FOREWORD

Renewing and updating of the Curriculum is the essential ingredient of any vibrant university academic system. There ought to be a dynamic Curriculum with necessary additions and changes introduced in it from time to time by the respective university with a prime objective to maintain updated Curriculum and also providing therein inputs to take care of fast paced development in the knowledge of the subject concerned. Revising the Curriculum should be a continuous process to provide an updated education to the students at large.

Leaving a few, there have been many universities where this exercise has not been done for years together and it is not uncommon to find universities maintaining, practicing and teaching still on the Curriculum as old as few years or even more than a decade. Not going through the reasons for this inertia, the University Grants Commission, realising the need in this context and in relevance to its mandate of coordinating and maintaining standard of higher education, decided to adopt a pro-active role to facilitate this change and to ensure that the university Curriculum are soon updated to provide a standard education all over the country.

Curriculum Development Committee for each subject was constituted with the respective Convenor as its nodal person. The Committee besides having five subject experts drawn from the university system, was given a wider representation of various sub subject experts attending meetings of the Committee as the esteemed co-opted members which kept on changing from time to time as the need arose. The Committees, therefore, had representations from a large number of experts and had many meetings before final updated Model Curricula were presented to UGC.

The University Grants Commission and I as its Chairman are grateful to the nodal persons, a large number of permanent and co-opted members in different subjects and their sub disciplines for having worked seriously with committed devotion to have produced a UGC Model Curriculum in 32 subjects within a record period of 18 months.

The exercise would not have been possible without the support of our entire academic community. We can only hope that the results will fulfil their expectations and also those of university community and Indian society.

The UGC Model Curriculum has been produced to take care of the lacuna, defects/shortcomings in the existing Curricula in certain universities, to develop a new Model Curriculum aiming to produce the one which is compatible in tune with recent development in the subject, to introduce innovative concepts, to provide a multi disciplinary profile and to allow a flexible cafeteria like approach including initiating new papers to cater to frontier development in the concerned subject.

The recommendations have been compiled by panels of experts drawn from across the country. They have attempted to combine the practical requirements of teaching in the Indian academic context with the need to observe high standards to provide knowledge in the frontier areas of their disciplines. It has also been aimed to combine the goals and parameters of global knowledge with pride in the Indian heritage and Indian contribution in this context.
Today all knowledge is interdisciplinary. This has been duly considered. Flexible and interactive models have been presented for the universities to extend them further as they would like. Each institution may have to work out certain uniform structures for courses at the same level, so that effective interaction between subjects and faculties is possible. The tendency across the country is now to move from the annual to the semester system, and from award of marks to award of credits. There is perceptible growing interest in modular framing as well.

The recommendations while taking all these features into account, have also made provisions for institutions who may not be in a position to undertake radical structural reform immediately. In any country, especially one as large and varied as India, academic institutions must be allowed enough autonomy and freedom of action to frame courses according to specific needs. The recommendations of the Curriculum Development Committees are meant to reinforce this. The purpose of our exercise has been to provide a broad common framework for exchange, mobility and free dialogue across the entire Indian academic community. These recommendations are made in a spirit of openness and continuous improvement.

To meet the need and requirement of the society and in order to enhance the quality and standards of education, updating and restructuring of the curriculum must continue as a perpetual process. Accordingly, the University Grants Commission constituted the Curriculum Development Committees. If you need to seek any clarification, you may contact Dr. (Mrs.) Renu Batra, UGC Deputy Secretary and Coordinator of CDC who shall accordingly respond to you after due consultation with the respective nodal person of the concerned subject.

The University Grants Commission feels immense pleasure in forwarding this Model Curriculum to the Hon'ble Registrars of all Universities with a request to get its copies made to be forwarded also to the concerned Deans and Heads of Departments requesting them to initiate an early action to get their Curriculum updated. The University Grants Commission Model Curricula is being presented to the Registrar of the university with options either to adopt it in toto or adopt it after making necessary amendments or to adopt it after necessary deletion/addition or to adopt it after making any change whatsoever which the university may consider right. This UGC Model Curriculum has been provided to the universities only to serve as a base and to facilitate the whole exercise of updating the Curriculum soon.

May I request Hon'ble Vice Chancellor and the Hon'ble Registrar including the esteemed Deans, Heads of Departments, Members of the Faculty, Board of Studies and Academic Council of the Universities to kindly update their Curriculum in each of the 32 subjects in consultation with Model Curriculum provided here. This has to be done and must be done soon. May I request the Academic administration of the universities to kindly process it immediately so that an updated Curriculum is adopted by the university latest by July, 2002.

The University Grants Commission requests the Hon'ble Registrars to confirm that this time bound exercise has been done and send a copy of the university's updated Curriculum in each subject to UGC by July 31, 2002. It is a must. It has to be done timely, failing which, the UGC may be forced to take an appropriate unpleasant action against the concerned university.

The UGC looks forward for your active participation in this joint venture to improve the standards to achieve excellence in higher education.

December 2001

HARI GAUTAM
MS (SURGERY) FRCS (EDIN) FRCS (ENG)
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CHAIRMAN, UGC
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The University Grants Commission constituted the Curriculum Development Committee in February 2001 for updating/framing the curricula in Mathematics at the undergraduate and postgraduate levels. In addition to recommending Syllabi for various courses, the Committee was asked to consider issues like multidisciplinary skills, linking the general studies with professional courses, introduction of bridge courses etc. allowing both the vertical and horizontal academic mobility. These are perfectly in tune with what Professor David Hilbert, one of the founder fathers of modern mathematics, had once posed at an international gathering of mathematicians—“What particular goals will there be toward which the leading mathematical spirits of coming generations will strive for?” Mathematics deals with changes and complexity of the natural and social world. The abstractions such as relationships, measure, pattern, order etc. which the mental organizing systems have to perform can be seen as prototypes of roots of mathematical ideas. The search for symmetries and regularities in the structure of the world continues to stay in the core of the pure mathematics. These symmetric patterns discovered by mathematicians quite often give birth to new technologies of great importance to human beings. One such example is that of X-ray tomography (CAT Scan). The generation of perfect codes has its clue in the arithmetic over prime numbers. Designs of large economically efficient networks of high connectivity owe its roots in the infinite dimensional representation of groups. Advanced Computer Graphics, visualization, and computer assisted design technologies grew due to basic mathematics developed to understand surfaces, matrices and certain types of geometries. These developments enabled Boeing to roll out its 777 jumbojet without ever building a mockup. Not only millions of dollars were saved but new standards for safety and reliability were also set. There is a wide class of problems typically coming from experimental sciences such as Chemistry, environmental sciences, earth sciences, medical sciences etc. where one has to deal with large amounts of loosely structured data. To make a breakthrough in tackling them one needs radical theoretical ideas, as well as new ways of doing mathematics with computers and a more closer collaboration with experimental scientists in order to match mathematical theories with available experimental data. Both the theoretical and industrial inputs of these developments are enormous and clearly visible today. These make the goal clear. Today students need thorough knowledge of fundamental principles, methods, results, and a clear perception of the enormous power of mathematical ideas and tools and knowhow to use them in all the three phases viz., modeling, solving and interpreting. The committee has made sincere efforts to recommend Syllabi which may enable a student to catch the right track.
I record my grateful thanks to all the hon'ble members of the Committee who have contributed to the framing of the recommended syllabi. A number of Professors from various universities and persons having industrial experience were consulted and we are grateful to all of them for their suggestions.

Finally, the Committee expresses its appreciation for the assistance provided by Dr. A.K. Parate, Deputy Secretary, University Grants Commission, and his office staff for completing this task.

(S.N. Lal)
Nodal Person & Convener
C.D.C. in Mathematics
CURRICULUM DEVELOPMENT COMMITTEE (MATHEMATICS)
University Grants Commission, New Delhi

Members who contributed to the framing of the Recommended Syllabi

1. Professor S.N. Lal
   Banaras Hindu University
   Nodal person and Convener

2. Professor P.K. Jain
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   Member

3. Professor S.S. Khare
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4. Professor S. Uma Maheswaram
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9. Professor H.D. Pandey
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10. Dr. Kapil Hari Paranjape
    Institute of Mathematical Sciences Taramani, Chennai
    Member

Dr. A.K. Parate, Deputy Secretary, UGC – Secretary to the Committee.
CURRICULUM DEVELOPMENT COMMITTEE IN MATHEMATICS

The members of the Committee deliberated at length on the goals set as spelled out in the Preface and went through the existing Syllabi of the various universities. As a result of these deliberations the Syllabi of the following Programs are being recommended.

