Syllabus for
M.Sc. in Mathematics (Professional) Program

Department of Mathematics
Jagannath University
Dhaka-1100

Syllabus for the M. Sc. in Mathematics (Professional) Program
Department of Mathematics
Jagannath University, Dhaka

Overview of the Program:

- The program consists of 2 Semesters in a year, Spring & Fall.
  (Spring Semester: January to June, Fall Semester: July to December)
- Duration of each semester: 6 (Six) Months.
- Class time: Friday and/or Saturday.
- Course structure of the program:
  (*i*) **Theory Courses**: 1 (one) pre-requisite course
  3 (three) compulsory courses
  5 (five) optional courses

  Total: 9 (nine) Theory Courses

  (Each theory course will be of 03 credits)

  Total Credit of theory courses: (9 × 3) = 27 (twenty seven) credits.

  (*ii*) **Lab Courses**: 1 (one) Lab course in each semester.
  (Each lab course will be of 03 credits)
  Total Credit of lab courses: (2 × 3) = 06 (six) credits.

- **Viva-voce**: 1 (one) viva-voce in the 2nd Semester.
  Total Credit of viva-voce: (2 × 1) = 02 (two) credits.

- **Project**: 3 (three) credits (in the 2nd Semester).
- **18 credits** in the 1st Semester and **20 credits** in the 2nd Semester.
- **Total Credits in 2 Semesters**: (27 + 06 + 02 + 03) = 38 (thirty eight) credits.

1st Semester

Course Code	Course Title	Credits
PMTH 5101	Fundamentals of Mathematics	03
PMTH 5102	Differential and Integral Equations	03
PMTH 5103	Lab-I (Introduction to Computer Application Lab)	03
Optional I		03
Optional II		03
Optional III		03
Total Credits		**18**
* 3 (three) Optional courses will be offered from the following courses. (As par decision of academic committee)		

Optional Courses

Course Code	Course Title	Credits
PMTH 5104	Operations Research	03
PMTH 5105	Theory of Numbers	03
PMTH 5106	Financial Mathematics	03
PMTH 5107	Analytical Dynamics	03
PMTH 5108	Topology and Advanced Analysis	03
PMTH 5109	Functional Analysis and Operator Theory	03
PMTH 5110	Mathematical Modeling in Biology	03

2nd Semester

Course Code	Course Title	Credits
PMTH 5201	Advanced Numerical Analysis	03
PMTH 5202	Fluid Dynamics and Heat Transfer	03
PMTH 5203	Lab-II (Programming with MATLAB)	03
Optional I		03
Optional II		03
PMTH 5214	Project	03
PMTH 5215	Viva Voce	02
Total Credits		**20**
* 2 (two) Optional courses will be offered from the following courses. (As par decision of academic committee)		

Optional Courses:

Course Code	Course Title	Credits
PMTH 5204	Dynamical Systems	03
PMTH 5205	Mathematical Modeling and Population Dynamics	03
PMTH 5206	Lattice Theory and Boolean Algebra	03
PMTH 5207	Fuzzy Mathematics	03
PMTH 5208	Advanced Mathematical Methods	03
PMTH 5209	Quantum Mechanics	03
PMTH 5210	Actuarial Mathematics	03

Semester Plan

1st Semester		
	Course No. Title of Courses	**Credit**
1	PMTH 5101 : Fundamental of Mathematics	03
2	PMTH 5102 : Topology and Advanced Analysis	03
3	PMTH 5103 : Lab-I (Introduction to Computer Application Lab)	03
4	* Optional Course –I	03
5	* Optional Course –II	03
6	* Optional Course –III	03
	Total credit:	**18**

* Optional courses will be offered from PMTH 5104 to PMTH 5110

* Optional courses will be selected by the academic committee of the Department

2nd Semester		
	Course No. Title of Courses	**Credit**
1	PMTH 5201 : Advanced Numerical Analysis	03
2	PMTH 5202 : Fluid Dynamics and Heat Transfer	03
3	PMTH 5203 : Lab-II (Programming with MATLAB)	03
4	* Optional Course –I	03
5	* Optional Course –II	03
6	PMTH 5214: Project	03
7	PMTH 5215 : Viva-Voce	02
	Total credit:	**20**

