70 Marks
Eight questions of equal value will be set, of which any five are to be answered.

References

1. F. Chorlton, A Text Book of Fluid dynamics.
2. L.M. Milne Thomosn, Theoretical Hydrodynamics.
3. P.P. Gupta, Hydrodynamics
4. M.D. Raisinghania, Introduction to Fluid Dynamics.

MAT 403: Partial Differential Equations 4 Credits

1. Introduction: Preliminaries, Classification, Differential operators and the superposition principle, Differential equations as mathematical models, Associated conditions, Simple examples.
2. First order equations: Definition of PDEs of First Order Quasi-linear PDEs; Solving PDEs of First Order: The method of characteristics; The existence and uniqueness theorem; The Lagrange method; Conservation laws and shock waves; The eikonal equation; General nonlinear equations.
3. Second order equations: Definition of General PDE, Classifications of Second Order PDEs as Parabolic, Hyperbolic, and Elliptic Equations; Canonical form of hyperbolic/ parabolic / elliptic equations.
4. The one dimensional wave equation: Introduction, Canonical form and general solution, The Cauchy problem and d'Alembert's formula, Fourier Transform methods, Domain of dependence and region of influence, The Cauchy problem for the nonhomogeneous wave equation, Two-Dimensional Wave Equation.
5. The Heat equation: The Cauchy Problem and initial conditions, The weak maximum principle, solutions on bounded intervals, on the real line and on the half line, the nonhomogeneous heat equation, The energy method and uniqueness.
6. Elliptic equations: Introduction, The maximum principle, Green's identities, Separation of variables for elliptic problems, Poisson's formula, Dirichlet and Neumann Problems, Green's functions and integral representations in a plane.

Evaluation: Incourse Assessment 30 Marks. Final examination (Theory, 3 hours): 70 Marks
Eight questions of equal value will be set, of which any five are to be answered.

Text Books:

1. Peter V. O'Neil, Beginning Partial Differential Equations, second edition, John Wiley & Sons.
2. Walter A. Strauss, Partial Differential Equations: An Introduction, Second edition, John Wiley & Sons.
3. T. Hillen, I E Leonard and H. Van Roessel, Partial Differential Equations: Theory and Completely Solved Problems, Friesen Press.
4. Nakhle *H.* Asmar, Partial Differential Equations and Boundary Value Problem*s* with Fourier Series, third edition, Dover Books on Mathematics.

MAT 404: Tensor Analysis 3 Credits

1. Coordinates, Vectors and tensors: Curvilinear coordinates, Kronecker delta, summation convention, space of *N* dimensions, Euclidean and Riemannian space, coordinate transformation, Contravariant and covariant vectors, the tensor concept, symmetric and skew-symmetric tensors.
2. Riemannian metric and metric tensors: Basis and reciprocal basis vectors, Euclidean metric in three dimensions, reciprocal or conjugate tensors, Conjugate metric tensor, associated vectors and tensor's length and angle between two vector's, The Christoffel symbols.
3. Covariant Differentiation of tensors and applications: Covariant derivatives and its higher rank tensor and covariant curvature tensor, Ricci tensor, zero tensor, Intrinsic derivative, Bianchi identity, Flat Space.
4. Applications of tensor analysis to elasticity theory and electromagnetic theory.

Evaluation: Incourse Assessment 30 Marks. Final examination (Theory, 3 hours): 70 Marks Eight questions of equal value will be set, of which any five are to be answered.

References

1. B. Spain, Tensor Calculus
2. I.S. Sokolnikoff, Tensor Analysis
3. L.P. Lebedev & M. J. Cloud, Tensor Analysis
4. A.J. McConnell, Applications of Tensor Analysis

MAT 405: Functional Analysis 4 Credits

1. Review of General Linear (Vector) spaces: Linear mappings, linear operators, elementary properties of linear operators, linear operators in finite dimensional spaces, linear functional, basis and its dual on finite dimensional space, Zorn's lemma, extension of linear functions, sublinear functional.
2. Inner product and norm (on a vector space over $\mathbb{R}$): Definitions and examples, Cauchy-Schwarz inequality, norm derived from inner product, Parallelogram law, metric derived from a norm, inner product space, orthogonality, Bessel's inequality.
3. Normed linear spaces: Sequence space, separability, Riesz's lemma, boundedness and continuity, Quotient space, spaces of bounded linear operators.
4. Banach spaces: Open mapping theorem, closed graph theorem, and their applications, Baire's category theorem, Uniform boundedness principle, normed conjugate of a NLS (Hahn-Banach theorem). Fixed point theorems: Contraction mapping, Banach fixed point theorem, Schauder fixed point theorem and applications of fixed-point theorems.
5. Hilbert spaces: Basic properties, Riesz representation theorem, adjoint of a linear operator.