2. B.A./B.Sc. (General) Mathematics (Program name : BMG).

About the Above Programs

In all the above programs there are Core Courses and Optional papers. The time required for covering each paper is explicitly mentioned. The topics recommended (parts a and b) in the Syllabi of the various papers can be covered in two semesters. But we have not explicitly separated the parts a and b. Consider, for example, the Course MM 401 (a & b) Advanced Abstract Algebra. The universities following semester system can divide the contents into two parts a and b according to their convenience and teach part a in one semester and part b in the next semester. There are one Semester Courses as well. The teaching program is expected to be supplemented by tutorials, problem solving sessions, seminars and group discussions.

It is recommended that each paper be further divided into Sections and questions from each Section be asked so as to ensure that the student has actually studied all the topics. In order to test the grasp of the underlying principles in the various topics, objective type questions and questions having short answers covering the entire syllabus may be asked.

The M.A./M.Sc. program is so designed that students from both B.A./B.Sc. (Honours) and B.A./B.Sc. (General) streams can study its various papers without much difficulty.

Inclusion of Computer Science Courses in B.A./B.Sc. and M.A./M.Sc. programs has several advantages. Students offering these courses will be in demand in Industry and shall get preference in teaching and research institutions.

A student after obtaining M.Sc. Tech (Industrial Mathematics with Computer Applications) degree is expected to be absorbed immediately in the Industry. Persons with M.Sc. Tech (Industrial Mathematics with Computer Applications) degree shall be considered to be holding a degree higher than M.A./M.Sc. (Mathematics) two year degree of any Indian University and they shall be eligible for appointment on all teaching, research and other positions where M.A./M.Sc.
Mathematics degree is the required qualification. A certificate to this effect may be separately issued by the institutions awarding M.Sc. Tech (Industrial Mathematics with Computer Applications) degree.

**Bridge Courses**

A student holding B.A./B.Sc.(General) Mathematics degree may earn B.A./B.Sc.(Honours) Mathematics degree by studying additional courses in the following manner.

(i) The students who earn B.A./B.Sc.(General) Mathematics degree by studying one optional paper BMG₁ 304 (a & b) (see COURSE STRUCTURE for B.A./B.Sc.(General) Mathematics) must study Two more papers in addition to the paper already studied out of the list of papers A through J of BMG₁ 304 (a & b).

(ii) The students who earn B.A./B.Sc. (General) Mathematics degree by studying one optional paper BMG₂ 303 (a & b) must study Three more papers in addition to the paper already studied out of the list of papers I through Xi of BMG₂ 303 (a & b).

**Course Structures and Details of Syllabi**

Course Structures and Details of Syllabi of the earlier mentioned four programs are given in the following pages.
B.A/B.Sc. (HONOURS) MATHEMATICS

Course Structure
(Duration: Six Semesters/Three Years)

B.A/B.Sc. (Honours) Mathematics Part I
(Duration: Two Semesters/One Year)
BMH 101 (a & b) Algebra and Trigonometry
BMH 102 (a & b) Calculus
BMH 103 (a & b) Vector Analysis and Geometry

B.A/B.Sc. (Honours) Mathematics Part II
(Duration: Two Semesters / One Year)
BMH 201 (a & b) Advanced Calculus
BMH 202 (a & b) Differential Equations
BMH 203 (a & b) Mechanics

B.A/B.Sc. (Honours) Mathematics Part III
(Duration: Two Semesters / One Year)

Core Courses
BMH 301 (a & b) Analysis
BMH 302 (a & b) Abstract Algebra
BMH 303 (a & b) Programming in C and Numerical Analysis
BMH 304 (a & b) Probability theory and Optimization
Practicals related to Linear Algebra and Papers BMH 303 (a & b) and BMH 304 (a & b).

Optional Papers (Any Two of the following)
Papers BMH 305 (a & b) and BMH 306 (a & b)
(i) Principles of Computer Science-Theory and Practical
(ii) Differential Geometry
(iii) Discrete Mathematics
(iv) Mechanics
(v) Mathematical Modeling
(vi) Applications of Mathematics in Finance and Insurance
(vii) Special Theory of Relativity
(viii) (a) Elementary Number Theory (One Semester Course) (b) Combinatorial Number Theory (One Semester Course).
(ix) Computational Mathematics Laboratory

Other Optional Papers according to the availability of subject experts may be added..
DETAILS OF SYLLABI

B.A/B.Sc. (HONOURS) PART I MATHEMATICS

BMH 101 (a & b) Algebra and Trigonometry

(Duration: Two Semesters/One Year)

Algebra

Mappings. Equivalence relations and partitions. Congruence modulo n.


Trigonometry


References


**B.A/B.Sc. (HONOURS) PART I MATHEMATICS**

**BMH 102 (a & b) Calculus**

(Duration: Two Semesters / One Year)

**Differential Calculus**


**Integral Calculus**


**Ordinary Differential Equations**


Linear differential equations of second order. Transformation of the equation by changing – the dependent variable / the independent variable. Method of variation of parameters.

Ordinary simultaneous differential equations.

**References**


B.A/B.Sc. (HONOURS) MATHEMATICS PART I

BMH 103 (a & b) Vector Analysis and Geometry

(Duration: Two Semesters/One Year)

Vector Analysis


Geometry


References
B.A/B.Sc. (HONOURS) MATHEMATICS PART II

BMH 201 (a & b) Advanced Calculus

(Duration: Two Semesters / One Year)


References
B.A/B.Sc. (HONOURS) MATHEMATICS PART II

BMH 202 (a & b) Differential Equations

(Duration: Two Semesters / One Year)


Partial differential equations of the first order. Lagrange's solution. Some special types of equations which can be solved easily by methods other than the general method. Charpit's general method of solution.


Calculus of Variations - Variational problems with fixed boundaries - Euler's equation for functionals containing first order derivative and one independent variable. Extremals. Functionals dependent on higher order derivatives. Functionals dependent on more than one independent variable. Variational problems in parametric form. Invariance of Euler's equation under coordinates transformation.

Variational Problems with Moving Boundaries - Functionals dependent on one and two functions. One sided variations.

Sufficient conditions for an Extremum - Jacobi and Legendre conditions. Second Variation. Variational principle of least action.

References

B.A/B.Sc. (HONOURS) MATHEMATICS PART II

BMH 203 (a & b) Mechanics

(Duration: Two Semesters / One Year)

Statics

Analytical conditions of equilibrium of Coplanar forces. Virtual work. Catenary.


Dynamics

Velocities and accelerations along radial and transverse directions, and along tangential and normal directions. Simple harmonic motion. Elastic strings.

Motion on smooth and rough plane curves. Motion in a resisting medium. Motion of particles of varying mass.

Central Orbits. Kepler’s laws of motion.

Motion of a particle in three dimensions. Acceleration in terms of different coordinate systems.

References
B.A/B.Sc. (HONS.) MATHEMATICS PART III

(Duration: Two Semesters / One Year)

Course: BMH 301 (a and b) Analysis

Real Analysis

Riemann integral. Integrability of continuous and monotonic functions. The fundamental theorem of integral calculus. Mean value theorems of integral calculus.


Partial derivation and differentiability of real-valued functions of two variables. Schwarz and Young’s theorem. Implicit function theorem.

Fourier series. Fourier expansion of piecewise monotonic functions.

Complex Analysis

Complex numbers as ordered pairs. Geometric representation of Complex numbers. Stereographic projection.


Elementary functions. Mapping by elementary functions.


Metric Spaces

References

B.A/B.Sc. (HONS.) MATHEMATICS PART III

(BMH 302 (a and b) Abstract Algebra)


Ring theory–Ring homomorphism. Ideals and Quotient Rings. Field of Quotients of an Integral Domain. Euclidean Rings. Polynomial Rings. Polynomials over the Rational Field. The Eisensten Criterion. Polynomial Rings over Commutative Rings. Unique factorization domain. R unique factorisation domain implies so is R [x_1, x_2, ..., x_n].


Modules, Submodules. Quotient modules. Homomorphism and Isomorphism theorems.

References

B.A/B.Sc. (HONS.) MATHEMATICS PART III
(Duration: Two Semesters/One Year)

BMH 303 (a and b) Programming in C and Numerical Analysis

Programming in C

References
Numerical Analysis


Interpolation: Lagrange and Hermite Interpolation, Divided Differences, Difference Schemes, Interpolation Formulas using Differences.