* Optional courses will be offered from PMTH 5204 to PMTH 5210

* Optional courses will be selected by the academic committee of the Department

Details of the Courses:

1st Semester

PMTH 5101: Fundamentals of Mathematics
100 Marks: 03 Credits

1. **Number System:** Field and order properties, Natural numbers, integers and rational numbers and irrational numbers, Absolute value, Basic inequalities. Definition of complex numbers as ordered pairs. De Moivre's theorem and its applications.
2. **2D Geometry:** General second degree equations representing pair of straight lines, angle between pair of straight lines, bisectors of angles between pair of straight lines. Algebra of vectors. Scalar and Vector product. Scalar triple product and vector triple product.
3. **Calculus:** Definition and basic concepts of limit and continuity, L'Hôpital's rule, Tangent lines and rates of change, Computation of derivatives, Derivatives of trigonometric functions, Implicit differentiation, Derivatives of logarithmic, exponential and inverse trigonometric functions, Rolle's theorem, Mean value theorem, Maximum and minimum values of functions, Absolute maximum and minimum values of functions. Anti-derivatives, The indefinite integral, Techniques of integration, The definite integral, The fundamental theorem of calculus, Basic properties of integration, Applications of integration in science and engineering.

Evaluation: Final exam (Theory, 3 hours): 50 marks. Eight questions will be set (each question contains equal value), of which five are to be answered. 30 Marks for Midterms,10 Marks for assignments/Presentation/Quiz/Class test and 10 Marks for class attendance.

Reference Books:

1. Higher Algebra- Prof. Md. Abdur Rahman
2. Analytic Geometry and Vector Analysis- Khosh Mohammad
3. Calculus - Howard Anton (11/E)
4. Differential Equations – S. L. Ross (3/E)

PMTH 5102: Differential and Integral Equations
100 Marks: 03 Credits

1. **Ordinary Differential Equation (ODE):** Basic concepts of differential equations, Formation of differential equation, Existence and uniqueness theorems, Solutions of 1st order 1st degree ordinary differential equations.
2. **Partial Differential Equation (PDE):** Complete integral, General solution, Cauchy problems, Method of characteristics for linear and quasilinear equations, Lagrange's method, Charpit's method for finding complete integrals, Methods for finding general solutions.

Second Order PDE equations: Classifications, Boundary value problems related to linear equations, Laplace's equation, wave equation and heat equation, Homogeneous and non-homogeneous boundary conditions.

3. **Integral equations**: Existence and general properties of solutions of Volterra integral equations, Fred-Holm theory of integral equations, Numerical solution of integral equations.
4. **Stability**: Stability theory of linear, non-linear system of differential equations, Lyapunov functions, Stability test of differential equations and Volterra integral equations by Lyapunov functions.

Evaluation: Final exam (Theory, 3 hours): 50 marks. Eight questions will be set (each question contains equal value), of which five are to be answered. 30 Marks for Midterms, 10 Marks for assignments/Presentation/Quiz/Class test and 10 Marks for class attendance.

Reference Books:

1. Volterra Integral and Differential Equations, T. A. Burton.
2. Integral Equations and Applications, C. Corduneanu.
3. Numerical Solution of Integral Equations, Michael A. Golberg.
4. Partial Differential Equations- Schaums Outlines Series.
5. Partial Differential Equations - J.M. Kar.

PMTH 5103: Lab-I(Introduction to Computer Application Lab)
100 Marks: 03 Credits

1. **Operating Systems: Windows:** Students will learn the basics of computer, how to operate them in two basic environments, Dos and Windows. **Word Processor:** Students will learn to use a popular word processor to create a camera ready test file complete with figures, columns and tables, **Spread Sheet:** Students will learn to use a popular Spread Sheet to maintain a small data base, minor book keeping and statistical and graphical analysis of data. **Presentation package:** Students will learn how to create multimedia slides and animation. **Bangla Typing:** As a mother language students will learn how to write anything using bangla font.
2. **Problem-solving using Mathematica:** Solving problems in Multivariative Calculus, Ordinary Differential Equations, Linear Algebra and Numerical Analysis-I.