Evaluation: In course Assessment 30 Marks. Final examination (Theory, 3 hours) 70 Marks. Eight questions will be set of which any Five are to be answered

References:

1. E. Taylor, Introduction to Functional Analysis, Wiley
2. E. Kreyszig, Introduction to Functional Analysis with Applications, Wiley
3. J. Maddox, Elements of Functional Analysis, Cambridge University Press
4. B, Rynne, M. A. Youngson, Linear Functional Analysis, Springer
5. M. Schechter, Principles of Functional Analysis, American Mathematical Society

MAT 406: Discrete Mathematics 3 Credits

1. **1.** Mathematical Reasoning: Inference and fallacies. Method of proof. Recursive definitions. Verification.
2. **2.** Strings, Sets and Binomial Coefficients: Introduction to enumeration of strings or letters or numbers with restrictions. Permutations and combinations. The binomial theorem.
3. **3.** Combinatorics : Counting –principles. Inclusion-exclusion principle. Pigeonhole principle. Generating functions. Recurrence relations .Non- homogeneous and non-linear recurrence equations. Applications to computer operations. A variant of induction suitable for recurrences, existence theorem, Strong Induction.
4. **4.** Algorithems and their efficiency : Searching Algorithms .Sorting Algorithems. Bin packing algorithems .Algorithem on integer operations. Recursive algorithem.
5. **5.** Graphs. Structure and symmetry of graphs. Adjacency matrix. Trees and connectivity. Path and trees. Eulerian and Hamilton graphs .Diagraphs. Planner graphs.
6. **6.** Algorithems on graphs : Shortest path problem (dijkstra's algorithm, Floyd-Warshall algorithm and their comparisons) Spanning tree problems.(kruskal's greedy algorithem, Prims greedy algorithm and their comparisons).
7. **7.** Probability : Basic concept' s and their to enumeration. Discrete random variables. Ramsey number. Ramsey's theorem and some of its variants. Concentration inequalities. An introduction to information theory.
8. **8.** Network flows : flows and cuts. Flow augmentation algorithms. Application of max-flow, min-cut theorem.

Evaluation: Incourse Assessment 30 marks. Final examination (Theory, 3 hours) 70 marks. Eight questions of equal value will be set, of which any five are to be answered.

References.

1. Schaum's outline series—Discrete Mathematics.
2. Kenth H.Rosen- Discrete Mathematics.
3. C. I. Liu- Discrete Mathematics.
4. B.Douglas – Introduction to graph theory

Choose any 3 (three)

MAT 407: Fuzzy Mathematics 3 Credits

1. Crisp sets and fuzzy sets : An overview of crisps sets; the notion of fuzzy sets; basic
2. concepts of fuzzy sets. An overview of classical logic; fuzzy logic.
3. Operations of fuzzy sets : General discussion; fuzzy complement; fuzzy union; fuzzy intersection combinations of operations; general aggregation operations.
4. Fuzzy arithmetic : fuzzy numbers, linguistic variables, arithmetic operations on intervals and fuzzy numbers, lattice of fuzzy numbers, fuzzy equations.
5. Fuzzy relations : Crisp and fuzzy relations ; binary relations on a set; equivalence and similarity relations; compatibility or tolerance relations; orderings; morphisms; fuzzy relational equations.
6. Applications of Fuzzy Set Theory.

Evaluation: Incourse Assessment: 30 Marks. Final examination (Theory, 3 hours): 70 Marks. Eight questions of equal value will be set, of which any five are to be answered.

References

1. G. J. Klir & U. Clair, Fuzzy Set Theory: Foundations and Applications, Prentice Hall
2. G. J. Klir & Bo Yuan, Fuzzy Sets & Fuzzy Logic Theory and Applications, Pearson
3. R. Lowen, Fuzzy Set Theory: Basic Concepts, Techniques and Bibliography, Springer
4. H.J. Zimmermann, Fuzzy Sets Theory and Its Applications, Springer

MAT 408: Topology 3 Credits

1. Topological Spaces: Definitions and examples (discrete, indiscrete, cofinite, cocountable topologies). Metiric topology. Cluster point of a set. Neighbourhood system. Base and subbase. Subspace. Topological properties.
2. Continuous functions in topological spaces: Countinuity. Sequential continuity. Uniform continuity. Homeomorphisms.
3. Separation axioms: Properties of T_0, T_1, T_2, T_3, T_4 spaces. Some related theorems. Completely regular spaces. Completely normal spaces.
4. Countability of topological spaces: First and and second countable spaces. Separable space. Lindelof 's theorems.
5. Compactness: Compact spaces. Concept of product spaces. Tychonoff's theorem. Locally compact spaces. Compactness in metric spaces. Totally boundedness, Lebesgue number. Equivalence of compactness, sequential compactness and Bolzano-Weierstrass property.
6. Connectedness: Connected spaces, totally disconnected spaces, components of space, locally and pathwise connected spaces.

Evaluation: Incourse Assessment 30 Marks. Final examination (Theory, 3 hours): 70 Marks
Eight questions of equal value will be set, of which any five are to be answered.