Numerical Differentiation.

Numerical Quadrature: Newton-Cote’s Formulas, Gauss Quadrature Formulas, Chebychev’s Formulas.

Linear Equations: Direct Methods for Solving Systems of Linear Equations (Guass Elimination, LU Decomposition, Cholesky Decomposition), Iterative Methods (Jacobi, Gauss-Seidel, Relaxation Methods).


Approximation: Different Types of Approximation, Least Square Polynomial Approximation, Polynomial Approximation using Orthogonal Polynomials, Approximation with Trigonometric Functions, Exponential Functions, Chebychev Polynomials, Rational Functions.

Monte Carlo Methods

Random number generation, congruential generators, statistical tests of pseudo-random numbers.

Random variate generation, inverse transform method, composition method, acceptance-rejection method, generation of exponential, normal variates, binomial and Poisson variates.

Monte Carlo integration, hit or miss Monte Carlo integration, Monte Carlo integration for improper integrals, error analysis for Monte Carlo integration.

Recommended Text


Other References

BMH 304 (a and b) Probability Theory and Optimization

(Duration: Two Semesters / One Year)

**Probability Theory**

Notion of probability: Random experiment, sample space, axiom of probability, elementary properties of probability, equally likely outcome problems.

Random Variables: Concept, cumulative distribution function, discrete and continuous random variables, expectations, mean, variance, moment generating function.

Discrete random variable: Bernoulli random variable, binomial random variable, geometric random variable, Poisson random variable.

Continuous random variables: Uniform random variable, exponential random variable, Gamma random variable, normal random variable.

Conditional probability and conditional expectations, Bayes theorem, independence, computing expectation by conditioning; some applications – a list model, a random graph, Palya’s urn model.

Bivariate random variables: Joint distribution, joint and conditional distributions, the correlation coefficient.

Functions of random variables: Sum of random variables, the law of large numbers and central limit theorem, the approximation of distributions.

Uncertainty, information and entropy, conditional entropy, solution of certain logical problems by calculating information.

**Optimization**


**References**

10. LINDO Systems Products (Visit Website http://www.lindo.com/productsf.htm)
   (i) LINDO (the linear programming solver).
       For more details about the above product one has to click on its name.

Other references available on the Related books page.

Optional Papers BMH 305 (a & b) and BMH 306 (a & b)
(Duration: Two Semesters / One Year)

(i) Principles of Computer Science


NOTE – C++ Programming is to be taught concurrently (see Chapters 1 to 10 and Chapter 13 of 2)).
References

Optional Papers BMH 305 (a & b) and BMH 306 (a & b)
(Duration: Two Semesters/One Year)

(ii) Differential Geometry


Transc Extension Theory of surfaces in R³ – Spherical image. Parallel translation for imbedded surfaces in R³. Classification of compact connected oriented surfaces in R³ relative to curvature.


References

Optional Papers BMH 305 (a & b) and BMH 306 (a & b)

(Duration: Two Semesters/One Year)

(iii) Discrete Mathematics


Permutations. Combinations and Discrete Probability.


Trees.

Finite State Machines - Equivalent Machines. Finite State Machines as Language Recognizers.


Discrete Numeric Functions and Generating Functions.


Brief review of Groups and Rings.


Recommended Text

Optional Papers BMH 305 (a & b) and BMH 306 (a & b)  
(Duration: Two Semesters / One Year)

(iv) Mechanics

Dynamics of Rigid Bodies:
D’Alembert’s principle. The general equations of motion of a rigid body. Motion of the Centre of inertia and motion relative to the Centre of inertia.
Motion about a fixed axis. The compound pendulum. Centre of percussion.
Motion of a rigid body in two dimensions under finite and impulsive forces.
Conservation of Momentum and Energy. Lagrange’s equations. Initial Motions.

Hydrostatics:
Fluid Pressure on plane surfaces. Centre of pressure. Resultant pressure on curved surfaces.

References

Optional Papers BMH 305 (a & b) and BMH 306 (a & b)  
(Duration: Two Semesters/One Year)

(v) Mathematical Modelling

The Process of Applied mathematics.

Setting up first-order differential equations — Qualitative solution sketching.
Difference and differential equation growth models — single-species population models.
Population growth — An age structure model. The spread of Technological innovation.
Traffic models – Car-following models. Equilibrium speed distributions.
Models from political science – Proportional representation-cumulative voting, comparison voting.
Applications in Ecological and Environmental subject areas – Urban waste water management planning.

References

All volumes published as modules in Applied Mathematics, Springer-Verlag, 1982.

Optional Papers BMH 305 (a & b) and BMH 306 (a & b)

(Duration: Two Semesters / One Year)

(vi) Application of Mathematics in Finance and Insurance

Application of Mathematics in Finance:


Taylor series and Bond Valuation. Calculation of Duration and Convexity of bonds.


Application of Mathematics in Insurance

Life Insurance Mathematics – Construction of Mortality Tables. Computation of Premium of Life Insurance for a fixed duration and for the whole life.

Determination of claims for General Insurance – Using Poisson Distribution and Negative Binomial Distribution—the Polya Case.

Determination of the amount of Claims in General Insurance – Compound Aggregate claim model and its properties, and claims of reinsurance. Calculation of a compound claim density function. F-recursive and approximate formulae for F.

References
2. John C. Hull, Options, Futures, and Other Derivatives, Prentice-Hall of India Private Limited.
5. C.D. Daykin, T. Pentikäinen and M. Pesonen, Practical Risk Theory for Actuaries, Chapman & Hall.

Optional Papers BMH 305 (a & b) and BMH 306 (a & b)

(Duration: Two Semesters/One Year)

(vii) Special Theory of Relativity


References

Optional Papers BMH 305 (a & b) and BMH 306 (a & b)
(Duration: One Semester / Half Year)

(viii) (a) Elementary Number Theory

References

(viii) (b) Combinatorial Number Theory
(Duration: One Semester / Half Year)

References
Optional Papers BMH 305 (a & b) and BMH 306 (a & b)

(Duration: Two Semesters / One Year)

(ix) Computational Mathematics Laboratory

The student is expected to familiarize himself / herself with popular softwares for numerical computation and optimization. Real life problems requiring knowledge of numerical algorithms for linear and nonlinear algebraic equations, Eigen value problems, Finite difference methods, Interpolation, Differentiation, Integration Ordinary differential equations etc. should be attempted. Capabilities to deal with linear, integer and nonlinear optimization problems need to be developed. The objective of such a laboratory is to equip students to model and simulate large-scale systems using optimization modeling languages. (The concerned teacher is expected to provide the necessary theoretical background before the student does the corresponding practical). To this end softwares like MATLAB, LINDO, MATHEMATICA, MAPLE can be adopted. Following course outline is suggested based on MATLAB and LINDO.

1. Plotting of functions.
2. Matrix operations, vector and matrix manipulations, matrix function.
3. Data analysis and curve fitting.
4. Use of FFT algorithms.
8. 2-D Graphics and 3-D Graphics – general purpose graphics functions, colour maps and colour controls.
9. Examples: Number theory, picture of an FFT, Function of a complex variable, Chaotic motion in 3-D.
11. Linear Programming, Integer Programming and Quadratic Programming – Modelling and simulation techniques.

References

1. MATLAB – High performance numeric computation and visualization software: User's guide.
B.A/B.Sc. (GENERAL) MATHEMATICS

COURSE STRUCTURE

(Duration: Six Semesters/Three Years)

B.A/B.Sc. (General) Mathematics Part I

(BMG 101 (a & b) Algebra and Trigonometry
BMG 102 (a & b) Calculus
BMG 103 (a & b) Vector Analysis and Geometry

(Duration: Two Semesters/One Year)

B.A/B.Sc. (General) Mathematics Part II

BMG 201 (a & b) Advanced Calculus
BMG 202 (a & b) Differential Equations
BMG 203 (a & b) Mechanics

(Duration: Two Semesters/One Year)

B.A/B.Sc. (General) Mathematics Part III

(For B.A./B.Sc. degree for which one more subject in addition to mathematics is required to be studied in the third year)

Core Courses

BMG, 301 (a & b) Analysis
BMG, 302 (a & b) Abstract Algebra
BMG, 303 (a & b) Programming in C and Numerical Analysis – Theory and Practical

Optional Paper BMG, 304 (a & b) – Any one of the following

A. Principles of Computer Science-Theory and Practical
B. Differential Geometry
C. Discrete Mathematics
D. Mechanics
E. Mathematical Modeling
F. Applications of Mathematics in Finance and Insurance
G. Special Theory of Relativity
H. (a) Elementary Number Theory (One Semester Course) (b) Combinatorial Number Theory (One Semester Course).
I. Computational Mathematics Laboratory
J. Probability theory and Optimization – Theory and Practical

Other Optional Papers according to the availability of subject experts may be added.