Evaluation: Final exam (Lab, 3 hours): 50 marks. Eight questions will be set; of which five are to be answered (each question contains equal value). 30 Marks for Midterms, 10 Marks for assignment/Presentation/Quiz/Class test and 10 Marks for class attendance.

PMTH 5104: Operations Research
100 Marks: 03 Credits

1. **Introduction to Operations Research:** Historical Background of OR, Definitions, Characteristic, Necessity, Scope, Classic function of problems, Formulation of OR models.
2. **Transportation and Assignment Problem:** Introduction, Formulation, Relationship with Linear Programming, Solution procedure and Applications.
3. **Network Models:** Network definition, Shortest Route problem, Minimal Spanning Tree problem and Maximal Flow problem, Critical Path Method (CPM), Network representation of simple projects.
4. **Integer Programming:** Introduction to Branch and bound Algorithm, Cutting-plane Algorithm, Applications.
5. **Game Theory:** Introduction, Minimax-maximum pure strategies, Mixed strategies and expected payoff, solution of 2×2 games, solution (2×n) and (m×2) games, solution of (m×n) games by linear programming.
6. **Dynamic Programming:** Introduction, Investment Problem, Production scheduling problem, Stagecoach problem, Equipment replacement problem.
7. **Nonlinear Programming:** Introduction, Unconstrained problem, Langrange's method for equality constraint problem, Kuhn-Tucker method for inequality constraint problem and Quadratic programming problem.

Evaluation: Final exam (Theory, 3 hours): 50 marks. Eight questions will be set (each question contains equal value), of which five are to be answered. 30 Marks for Midterms, 10 Marks for assignments/Presentation/Quiz/Class test and 10 Marks for class attendance.

Reference Books:

1. An Introduction to Management Science - Anderson, Sweeney, Williams.
2. Operations Research, Macmillan publishing company, Hamdy. A. Taha .
3. Operations Research, John Wiley and Sons, A. Rabindran, D. T. Phillips, J. J. Solberg.
4. Introduction to Operations Research McGraw-Hill Publishing company, B. E. Gillett.
5. Dynamic programming, Richard Bellman.

PMTH 5105: Theory of Numbers
100 Marks: 03 Credits

1. Divisibility, prime numbers, division algorithm, Euclidean algorithm, continued fractions.
2. The fundamental theorems of arithmetic, sum and product of divisors, perfect number, Fermat number, Mersenne number.
3. Congruences, residue systems, residue classes, Fermat's theorem, Euler's theorem, Wilson's theorem, Euler's Phi-function.

4. Chinese remainder theorem, linear Diophantine equations.
5. Arithmetical functions, Dirichlet product, multiplicative functions, Mobius function, and Mobius inversion formula.

Evaluation: Final exam (Theory, 3 hours): 50 marks. Eight questions will be set (each question contains equal value), of which five are to be answered. 30 Marks for Midterms, 10 marks for assignments/Presentation/Quiz/Class test and 10 Marks for class attendance.

Reference Books:

1. An Introduction to the Theory of Numbers- Niven, H.S. Zuckerman.
2. Essentials of Number Theory- M. R. Chowdhury & Fatema Chowdhury.
3. An Introduction to the Theory of Numbers- G.H Hardy & E.N. Wright.

PMTH 5106: Financial Mathematics
100 Marks: 03 Credits

1. **Mathematics for Finance:** Simple and compound interest and discounts. Investments in stocks and bonds. Mathematics of real estates. Mathematics of insurance. Elements of actuarial science. Interest rate models: Risk and risk-free asset, Bond and risk-free interest rate, Bond pricing with known interest rates and dividend payments; Zero-coupon bond pricing; Measure of future values of interest rate; Term structure of interest rate (Yield curve); Annuity; present and future value of annuity, Application of Annuity: Amortization and Sinking fund.
2. **Economic Application of graphs and Equations:** Iso-cost analysis, Equilibrium in demand and supply, Marginal cost, Marginal revenue.
3. **Marketing Mathematics:** Markup and mark-down. Break-Even Interpretation. Merchandise and profit. Trade discounts and cash discounts.
4. **Modeling in Finance:** One-step and two-steps binomial trees; Binomial model for stock price; Option pricing on binomial tree; Matching volatility _ with u and d; American put option pricing on binomial tree.
5. **Black-Scholes analysis:** Black-Scholes model; Black-Scholes Equation; Boundary conditions for call and put options; Exact solution to Black-Scholes equation; Delta-hedging; the Greek letters; Black-Scholes equation and replicating portfolio; Static and dynamic risk-free portfolio; Option on dividend-paying stock; American put option.