References

1. G.F. Simmons, Introduction to Topology and Modern Analysis
2. S.Lipschutz, General Topology.
3. J. Kelly, General Topology.
4. Munkres. James, Topology. Pearson

MAT 409: Difference Equations 3 Credits

1. Review of calculus of differences. Difference equations: Basic terminology, definition and simple examples, Formation of difference equations, Discrete analogy to differential equations, order and degree of a difference equation.
2. Homogeneous Linear difference equations (constant coefficient equations and their solutions, linear dependence and independence, initial value and boundary value problems, reduction of order, Euler equation, generating functions, eigenvalue problems).
3. Inhomogeneous linear difference equations (operator methods, variation of parameters, reduction of order, method of undetermined coefficients).
4. Linear difference equations with variable coefficients and their solutions.
5. Simple nonlinear difference equations; pseudo-nonlinear equations. The Z-transform and it use in solving difference equations.
6. Differential-difference equations. Extension of difference equation to functions of a continuous variable. Partial difference equations.
7. Modelling with difference equations. Simple applications (application to vibrating systems, electrical networks, beams, collisions, probability, the Fibonacci numbers, integration, geometry, determinants, power series solutions, investigation of special functions, biology). Commercial applications (simple interest, compound interest, annuities). Application to chaos, Julia sets and the Mandelbrot set.

Evaluation: Incourse Assessment 30 Marks. Final examination (Theory, 3 hours). 70 Marks
Eight questions of equal value will be set, of which any five are to be answered.

References

1. H. Levy & F. Lessman , Finite Difference Equations.
2. N. Finizio & G. Ladas, An Introduction to Differential Equations with Difference Equations.
3. Murray R. Spiegel, Theory and Problems of Calculus of Finite Differences and Difference Equations.
4. Frank Chorlton, Ordinary Differential and Difference Equations Theory and Applications.

MAT 410: Astronomy 3 Credits

1. Sphere and spherical triangles, the celestial sphere, problems connceted with diurnal motion.
2. Astronomical refraction, Astronomical instruments. Finding the latitude of a place. Conversion of coordinates fixing. The ecliptic and the first point of Aries.
3. Kepler's laws: Equations of time, unit of time,
4. Geocentric parallax, The moon, Local line, Eclipses.
5. The Solar System.
6. Precession and mutation, Annual parallax. Aberration of light.
7. The stellar universe.
8. Modern finding of astronomical objects. Working process of the Hubble telescope and its finding.

Evaluation: Incourse Assessment 30 Marks. Final examination (Theory, 3 hours): 70 Marks
Eight questions of equal value will be set, of which any five are to be answered.

References

1. A.F.M. Abdur Rahman, A Text Book of Modern Astronomy.
2. K.R. Khan & A.Z. Sikder, Astronomy.
3. W.R. Smart, Spherical Astronomy.
4. G.V. Ramnchandran, A Text Book of Astronomy.

MAT 411: Mathematical Modeling in Biology 3 Credits

1. Basic Concepts: Population dynamics, phase space, phase portrait, discrete and continuous systems, conjugacy, fixed point, periodic points, hyperbolic point and stability.
2. Dynamics of one dimensional maps: One parameter family of maps, contraction mapping, stability of fixed points and periodic points, family of logistic map, tent map, doubling map, linear maps, iterative map and quadratic family.
3. Population Dynamics for Single Species: Single species population model, growth models, Malthusian model, logistic model, migration model, Smith model, time-varying environment model, time-delay model, harvesting model.
4. Continuous Models for Interacting Population: Two species population model, Lotka-Volterra model, competition model, cooperation model, war model and multi-species population model.
5. Discrete Population Models: Simple discrete models, Malthusian discrete model, logistic discrete model, discrete growth models for interacting populations, discrete delay models.

6. Disease Models: Simple epidemic models - SI model, SIS model, SIR model, some infectious disease models (HIV/AIDS, TB model, etc), control of epidemic model.

Evaluation: In course Assessment 30 Marks. Final examination (Theory, 3 hours) 70 Marks.
Eight questions will be set of which any Five are to be answered

Text Books:

1. Steven H Strogatz, Nonlinear Dynamics and Chaos. CRC Press.
2. F Brauer, C Castillo-Chavez, Mathematical models in population biology and Epidemiology. Springer.
3. Leah Edelstein-Keshet, Mathematical Models in Biology. SIAM.
4. J. D. Murray, Mathematical Biology, Springer.

Evaluation: Incourse Assessment 30 Marks. Final examination (Theory, 3 hours). 70 Marks
Eight questions of equal value will be set, of which any five are to be answered.

MAT 450 Math Lab IV (Mathematica) 4 Credits

Problem-solving in concurrent courses using MATHEMATICA.

Lab Assignments:

Evaluation: Internal Assessment (Laboratory works). 40 Marks

Final Examination (Lab, 3 hours). 60 Marks

MAT 499 Viva Voce IV (Comprehensive) 3 Credits

Viva Voce on all the courses taught from First Year to Fourth Year.

N.B. In the grading system the evaluation of any course (irrespective of its credit hours) should be carried out of 100 marks. In each theoretical course 30% will be reserved for internal assessment; in each Lab course 40% will be reserved for internal assessment.