**B.A./B.Sc. (General) Mathematics Part III**

(Duration: Two Semesters/One Year)

(For B.A./B.Sc. degree for which Two more subjects in addition to mathematics are required to be studied in the third year)

**Core Courses**

BMG₂ 301 (a & b) Analysis
BMG₂ 302 (a & b) Abstract Algebra
Optional Paper BMG₂ 303 (a & b) – Any One of the following
I. Principles of Computer Science-Theory and Practical
II. Differential Geometry
III. Discrete Mathematics
IV. Mechanics
V. Mathematical Modeling
VI. Applications of Mathematics in Finance and Insurance
VII. Special Theory of Relativity
VIII. (a) Elementary Number Theory (One Semester Course) (b) Combinatorial Number Theory (One Semester Course).
IX. Computational Mathematics Laboratory
X. Probability theory and Optimization – Theory and Practical
XI. Programming in C and Numerical Analysis – Theory and Practical

Other Optional Papers according to the availability of subject experts may be added.
DETAILS OF SYLLABI

B.A/B.Sc. (General) Mathematics Part I
(Duration: Two Semesters/One Year)

**BMG 101 (a & b) Algebra and Trigonometry**
Syllabus Contents same as given in BMH 101 (a & b).

**BMG 102 (a & b) Calculus**
Syllabus Contents same as given in BMH 102 (a & b).

**BMG 103 (a & b) Vector Analysis and Geometry**
Syllabus Contents same as given in BMH 103 (a & b).

B.A/B.Sc. (General) Mathematics Part II
(Duration: Two Semesters/One Year)

**BMG 201 (a & b) Advanced Calculus**
Syllabus Contents same as given in BMH 201 (a & b).

**BMG 202 (a & b) Differential Equations**
Syllabus Contents same as given in BMH 202 (a & b).

**BMG 203 (a & b) Mechanics**
Syllabus Contents same as given in BMH 203 (a & b).

B.A/B.Sc. (General) Mathematics Part III
(Duration: Two Semesters/One Year)

(For B.A./B.Sc. degree for which one more subject in addition to mathematics is required to be studied in the third year)

**Core Courses**
BMG, 301 (a & b) Analysis
Syllabus Contents same as given in BMH 301 (a & b)
BMG, 302 (a & b) Abstract Algebra
Syllabus Contents same as given in BMH 302 (a & b)
BMG, 303 (a & b) Programming in C and Numerical Analysis – Theory and Practical
Syllabus Contents same as given in BMH 303 (a & b)
Optional Paper BMG, 304 (a & b)

A. Principles of Computer Science-Theory and Practical
Syllabus Contents same as given in BMH 305 (a & b) and BMH 306 (a & b) (i)

B. Differential Geometry
Syllabus Contents same as given in BMH 305 (a & b) and BMH 306 (a & b) (ii)

C. Discrete Mathematics
Syllabus Contents same as given in BMH 305 (a & b) and BMH 306 (a & b) (iii)

D. Mechanics
Syllabus Contents same as given in BMH 305 (a & b) and BMH 306 (a & b) (iv)

E. Mathematical Modeling
Syllabus Contents same as given in BMH 305 (a & b) and BMH 306 (a & b) (v)

F. Applications of Mathematics in Finance and Insurance
Syllabus Contents same as given in BMH 305 (a & b) and BMH 306 (a & b) (vi)

G. Special Theory of Relativity
Syllabus Contents same as given in BMH 305 (a & b) and BMH 306 (a & b) (vii)

H. (a) Elementary Number Theory (One Semester Course) (b) Combinatorial Number Theory (One Semester Course)
Syllabus Contents same as given in BMH 305 (a & b) and BMH 306 (a & b) (viii)(a) and (b).

I. Computational Mathematics Laboratory
Syllabus Contents same as given in BMH 305 (a & b) and BMH 306 (a & b) (ix)

J. Probability theory and Optimization – Theory and Practical
Syllabus Contents same as given in BMH 304 (a & b)

B.A/B.Sc. (General) Mathematics Part III

(Duration: Two Semesters/One Year)

(For B.A./B.Sc. degree for which Two more subjects in addition to mathematics are required to be studied in the third year)

Core Courses

BMG 301 (a & b) Analysis
Syllabus Contents same as given in BMH 301 (a & b)

BMG 302 (a & b) Abstract Algebra
Syllabus Contents same as given in BMH 302 (a & b)
Optional Paper BMG₂ 303 (a & b)

I. Principles of Computer Science-Theory and Practical
Syllabus Contents same as given in BMH 305 (a & b) and BMH 306 (a & b) (i).

II. Differential Geometry
Syllabus Contents same as given in BMH 305 (a & b) and BMH 306 (a & b) (ii).

III. Discrete Mathematics
Syllabus Contents same as given in BMH 305 (a & b) and BMH 306 (a & b) (iii).

IV. Mechanics
Syllabus Contents same as given in BMH 305 (a & b) and BMH 306 (a & b) (iv).

V. Mathematical Modeling
Syllabus Contents same as given in BMH 305 (a & b) and BMH 306 (a & b) (v).

VI. Applications of Mathematics in Finance and Insurance
Syllabus Contents same as given in BMH 305 (a & b) and BMH 306 (a & b) (vi).

VII. Special Theory of Relativity
Syllabus Contents same as given in BMH 305 (a & b) and BMH 306 (a & b) (vii).

VIII. (a) Elementary Number Theory (One Semester Course) (b) Combinatorial
Number Theory (One Semester Course)
Syllabus Contents same as given in BMH 305 (a & b) and BMH 306 (a & b) (viii) (a) and (b).

IX. Computational Mathematics Laboratory
Syllabus Contents same as given in BMH 305 (a & b) and BMH 306 (a & b) (ix).

X. Probability theory and Optimization – Theory and Practical
Syllabus Contents same as given in BMH 304 (a & b).

XI. Programming in C and Numerical Analysis – Theory and Practical
Syllabus Contents same as given in BMH 303 (a & b).
M.A/M.Sc. MATHEMATICS

COURSE STRUCTURE

(M.A/M.Sc. Mathematics (Previous) (Duration: Two Semesters/One Year)

MM 401 (a & b) Advanced Abstract Algebra
MM 402 (a & b) Real Analysis
MM 403 (a & b) Topology
MM 404 (a & b) Complex Analysis
MM 405 (a & b) (i) Differential Equations/or (ii) Advanced Discrete Mathematics/or (iii) Differential Geometry of Manifolds

(M.A/M.Sc. Mathematics (Final) (Duration: Two Semesters/One Year)

Core Courses

MM 501 (a & b) Integration theory and Functional Analysis
MM 502 (a & b) Partial Differential Equations and Mechanics

Optional Papers (Three papers out of the following have to be chosen keeping in view the prerequisites and suitability of the combination)

Papers MM 503 (a & b), MM 504 (a & b) and MM 505 (a & b)
1. Programming in C (with ANSI features)—Theory and Practical
2. Fundamentals of Computer Science—Theory and Practical
3. Advanced Functional Analysis
4. (i) Advanced Theory of Partial Differential Equations/or (ii) Sobolev Spaces
5. Theory of Ordinary Differential Equations
6. Difference Equations
7. Dynamical Systems
8. Fluid Mechanics
9. Magneto Fluid Dynamics
10. Differentiable Structures on a Manifold  
11. Computational Fluid Dynamics  
12. Mathematics of Finance and Insurance  
13. (i) Harmonic Analysis /or (ii) Abstract Harmonic Analysis  
14. Bases in Banach Spaces  
15. Space Dynamics  
16. Information Theory  
17. Algebraic Coding Theory  
18. Algebraic Topology  
19. Fractal Geometry  
20. Mechanics of Solids  
21. Operations Research  
22. Non-Linear Programming  
23. Geometry of Numbers  
24. Mathematical Biology  
25. Computational Biology  
26. Non-linear Optimization in Banach Spaces  
27. General Relativity and Cosmology  
28. Banach Algebras  
29. Fuzzy Sets and Their Applications  
30. Category Theory  
31. Projective representations of the Symmetric Groups  
32. Wavelets  
33. Non-Commutative Rings  
34. Integral Equations and Boundary Value Problems.  
35. Theory of Linear Operators  
36. Fundamentals of Applied Functional Analysis  
37. Biomechanics  
38. Global Differential Geometry  
39. Analytic Number Theory  
40. Algebraic Number Theory  
41. Algebraic Curves

Other optional papers according to the availability of subject experts may be added.
DETAILS OF SYLLABI

M.A/M.Sc. Mathematics (Previous)

(Duration: Two Semesters/One Year)

MM 401 (a & b) Advanced Abstract Algebra


Smith normal form over a principal ideal domain and rank.