Evaluation: Final exam (Theory, 3 hours): 50 marks. Eight questions will be set (each question contains equal value), of which five are to be answered. 30 Marks for Midterms, 10 Marks for assignments/Presentation/Quiz/Class test and 10 Marks for class attendance.

Reference Books:

1. Mathematics of Finance- L.L.Smail.

2. Mathematics of Finance -P.H. Chartes.
3. Business Mathematics -L. W. T. Stafford.
4. Mathematics with application in management and Economics-Earl K.Bowen

PMTH 5107: Analytical Dynamics
100 Marks: 03 Credits

1. Motion relative to rotating earth, Motion of a rigid body about a fixed point,Poinsot's construction of rigid body motion.
2. Inertia tensor and related properties.
3. Holonomic and non-holonomic dynamical systems, derivation of Lagrange's equations in generalized coordinates.
4. Hamiltonian and Hamilton's equations, Hamilton's canonical equations of motion.
5. Ignorable coordinates and Routhian functions.
6. Poisson's and Lagrange's brackets and applications to Hamilton's mechanics.
7. Canonical transformations, Generating function, Invariance of Canonical transformations.

Evaluation: Final exam (Theory, 3 hours): 50 marks. Eight questions will be set (each question contains equal value), of which five are to be answered. 30 Marks for Midterms, 10 Marks for assignments/Presentation/Quiz/Class test and 10 Marks for class attendance.

Reference Books:
1. Theoretical Mechanics----- Murry R. Spiegel (Shaum's Outline Series).
2. Text Book of Dynamics----- Frank Charlton.
3. Classical Mechanics ----- H. Goldstein.

PMTH 5108: Topology and Advanced Analysis
100 Marks: 03 Credits

1. **Topological spaces:** Metric spaces, Definition and Properties of Topological spaces, Bases and Sub-bases, Continuous functions, compactness, connectedness.
2. **Separation axioms:** T_1 &T_2Spaces, Regular spaces, Completely Regular spaces, Normal spaces.
3. **Element of measurable spaces:** Measurable spaces, Measurable sets and functions, simple functions, Positive measures and properties.
4. **Lebesgue integrations:** Integration of non-negative and complex functions, Momotone convergence theorem, Dominated convergence theorem, Concept of almost everywhere.
5. **Hilbert spaces:** Real and complex vector spaces, Inner product spaces, Hilbert Spaces and their properties.
6. **Banach spaces:** Normed linear spaces and Banach spaces and their properties.

7. **Fourier analysis:** Definition of odd and even functions, periodic and aperiodic functions. Trigonometric and exponential Fourier series, Fourier transform and its basic properties.
8. **Laplace transform:** Definition and basis properties of Laplace transform, Solution of Differential and Integro-differential equations by Laplace transform.

Books Recommended:

1. Lipschutz, S. : General Topology.
2. Simmons, G.F. : Introduction to Topology and Modern Analysis.
3. Sharma, J.N. : Topology.
4. Chow, F. & Cho, M : Essentials of Topology and Functional Analysis.
5. Rudin,W. : Real and Complex analysis
6. Rudin,W. : Functional Analysis
7. Lathi, B.P. : Signal Processing & Linear Systems.
8. Proakis J.G. : Digital Signal Processing.