Fundamental structure theorem for finitely generated modules over a principal ideal domain and its applications to finitely generated abelian groups. Rational canonical form. Generalised Jordan form over any field.

References


**M.A/M.Sc. Mathematics (Previous)**

(Duration: Two Semesters/One Year)

**MM 402 (a & b) Real Analysis**

Definition and existence of Riemann-Stieltjes integral, Properties of the Integral, Integration and differentiation, the fundamental theorem of Calculus, integration of vector-valued functions, Rectifiable curves.

- Rearrangements of terms of a series, Riemann's theorem.
- Sequences and series of functions, pointwise and uniform convergence, Cauchy criterion for uniform convergence, Weierstrass M-test, Abel's and Dirichlet's tests for uniform convergence, uniform convergence and continuity, uniform convergence and Riemann–Stieltjes integration, uniform convergence and differentiation, Weierstrass approximation theorem, Power series, uniqueness theorem for power series, Abel's and Tauber's theorems.
- Functions of several variables, linear transformations, Derivatives in an open subset of $\mathbb{R}^n$, Chain rule, Partial derivatives, interchange of the order of differentiation, Derivatives of higher orders, Taylor's theorem, Inverse function theorem, Implicit function theorem, Jacobians, extremum problems with constraints, Lagrange's multiplier method, Differentiation of integrals, Partitions of unity, Differential forms, Stoke's theorem.
Mathematics

References

7. P.K. Jain and V.P. Gupta, Lebesgue Measure and Integration, New Age International (P) Limited Published, New Delhi, 1986 (Reprint 2000).

M.A/M.Sc. Mathematics (Previous)

(Duration: Two Semesters/One Year)

MM 403 (a & b) Topology


Alternate methods of defining a topology in terms of Kuratowski Closure Operator and Neighbourhood Systems.

Continuous functions and homeomorphism.

Separation axioms $T_0$, $T_1$, $T_2$, $T_{3\frac{1}{2}}$, $T_4$; their characterizations and basic properties. Urysohn’s lemma. Tietze extension theorem.


Embedding and metrization. Embedding lemma and Tychonoff embedding. The Urysohn metrization theorem.


The fundamental group and covering spaces—Homotopy of paths. The fundamental group. Covering spaces. The fundamental group of the circle and the fundamental theorem of algebra

References
2. J. Dugundji, Topology, Allyn and Bacon, 1966 (Reprinted in India by Prentice Hall of India Pvt. Ltd.).

M.A/M.Sc. Mathematics (Previous)
(Duration: Two Semesters/One Year)

MM 404 (a & b) Complex Analysis


Bilinear transformations, their properties and classifications. Definitions and examples of Conformal mappings.

Spaces of analytic functions. Hurwitz's theorem. Montel's theorem Riemann mapping theorem.


Univalent functions. Bieberbach's conjecture (Statement only) and the "¼- theorem.

References
M.A/M.Sc. Mathematics (Previous)

(Duration: Two Semesters/One Year)

MM 405 (a & b) (i) Differential Equations

Preliminaries—Initial value problem and the equivalent integral equation, mth order equation in d-dimensions as a first order system, concepts of local existence, existence in the large and uniqueness of solutions with examples.

Basic Theorems—Ascoli–Arzela Theorem. A theorem on convergence of solutions of a family of initial value problems.


Egres points and Lyapunov functions. Successive approximations.

Linear Differential Equations—Linear Systems, Variation of constants, reduction to smaller systems. Basic inequalities, constant coefficients. Floquet theory. Adjoint systems, Higher order equations.

Dependence on initial conditions and parameters; Preliminaries. Continuity. Differentiability. Higher Order Differentiability.
Mathematics

Poincare–Bendixson Theory–Autonomous systems. Umlanfsatz. Index of a stationary point.

Poincare–Bendixson theorem. Stability of periodic solutions, rotation points, foci, nodes and saddle points.


Use of Implicit function and fixed point theorems–Periodic solutions. Linear equations. Nonlinear problems.


Recommended Text

References

MM 405 (a & b) (ii) Advanced Discrete Mathematics


Lattices–Lattices as partially ordered sets. Their properties. Lattices as Algebraic systems. Sublattices, Direct products, and Homomorphisms. Some Special Lattices e.g., Complete, Complemented and Distributive Lattices.


Turing Machine and Partial Recursive Functions.


Notions of Syntax Analysis. Polish Notations. Conversion of Infix Expressions to Polish Notations. The Reverse Polish Notation.

References
7. N. Deo, Graph Theory with Applications to Engineering and Computer Sciences, Prentice Hall of India.

MM 405 (a & b) (iii) Differential Geometry of Manifolds


References

M.A/M.Sc. Mathematics (Final)
(Duration: Two Semesters/One Year)

MM 501 (a & b) Integration theory and Functional Analysis

Integration Theory

Baire sets. Baire measure, continuous functions with compact support. Regularity of measures on locally compact spaces. Integration of continuous functions with compact support, Riesz-Markoff theorem.

Functional Analysis

References
27. B.V. Limaye, Functional Analysis, Wiley Eastern Ltd.
M.A/M.Sc. Mathematics (Final)

(Duration: Two Semesters/One Year)

MM 502 (a & b) Partial Differential Equations and Mechanics

Partial Differential Equations

Examples of PDE. Classification.


Mechanics

Analytical Dynamics:


Gravitation:


**References**

2. Books with the above title by I.N. Sneddon, F. John, P. Prasad and R. Ravindran, Amarnath etc.

**M.A/M.Sc. Mathematics (Final)**

Optional Papers MM 503 (a & b), MM 504 (a & b) and MM 505 (a & b)

(Duration: Two Semesters/One Year)

1. **Programming in C (with ANSI features)—Theory and Practical**

An overview of programming. Programming language, Classification.


Operators and Expressions-Precedence and Associativity. Unary Plus and Minus operators. 
Binary Arithmetic Operators. Arithmetic Assignment Operators. Increment and Decrement 
Operator. Memory Operators.

Arrays and Pointers-Declaring an Array. Arrays and Memory. Initializing Arrays. Encryption 
and Decryption. Pointer Arithmetic. Passing Pointers as Function Arguments. Accessing Array 

Storage Classes-Fixed vs. Automatic Duration. Scope. Global variables. The register 
Specifier. ANSI rules for the syntax and Semantics of the storage-class keywords. Dynamic 
Memory Allocation.


The main ( ) Function. Complex Declarations.

The C Preprocessor-Macro Substitution. Conditional Compilation. Include Facility. Line 
Control.

Input and Output-Streams, Buffering. The <stdio.h> Header File. Error Handling. Opening 
and Closing a File. Reading and Writing Data. Selecting an I/O Method. Unbuffered I/O Random 
Access. The standard library for Input/Output.

Recommended Text:
1. Peter A. Darnell and Philip E. Margolis, C: A Software Engineering Approach, Narosa Publishing House 

References
Hall 1989.

M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b) and MM 505 (a & b) 
(Duration: Two Semesters/One Year)

Prerequisite courses: BMG, 304 (a & b) A Principles of Computer Science

2. Fundamentals of Computer Science-Theory and Practical
Object Oriented Programming-DHclasses and Scope, nested classes, pointer class members; 
Class initialization, assignment and destruction; Overloaded functions and operators; Templates 
including class templates; class inheritance and subtyping, multiple and virtual inheritance.
Data Structures-Analysis of algorithms, q, W, 0, c, w notations; Lists, Stacks, and queues: Sequential and linked representations; Trees: Binary tree—search tree implementation, B-tree (concept only); Hashing—open and closed; Sorting: Insertion sort, shell sort, quick-sort, heap sort and their analysis.

Database Systems-Role of database systems, database system architecture; Introduction to relational algebra and relational calculus; SQL—basic features including views; Integrity constraints; Database design-normalization upto BCNF.

Operating Systems-User interface, processor management, I/O management, memory management, concurrency and Security, network and distributed systems.

References
1. S.B. Lipman, J. Lajoie: C++ Primer, Addison Wesley.
3. C.J. Date : Introduction to Database Systems, Addison Wesley.

M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b) and MM 505 (a & b)
(Duration: Two Semesters/One Year)

3. Advanced Functional Analysis

Definition and examples of topological Vector Species. Convex, balanced and absorbing sets and their properties. Minkowski’s functional, subspace, product space and quotient space of a topological Vector space.


Extreme points and Extremal sets. Krein-Milman’s theorem.


References

M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)
(Duration: Two Semesters/One Year)

4. (i) Advanced Theory of Partial Differential Equations


Sobolev Spaces–Basic Properties, Approximation by Smooth Functions, Extension Theorems, Compactness Theorems, Dual Spaces, Fractional Order Spaces, Trace Spaces, Trace Theory. Inclusion Theorem.


References

M.A/M.Sc. Mathematics (Final)
Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)
(Duration: Two Semesters/One Year)

4. (ii) Sobolev Spaces
Distributions—Test function spaces and distributions, convergence distributional derivatives.


Sobolev Spaces—The spaces W¹,p(Ω) and W¹,∞(Ω). Their simple characteristic properties, density results. Min and Max of W¹,p-functions. The space H¹(Ω) and its properties, density results.


Other Sobolev Spaces—Dual Spaces, Fractional Order Sobolev spaces, Trace spaces and trace theory.

Weight Functions—Definition, motivation, examples of practical importance. Special weights of power type. General Weights.

Weighted Spaces—Weighted Lebesgue space P(Ω,σ) weighted Sobolev spaces W¹,p(Ω,σ), W₀¹,p(Ω,σ), and their properties.

Domains—Methods of local coordinates, the classes C₀, C₀,k, Holder’s condition, Partition of unity, the class K (x₀) including Cone property.

Inequalities—Hardy inequality, Jensen’s inequality, Young’s inequality, Hardy–Littlewood– Sobolev inequality, Sobolev inequality and its various versions.

References
M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)

(Duration: Two Semesters/One Year)

5. **Theory of Ordinary Differential Equations**


**Recommended Text**


**References**

M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)

(Duration: Two Semesters/One Year)

6. Difference Equations

Introduction, Difference Calculus—The Difference Operator, Summation, Generating functions and approximate summation.


Partial Differential Equations.

Discretization of Partial Differential Equations.

Solution of Partial Differential Equations.

Recommended Text


References

M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)

(Duration: Two Semesters/One Year)

7. **Dynamical Systems**

Orbit of a map, fixed point, equilibrium point, periodic point, circular map, configuration space and phase space.


Turning point, transcritical, pitch work. Hopf bifurcations. Period doubling phenomena.


**References**


M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)

(Duration: Two Semesters/One Year)

8. **Fluid Mechanics**


Two-dimensional irrotational motion produced by motion of circular, co-axial and elliptic cylinders in an infinite mass of liquid. Kinetic energy of liquid. Theorem of Blasius. Motion of a
sphere through a liquid at rest at infinity. Liquid streaming past a fixed sphere. Equation of motion of a sphere. Stoke's stream function.


References

M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)

(Duration: Two Semesters/One Year)

9. Magneto Fluid Dynamics


approximations. MFD Flow past on infinite flat plate. MFD flow past a semi-infinite flat plate. MFD Rayleigh problem. MFD wakes.


MFD Applications—Astrophysical and geophysical applications. MFD ejectors. MFD accelerators. MFD Lubrication. MFD thin airfoil. MFD power generation.

Tensor electrical conductivity. Hall current and ion slip. MHD channel flow and quasi one-dimensional flow with tensor electrical conductivity.

References

M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)  
(Duration: Two Semesters/One Year)

10. Differentiable Structures on a Manifold


Almost analytic vector fields.

Almost Analytic Vector Fields.


Almost Contact Metric manifolds—Almost Grayan manifolds. K-Contact Riemannian manifolds.  
Sasakian manifolds. Cosymplectic manifolds.

Submanifolds of almost Hermite and Kähler manifolds. Sub-manifolds of almost contact metric manifolds. CR-submanifolds of Kähler manifolds and Sasakian manifolds, the integrability of distributions.

Books Recommended
M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)

(Duration: Two Semesters/One Year)

11. **Computational Fluid Dynamics**


- Basic equations of Fluid Dynamics.
- Analytic Aspects of PDE.
- Finite Volume and Finite Difference Methods on Nonuniform Grids.
- Stationary Convection–Diffusion Equation (Finite Volume Discretization, Schemes of Positive Type, Upwind Discretization).
- Incompressible Navier-Stokes (NS) Equations–Boundary Conditions. Spatial and Temporal Discretization on Collocated and on Staggered Grids.
- Shallow water Equations—One and Two Dimensional Cases.
- Scalar Conservation Laws–Godunov’s Order Barrier Theorem, Linear Schemes.
- Discretization in General Domains–Boundary Fitted Grids. Equations of Motion in General Coordinates.
- Numerical Solution of Euler Equation in General Coordinates.
- Numerical Solution of NS Equations in General Domains.

**Recommended Text**


**References**


**Note**: This is a rapidly emerging area and books are being published at a very fast rate. Visit the website www.cfd-online.com for an up-to-date list.
M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)  
(Duration: Two Semesters/One Year)

12. Mathematics of Finance and Insurance

Prerequisite—Application of Mathematics and Finance and Insurance-Optional Paper BMG, 304 (a & b) F
Financial Derivatives—An Introduction; Types of Financial Derivatives-Forwards and Futures;  
Options and its kinds; and SWAPS.

The Arbitrage Theorem and Introduction to Portfolio Selection and Capital Market Theory:  
Static and Continuous-Time Model.

Pricing by Arbitrage—A Single-Period option Pricing Model; Multi-Period Pricing Model-Cox  
-Ross-Rubinstein Model; Bounds on Option Prices.

The Ito’s Lemma and the Ito’s Integral.

The Dynamics of Derivative Prices—Stochastic Differential Equations (SDEs)-Major Models  
of SDEs: Linear Constant Coefficient SDEs; Geometric SDEs; Square Root Process; Mean  
Reverting Process and Omstein-Uhlenbeck Process.

Martingale Measures and Risk-Neutral Probabilities: Pricing of Binomial Options with  
equivalent martingale measures.

The Black-Scholes Option Pricing Model—using no arbitrage approach, limiting case of  
Binomial Option Pricing and Risk-Neutral probabilities.

The American Option Pricing—Extended Trading Strategies; Analysis of American Put  
Options; early exercise premium and relation to free boundary problems.

Concepts from Insurance: Introduction; The Claim Number Process; The Claim Size  
Process; Solvability of the Portfolio; Reinsurance and Ruin Problem.

Premium and Ordering of Risks—Premium Calculation Principles and Ordering Distributions.  
Distribution of Aggregate Claim Amount—Individual and Collective Model; Compound  
Distributions; Claim Number of Distributions; Recursive Computation Methods; Lundberg Bounds  
and Approximation by Compound Distributions.

Risk Processes—Time-Dependent Risk Models; Poisson Arrival Processes; Ruin Probabilities  
and Bounds Asymptotics and Approximation.

Time Dependent Risk Models—Ruin Problems and Computations of Ruin Functions; Dual  
Queueing Model; Risk Models in Continuous Time and Numerical Evaluation of Ruin Functions.

References
1. John C. Hull, Options, Futures, and Other Derivatives, Prentice-Hall of India Private Limited.
5. Robert C. Merton, Continuous-Time Finance, Basil Blackwell Inc.

M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)  
(Duration: Two Semesters/One Year)

13. (i) Harmonic Analysis

Basic properties of topological groups, subgroups, quotient groups and connected groups. Discussion of Haar Measure without proof on R, T, Z, and some simple matrix groups. $L^1(G)$ and convolution with special emphasis on $L^1(R)$, $L^1(T)$, $L^1(Z)$. Approximate identities. Fourier series. Fejer's theorem. The classical kernels. Fejer's Poisson's and Dirichlet's summability in norm and point wise summability. Fatou's Theorem. The inequalities of Hausdorff and Young. Examples of conjugate function series. The Fourier transform. Kernels on R. The Plancherel theorem on R. Plancherel measure on R, T, Z. Maximal ideal space of $L^1(R)$, $L^1(T)$ and $L^1(Z)$.