PMTH 5109: Functional Analysis and Operator Theory
100 Marks: 03 Credits

1. **Normed and Banach Spaces:** Definitions and Elementary properties, Some Concrete Normed and Banach Spaces, Subspaces, Quotient Spaces, Completion of Normed Spaces
2. **Bounded Linear Operators:** Definitions, Examples and Basic Properties, Spaces of Bounded Linear Operators, Equivalent Norms, Finite Dimensional Nor med Spaces and Compactness, Open Mapping theorem and its consequences, Closed Graph Theorem and Its Consequences, Uniform Boundedness Principle
3. **Bounded Linear Functionals:** Definitions, Examples and Basic Properties, The Form of Some Dual Spaces, Hahn-Banach Theorem and its Consequences, Embedding and Reflexivity of Normed Spaces, Adjoint of Bounded Linear Operators, Weak Convergence.
4. **The Concept and Specific Geometry of Hilbert Spaces:** Definitions and Basic Properties of Inner Product Spaces and Hilbert Spaces, Completion of Inner Product Spaces, Orthogonality of Vectors, Orthogonal Complements and Projection Theorem, Orthonormal Sets and Fourier Analysis, Complete Orthonormal Sets
5. **Functionals and Operators on Hilbert Spaces:** Bounded Linear Functionals, Hilbert-Adjoint Operators, Self-Adjoint Operators, Normal Operators, Unitary Operators, Orthogonal Projection Operators
6. **Spectral Theory:** Eigenvalues of a Linear Operator, The Spectrum of a Bounded Linear Operator, Spectral Properties of Bounded Linear Operators, Complex Analysis and Spectral Theory.

Evaluation: Final exam (Theory, 3 hours): 50 marks. Eight questions will be set (each question contains equal value), of which five are to be answered. 30 Marks for Midterms, 10 Marks for assignments/Presentation/Quiz/Class test and 10 Marks for class attendance.

Reference Books:

1. Introduction to Topology and Modern Analysis – G. F. Simmons
2. Introductory functional analysis with applications - Erwin Kreyszig
3. Functional Analysis – P. K. Jain, O. P. Ahuja, Khalil Ahmed

PMTH 5110: Mathematical Modeling in Biology
100 Marks: 03 Credits

1. **Continuous Population models for single species**: Continuous growth models, Delay models and application in diseases, Periodic fluctuations, Harvesting models for a single natural population.
2. **Discrete Population models for single species** : Simple model, Discrete logistic models-Chaos, Discrete delay models.
3. **Models for interacting populations** : Predator-prey models: Lotka-Voltera systems, Complexity and stability, Periodic behavior: Parameter Domains of Stability, Competition models, Mutualism or Symbiosis.
4. **Discrete growth models for interacting populations** : Predator-prey models, Competition models.
5. **Epidemic models and dynamics of infectious diseases** : Simple epidemic models, AIDS: Modelling the Transmission Dynamics of the Human Immunodeficiency Virus (HIV), HIV: Modelling Combination Drug Therapy.

Evaluation: Final exam (Theory, 3 hours): 50 marks. Eight questions will be set (each question contains equal value), of which five are to be answered. 30 Marks for Midterms, 10 Marks for assignments/Presentation/Quiz/Class test and 10 Marks for class attendance.

Reference Books:

1. Mathematical Biology- J. D. Murray
2. Introduction to Population Modeling- C. Frauenthal
3. Mathematical model in Biology and Medicine- J. N. Kapur

2nd Semester

PMTH 5201: Advanced Numerical Analysis
100 Marks: 03 Credits

Finite Difference Method

1. **IVP for ODE:** Euler's Method, Higher Order Taylor's Method, Runge-Kutta Methods (Order two and four).
2. **BVP for ODE:** Finite Difference Methods for linear problems.
3. **BVP for PDE:** (a) Elliptic problems (Poisson Equation and Laplace's Equation),
   (b) Parabolic problems (Heat Equation, Crank-Nicholson Method), (c) Hyperbolic problems (Wave Equation in time dependent and two space dimension) by Finite Difference Method.

Finite Element Method:

4. **Introduction:** Discretization, Basis functions (one and two dimensional elements up to order three).
5. **Matrix Formulation:** Galerkin Weighted Residual Method, Modified Galerkin Techniques.

Evaluation: Final exam (Theory, 3 hours): 50 marks. Eight questions will be set (each question contains equal value), of which five are to be answered. 30 Marks for Midterms, 10 Marks for assignments/Presentation/Quiz/Class test and 10 Marks for class attendance.

Reference Books:

1. Numerical Analysis --- R.L. Burden and J. D. Faires.
2. Finite Element Method --- J. N. Reddy.
3. The finite element methods, Principles and Application---P.E. Lewis and J. P. Ward (Addson Wesley).
4. Finite Elements and Approximations --- O. C. Zienkiewicz and K. Morgan (John Wiley and Sons).

PMTH 5202: Fluid Dynamics and Heat Transfer
100 Marks: 03 Credits

1. Basic definition of fluids and its dynamics with definition of some useful dimensionless numbers.
2. Newton's law of viscosity, Newtonian and Non-Newtonian fluids, rotational and irrotational flow, compressible and incompressible fluids, stream function.
3. Derivation of the Navier-Stoke's equations of motion and its general properties. Equation of motion in Cartesian and Cylindrical coordinate systems.
4. Derivation of energy equation, introduction to heat transfer.
5. Parallel flow through a straight channel, Plane and generalized Couette flow, Plane Poiseuille flow, Flow through convergent and divergent channel, Unsteady flows.

6. Differential equation of very slow motion, Slow motion over a sphere (Stoke's solutions).
7. General concepts and properties of boundary layer, Prandtl's boundary layer equations, Similarity concept and similarity solutions of the boundary layer equations, Flow in a convergent channel. Von-Karman's integral and momentum equation.
8. Basic definitions of natural and force convection, Determination of heat transfer from a vertical plate using the integral method, Derivation of thermal boundary layer equation.

Evaluation: Final exam (Theory, 3 hours): 50 marks. Eight questions will be set (each question contains equal value), of which five are to be answered. 30 Marks for Midterms, 10 Marks for assignments/Presentation/Quiz/Class test and 10 Marks for class attendance.

Reference Books:

1. Fundamentals Mechanics of Fluids, I. G. Currie
2. Heat and Mass Transfer, Yunus A. Cengel
3. Fluid Dynamics, M. D. Raisinghania.
4. Boundary layer Theory, Schlichting, H.
5. Viscous fluid flow, F. M. White

PMTH 5203: Lab-II: (Programming with MATLAB)
100 Marks: 03 Credits

Problem solving in various courses using **MATLAB.**

Evaluation: Final exam (Lab, 3 hours): 50 marks. Eight questions will be set; of which five are to be answered (each question contains equal value). 30 Marks for Midterms, 10 Marks for assignment/Presentation/Quiz/Class test and 10 Marks for class attendance.

PMTH 5204: Dynamical Systems
100 Marks: 03 Credits

1. **Introduction:** Historical background, General ideas of dynamical systems, Tool kits of dynamical activities, Applications of dynamical systems, Examples of dynamical systems.
2. **Iterations:** Types of iterations, Orbits, Fixed points, Graphical Analysis, Orbit Analysis, Phase portrait, Finding roots and solving equations, Theorems related to fixed points.
3. **Bifurcations:** Dynamics of linear parameterized family**,** Dynamics of quadratic map. First and second bifurcations, Saddle-node bifurcation, Period-doubling bifurcation. Dynamics of quadratic families, Cantorsets and their dynamical behavior.
4. **The Chaotic Systems:** Several chaotic phenomena, Definitions of chaos, Several Chaotic Approaches, Relationship among the chaotic three conditions, Observations on chaotic systems, Generating chaotic maps by homeomorphisms.

5. **Fractal Geometry:** The chaos game, Cantor set revisited, Sierpinski Triangle, Koch Snowflake, Topological Dimension, Fractal Dimension, Finding areas, Perimeters and Lengths with generalizations of Fractals. Dynamics of Cantor Sets, Generalized Cantor sets. Generating Fractals.
6. **Dynamics in Schwarzian derivative and Newton's Method:** The Schwarzian derivatives, Chain rule for Schwarzian derivatives, Schwarzian min-max principle, Dynamics of negative Schwarzian derivatives, Critical point and basins of attractions.
7. **The Julia & Mandelbrot Sets:** Dynamical behavior in the plane**,** Squaring function, Chaotic quadratic function, Cantor sets, Filled Julia sets and Critical orbits.