References

M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)  
(Duration: Two Semesters/One Year)

13. (ii) Abstract Harmonic Analysis

Definition of a topological group and its basic properties. Subgroups and quotient groups. Product groups and projective limits. Properties of topological groups involving connectedness. Invariant pseudo-metrics and separation axioms. Structure theory for compact and locally compact Abelian groups. Some special locally compact Abelian groups.
The Haar integral. Haar measure. Invariant means defined for all bounded functions. Invariant means on almost periodic functions.

Convolutions, Convolutions of functions and measures. Elements of representation theory. Unitary representations of locally compact groups.

The character group of a locally compact Abelian group and the duality theorem.

**Recommended Text**

**Other Reference**

**M.A/M.Sc. Mathematics (Final)**

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)

(Duration: Two Semesters/One Year)

**14. Bases in Banach Spaces**


Biorthogonal systems. Associated sequences of partial sum operators-E-complete, regular and irregular biorthogonal systems. Characterizations of regular biorthogonal systems. Basic sequences. Banach space (separable or not) and basic sequence.

Some types of linear independence of sequences-Linearily independent (finitely) W-linearly independent and minimal sequences of elements in Banach spaces. Their relationship together with examples and counter-examples.

Problem of uniqueness of basis--Equivalent bases, Stability theorems of Paley-Wiener type. Block basic sequences with respect to a sequence (basis) and their existence. Bessaga–Pelczynski theorem.

Properties of strong duality. Weak bases and weak Schauder bases in a Banach space. Weak basis theorem. Weak* bases in conjugate spaces and their properties.

Shrinking bases and boundedly complete bases together with their relationship.


Bases and structure of the space Bases and completeness. Bases and reflexivity.


Characterization of a Schauder decomposition. Example that a decomposition is not always Schauder. Various possibilities for a Banach space to possess a Schauder decomposition. Shrinking decompositions, boundedly complete decompositions and unconditional decompositions. Reflexivity of Banach spaces having a Schauder decomposition.

Bases and Decompositions in the space C [0, 1].


Monotone and strictly monotone bases, co-monotone and strictly co-monotone bases. Examples and counter-examples.

T-norm, K-norm and KT-norm on Banach spaces having bases. Their characterization in terms of monotone and comonotone bases. Various equivalent norms on a Banach space in terms of their bases.

References

M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)
(Duration: Two Semesters/One Year)

15. Space Dynamics

Basic Formulae of a spherical triangle–The Two-body Problem: The Motion of the Center of Mass. The relative motion. Kepler’s equation. Solution by Hamilton Jacobi theory.

The Determination of Orbits–Laplace’s Gauss Methods.


Perturbation–Osculating orbit, Perturbing forces, Secular & Periodic perturbations. Lagrange’s Planetary Equations in terms of pertaining forces and in terms of a perturbed Hamiltonian.

Motion of the moon–The perturbing forces. Perturbations of Keplerian elements of the Moon by the Sun.

Rocket Performance with Aerodynamic forces.


References

M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)
(Duration: Two Semesters/One Year)

16. Information Theory


Discrete Memoryless Channel—Classification of channels. Information processed by a channel. Calculation of channel capacity. Decoding schemes. The ideal observer. The fundamental theorem of information theory and its strong and weak converses.

Continuous Channels—The time-discrete Gaussian channel. Uncertainty of an absolutely continuous random variable. The converse to the coding theorem for time-discrete Gaussian channel. The time-continuous Gaussian channel. Band-limited channels.

Some intuitive properties of a measure of entropy—Symmetry, normalization, expansibility, boundedness, recursivity maximality, stability, additivity, subadditivity, nonnegativity, continuity, branching etc. and interconnections among them. Axiomatic characterization of the Shannon entropy due to Shannon and Fadeev.

Information functions, the fundamental equation of information, information functions continuous at the origin, nonnegative bounded information functions, measurable information functions and entropy. Axiomatic characterizations of the Shannon entropy due to Tverberg and Leo. The general solution of the fundamental equation of information. Derivations and their role in the study of information functions.
The branching property. Some characterizations of the Shannon entropy based upon the branching property. Entropies with the sum property. The Shannon inequality. Subadditive, additive entropies.

The Renji entropies. Entropies and mean values. Average entropies and their equality, optimal coding and the Renji entropies. Characterization of some measures of average code length.

References

M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)  
(Duration: Two Semesters/One Year)

17. Algebraic Coding Theory


References

M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)
(Duration: Two Semesters/One Year)

18. Algebraic Topology

Fundamental group functo, homotopy of maps between topological spaces, homotopy equivalence, contractible and simply connected spaces, fundamental groups of $S^n$, and $S^1 \times S^1$ etc.

Calculation of fundamental group of $S^n$, $n > 1$ using Van Kampen's therem, fundamental groups of a topological group, Brouwer's fixed point theorem, fundamental theorem of algebra, vector fields on planer sets, Frobenius theorem for 3x3 matrices.

Covering spaces, unique path lifting theorem, covering homotopy theorems, group of covering transformations, criterion of lifting of maps in terms of fundamental groups, universal covering, its existence, special cases of manifolds and topological groups.

Singular homology, reduced homology, Eilenberg Steenrod axioms of homology (no proof for homotopy invariance axiom, excision axiom and exact sequence axiom) and their application, relation between fundamental group and first homology.

Calculation of homology of $S^n$, Brouwer's fixed point theorem for $f: E^n \to E^n$, application spheres, vector fields, Mayer-Vietoris sequence (without proof) and its applications.

Mayer Vietoris sequence (with proof) and its application to calculation of homology of graphs, torus and compact surface of genus g, collared pairs, construction of spaces by attaching of cells, spherical complexes with examples of $S^n$, r-leaved rose, torus, $RP^n$, $CP^n$ etc.

Computation of homology of $CP^n$, $RP^n$, torus, suspension space, XXY, compact surface of genus g and non-orientable surface of genus h using Mayer Vietoris sequence, Betti numbers and Euler characteristics and their calculation for $S^n$, r-leaved rose, $RP^n$, $CP^n$, $S^2 \times S^2$, $X + Y$ etc.

Singular cohomology modules, Kronecker product, connecting homomorphism, contra-
functionality of singular cohomology modules, naturality of connecting homomorphism, exact cohomology sequence of pair, homotopy invariance, excision properties, cohomology of a point. Mayer Vietoris sequence and its application in computation of cohomology of $S^n$, $RP^n$, $CP^n$, torus, compact surface of genus g and non-orientable compact surface.
Compact connected 2-manifolds, their orientability and non-orientability, examples, connected sum, construction of projective space and Klein’s bottle from a square, Klein’s bottle as union of two Mobius strips, canonical form of sphere, torus and projective planes. Klein’s bottle. Mobius strip, triangulation of compact surfaces.

Classification theorem for compact surfaces, connected sum of torus and projective plane as the connected sum of three projective planes, Euler characteristic as a topological invariant of compact surfaces, connected sum formula, 2-manifolds with boundary and their classifications, Euler characteristic of a bordered surface, models of compact bordered surfaces in $\mathbb{R}^3$.

References

M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)

(Duration: Two Semesters/One Year)

19. Fractal Geometry

Construction of the middle third cantor set; Von Koch curve, Sierpinski gasket, self Similar fractals with different similarity ratio, Julia set, measures and mass distributions, Hausdorff measure, scaling property, effect of general transformations on Hausdorf measures, Hausdorff dimension and its properties, s-sets, calculation of Hanusdorff dimension in simple cases.

Measurement of a set at scale d, box dimensions, its equivalent versions, Properties of Box dimension, box dimension of middle third Cantor set and other simple sets, some other definitions of dimension, upper estimate of box dimension, mass distribution principle, generalized cantor set and its dimension.

Uniform cantor set and its dimension, covering lemma, Borel set and its dimension, subsets of finite measure, Borel set of finite measure, potential theoretic method for calculating Hausdorff dimension, fractals, local structure of fractals, density of a subset F of the plane and its properties, regular and irregular sets, density of an s-set, relation between s-set and irregular set, structure of 1-sets, rectifiable curve and its Hausdorff dimension, curve-like set, curve-free set and its properties, tangents to s-sets, tangents to a rectifiable curve, regular 1-set and irregular 1-set.