Evaluation: Final exam (Theory, 3 hours): 50 marks. Eight questions will be set (each question contains equal value), of which five are to be answered. 30 Marks for Midterms,10 Marks for Assignments/Presentation/Quiz/Class test and 10 Marks for class attendance.

Reference Books:

1. A First course in chaotic dynamical systems, R. L. Devaney, West view Press 1992.
2. A First course in discrete dynamical systems, R. A. Holmgren, Springer 1996.
3. Four Tool Kit of Dynamical Activities, R. L. Devaney

PMTH 5205: Mathematical Modeling and Population Dynamics
100 Marks: 03 Credits

1. Mathematical Models: Single and Two-species population models, Simple prey-predator model, Numerical analysis of prey-predator model, Competition model, Model in Medical sciences. Chaotic phenomena in population dynamics. Lotka Volterra population models, multispecies population models, optimal population models.
2. Differential equations in the theory of epidemics, blood flow through artery with mild stenosis, models of gas exchange and air flow in lungs, Glucose concentration in blood, a heart function test, nervous excitation.

Evaluation: Final exam (Theory, 3 hours): 50 marks. Eight questions will be set (each question contains equal value), of which five are to be answered. 30 Marks for Midterms,10 Marks for Assignments/Presentation/Quiz/Class test and 10 Marks for class attendance.

PMTH 5206: Lattice Theory and Boolean Algebra
100 Marks: 03 Credits

1. Definitions: Poset, Lattice, Semilattice, Sublattice, Convex sublattice, complete lattice, Some elementary properties, Direct product.
2. Ideal: Ideal, dual ideal, Prime ideal, Principal ideal.
3. Morphisms, Join irreducible element, Atom.

4. Modular and distributive lattices.
5. Quotient Lattice and Metric Lattices, Applications.
6. Boolean Algebra and Boolean ring.
7. Boolean function and switching circuit and its Applications.
8. Congruence on distributive lattices: Smallest and largest congruence containing an ideal as a class. Compact element and Algebraic lattice. Generalized Boolean lattice, Isomorphism of I (L) and C (L).

Evaluation: Final exam (Theory, 3 hours): 50 marks. Eight questions will be set (each question contains equal value), of which five are to be answered. 30 Marks for Midterms, 10 Marks for Assignments/Presentation/Quiz/Class test and 10 Marks for class attendance.

Reference Books:

1. Lattice theory- First concepts and distributive lattices, G. Gratzer
2. Lattice theory, V. K. Khanna
3. Introduction to lattice theory, D. K. Rutherford
4. Lattice theory, G. Bikhoff

PMTH 5207: Fuzzy Mathematics
100 Marks: 03 Credits

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

Evaluation: Final exam (Theory, 3 hours): 50 marks. Eight questions will be set (each question contains equal value), of which five are to be answered. 30 Marks for Midterms,10 Marks for Assignments/Presentation/Quiz/Class test and 10 Marks for class attendance.

Reference Books:

1. G. J. Khir & Bo Yuan., Fuzzy Sets & Fuzzy Logic Theory and Applications.
2. G. J. Khir & U. Clair, Fuzzy Set Theory.
3. H.J. Zimmermann, Fuzzy Sets Theory and Its Applications.

PMTH 5208: Advanced Mathematical Methods
100 Marks: 03 Credits

1. **Fourier series:** Definition of Fourier series, Dirichlet condition, Half-Range Fourier sine or cosine series, Parseval's identity, Complex form of Fourier series, Applications of Fourier series in solving ODE and PDE such as steady periodic solution of 2^{nd} order ODE and solution of PDE (Heat, Wave and Laplace's equation).
2. **Fourier transform:** Finite and infinite Fourier sine and cosine transforms, Convolution theorem for Fourier transforms, Parseval's identities for Fourier transforms, Relation between Fourier and Laplace transforms, Applications of Fourier transforms in solving boundary value problems.
3. **Laplace transform:** Definition of Laplace transforms, Existence theorem, Laplace transforms of some elementary functions, Some important properties of Laplace transforms, Definition of inverse Laplace transforms, Some important properties of inverse Laplace transforms, The Convolution theorem and its applications, Methods of finding inverse Laplace transforms, Applications of Laplace transforms to solve both the ordinary and partial differential equations.

Evaluation: Final exam (Theory, 3 hours): 50 marks. Eight questions will be set (each question contains equal value), of which five are to be answered. 30 Marks for Midterms,10 Marks for Assignments/Presentation/Quiz/Class test and 10 Marks for class attendance.

Reference Books:

1. Fourier Analysis with applications to boundary value problems- M.R. Spiegel
2. Laplace Transforms- M.R. Spiegel
3. Mathematical Methods –Vol. I & II – Md. Abdur Rahman

PMTH 5209: Quantum Mechanics
100 Marks: 03 Credits

1. Black body radiation; Planke's radiation low; Einstein Photon theory; Compton effect;
2. Principals of Uncertainty; De Broglie wave and matter-wave duality.
3. Bohr-Sommerfield quantization rule; Equation of continuity and boundary conditions of wave function.
4. Wave packets in space and time; Schrodinger wave equation; Normalization of wave function; Probability current density.
5. Finite potential step and one-dimensional square well potential.
6. Energy Eigen value and energy eigen function.
7. Box normalization and closure property.

Evaluation: Final exam (Theory, 3 hours): 50 marks. Eight questions will be set (each question contains equal value), of which five are to be answered. 30 Marks for Midterms,10 marks for Assignments/Presentation and 10 Marks for class attendance.

PMTH 5210: Actuarial Mathematics
100 Marks: 03 Credits

1. Survival models: Survival models, Some actuarial concepts in survival analysis, Force of Mortality, Expectation of life, Curtate failure, Selected survival models, Common Analytical Survival Models, Mixture models.

2. Life Tables: Life tables, Actuarial Models, Deterministic survivorship group and random survivorship group, Continuous computations, Interpolating life tables, Select and Ultimate Tables.

3. Life insurance: Introduction to life insurance, Payments paid at the end of the year of death. Further properties of the APV for discrete insurance, Non-level payments paid at the end of the year, Payments at the end of the m-thly time interval, Level benefit insurance in the continuous case. Further properties of the APV for continuous insurance, Non-level payments paid at the end of the year, Computing APV's from a life table.

4. Life annuities: Whole life annuity, n-year deferred annuity, n-year temporary annuity, n-year certain annuity, Contingencies paid m times a year, Non-level payments annuities, Computing present values from a life table.

5. Benefit premiums: Funding a liability. Fully discrete benefit premiums. Benefits paid annually funded continuously. Benefit premiums for fully continuous insurance. Benefit premiums for semi continuous insurance. Benefit premium for an n-year deferred annuity. Premiums paid m times a year. Non-level premiums and/or benefits. Computing benefit premiums from a life table, Premiums found including expenses.

6. Benefit reserves: Benefit reserves, Fully discrete insurance. Fully continuous insurance, Reserves for insurance paid immediately and funded discretely, Reserves for insurance paid discretely and funded continuously, Benefit reserves for general fully discrete insurance, Benefit reserves for general fully continuous insurance, Benefit reserves for m-thlypayed premiums. Benefit reserves including expenses. Benefit reserves at fractional durations.

7. Multiple life functions : Multivariate random variables, Joint life status, Last survivor status, Joint survival functions, Common shock model, Insurance for multi--life models, Problems for recent actuarial exams,

8. Markov chains: Stochastic processes. Markov chains, Random walks, Hitting probabilities, Gambler's ruin problem, Some actuarial applications.

Reference Books:

1. Fundamentals of Actuarial Mathematics 3nd Edition by S. David Promislow, Willy publishers
2. Actuarial Mathematics and Life table Statistics By Eric V. Slud, Mathematics Department, University of Maryland, College Park
3. Newton L. Bowers, Hans U. Gerber – Actuarial Mathematics, Society of Actuaries.

PMTH 5214: Project
100 Marks: 03 Credits

Mathematics Project: Each student is required to work on a project and present a project report for evaluation. Such projects should be extension or applications of materials included in different courses and may involve field work and use of technology. There may be group projects as well as individual projects.

PMTH 5215: Viva Voce
50 Marks: 02 Credits

Viva-Voce on courses taught in the 2nd Semester.