Intersection of fractals, intersection of ‘dust like’ set with various congruent copies of a curve intersection formulae for fractals, general construction of fractals through iterated function
schemes, contraction map, invariant set, similarity, self-similar sets open set condition for a similarity, dimension of the invariant set of a finite collection of similarities, dimension of Sierpinski gasket and modified Von Koch curve, dimension of the invariant set of collection of contractions (which are not similarities), non-linear cantor set and its dimension.

Affine transformation, self-affine sets, the affine transformation mapping unit square on to rectangles, the affine transformation mapping square on to selected 1/p x 1/q rectangles from the p x q array; applications to encoding images, fern and grass as invariant sets of four and six affine transformations respectively, collage theorem and its consequence, examples of fractals from number theory, distribution of digits of numbers, Hausdorff dimension of the set F (p_0, ..., p_m), fractions, Diophantine approximation, Jarnik’s theorem; dimension of graphs, Weierstrass function and its dimension, dimension of self-affine curves.

Examples of fractals from pure mathematics, duality and Kakeya problem, the lime set L (F) of a set F, dimension of line set of a Borel set, Vitushkin’s conjecture, convex surfaces, groups and rings of fractional dimension, discrete dynamical system, attractor, repellers and iterated function schemes, tent map, logistic map, stretching and folding transformations, Baker’s transformation, horseshoe map, Henon map, solenoid.


Random fractals, random Cator set and its dimension, random Von Koch curve, fractal percolation, random fractal F_p and its properties, Brownian motion, random function, Brownian sample functions and its graph, properties of Brownian sample function, fractional Brownian motion of index α (0 < α < 1) and its properties stable processes, Brownian surfaces.

Multifractal measure, multifractal formalism, examples, multifractal spectrum of a measure, entropy of a partition of a measure, information dimension of a measure, physical applications of fractals, fractal growth, electrolysis of copper sulphate leading to fractal-like deposits of copper, diffusion-limited aggregation model, singularities of electrostatic and gravitational potentials, fluid dynamic and turbulence, application of fractals in gun factories.

References
M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)  
(Duration: Two Semesters/One Year)

20. Mechanics of Solids


Waves-Propagation of waves in an isotropic elastic solid medium. Waves of dilatation and distortion. Plane waves. Elastic surface waves such as Rayleigh and Love waves.


References
M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)

(Duration: Two Semesters/One Year)

21. Operations Research


Transportation and Assignment Problems.


Integer Programming—Branch and Bound Technique.


References

10. LINDOSystems Products (Visit website http://www.lindo.com/productsf.html)
   (i) LINDO (the linear programming solver)
   (ii) LINDO Callable Library (the premier optimization engine)
   (iii) LINGO (the linear, non-linear, and integer programming solver with mathematical modeling language)
   (iv) What's Best! (the spreadsheet add-in that solves linear, non-linear, and integer problems).
      All the above four products are bundled into one package to form the Solver Suite. For more details about
      any of the four products one has to click on its name.
   (v) Optimization Modeling with LINDO (5th edition) by Linus Schrage.
   (vi) Optimization Modeling with LINGO by Linus Schrage.

More details available on the Related Books page.

**M.A/M.Sc. Mathematics (Final)**

**Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)**

(Duration: Two Semesters/One Year)

22. **Non-Linear Programming**

   The non-linear programming problem and its fundamental ingredients.

   Linear inequalities and theorems of the alternative—Tucker's theorem. The Optimality criteria of linear programming. Tucker's lemma and existence theorems. Theorems of the alternative.

   Convex sets—Separation theorems.


   Differentiable Convex and Concave functions—Some basic properties. Twice-differentiable convex and concave functions. Theorems in cases of strict convexity and concavity of functions.


Pseudoconvex and pseudoconcave functions. Relationship between pseudoconvex functions and strictly quasiconvex functions. Differentiable convex functions and pseudoconvex functions.


**Recommended Text**


**References**


**M.A/M.Sc. Mathematics (Final)**

**Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)**

(Duration: Two Semesters/One Year)

**23. Geometry of Numbers**


**References**


M.A./M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)

(Duration: Two Semesters/One Year)

24. Mathematical Biology

Mathematical Biology is one of the fastest growing areas of applied mathematics. A number of topics are listed below. One can choose some of them depending on his/her interest.

1. Mathematical aspects of Vision
2. Application of Population Isolates in Gene
3. Calcium Excitability: The Dynamics of Calcium Homeostasis
4. Modeling Viral Infection
5. Pattern Tissue Interaction Models
6. Immune Networks and Immune Response
7. Population Genetics Theory
8. Social Animal Aggregation
9. Stochastic Demography and Life Historia
10. Spatial Chaos and its role in Ecology and Evolution
11. Uncertainty and Fisheries Biology
12. Model building as an Inverse Problem in Biomathematics.

References
2. Mathematical Biology (AMS Short Course) Notes of the AMS No. 9, 1214-1217 (October-2000).

M.A./M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)

(Duration: Two Semesters/One Year)

25. Computational Biology

Basic concepts of molecular biology, DNA and Proteins. The Central Dogma. Gene and Genome Sequences.

Restriction Maps—Graphs, Interval graphs. Measuring Fragment sizes.

Sequence Assembly–Sequencing strategies. Assembly in practices, fragment overlap statistics, fragment alignment, sequence accuracy.

Sequence comparisons Methods–Local and global alignment. Dynamic programming method. Multiple sequence alignment.


References

M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)

(Duration: Two Semesters/One Year)


Review of Weak Convergence in normed spaces, reflexivity of Banach spaces. Hahn-Banach theorem and partially ordered linear spaces


Some special optimization problems-Linear quadratic optimal control problems. Time minimal control problems.

Recommended Text

References
M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)

(Duration: Two Semesters/One Year)

27. General Relativity and Cosmology


Cosmology–Mach's principle, Einstein modified field equations with cosmological term. Static Cosmological models of Einstein and De-Sitter, their derivation, properties and comparison with the actual universe.


References

M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)

(Duration: Two Semesters/One Year)

28. Banach Algebras


References
M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)
(Duration: Two Semesters/One Year)

29. **Fuzzy Sets and Their Applications**


An Introduction to Fuzzy Control—Fuzzy controllers. Fuzzy rule base. Fuzzy inference engine. Fuzzification. Defuzzification and the various defuzzification methods (the centre of area, the centre of maxima, and the mean of maxima methods).


**References**


M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)
(Duration: Two Semesters/One Year)

30. **Category Theory**


References

M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)
(Duration: Two Semesters/One Year)

31. Projective Representations of the Symmetric Groups

Objects in G, the class of triple (G, z, o), where G is a finite group, z is an element of order 2 in the centre of G and o is a homomorphism from G to Z (2) with o (z) = 0. A Construction for Negative Representations.


References

M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)
(Duration: Two Semesters/One Year)

32. Wavelets

Preliminaries.


Discrete transforms and algorithms—The discrete and the fast Fourier transforms. The discrete and the fast cosine transforms. The discrete version of the local sine and cosine bases. Decomposition and reconstruction algorithms for wavelets.

**Recommended text**


**References**


**M.A/M.Sc. Mathematics (Final)**

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)  
(Duration: Two Semesters/One Year)

33. **Non-Commutative Rings**


**References**


**M.A/M.Sc. Mathematics (Final)**

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)  
(Duration: Two semesters/One year)

34. **Integral Equations and Boundary Value Problems**


Classical Fredholm Theory. Fredholm Theorems.


Integral representation formulas for the solution of the Laplace’s and Poisson’s equations. Newtonian single-layer and double layer potentials. Interior and exterior Dirichlet and Neumann boundary value problems for Laplace’s equation. Green’s function for Laplace’s equation in a free space as well as in a space bounded by a ground vessel. Integral equation formulation of boundary value problems for Laplace’s equation.

Poisson’s integral formula, Green’s function for the space bounded by grounded two parallel plates or an infinite circular cylinder.

Perturbation techniques and its applications to mixed boundary value problems. Two-part and three-part boundary value problems.

Solutions of electrostatic problems involving a charged circular disk and annular circular disk, a spherical cap, an annular spherical cap in a free space or a bounded space

References
M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)

(Duration: Two semesters/One year)

35. **Theory of Linear Operators**


**References**

M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)

36. **Fundamentals of Applied Functional Analysis**

(Duration: Two semesters/One year)

Review of basic properties of Hilbert spaces.


**Recommended Text**


**References**


M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)

37. **Biomechanics**

(Duration: Two Semesters/One Year)

Prerequisite: Fluid Mechanics (See MM 503, MM 504, MM 505-8)


Segmental Movement and Vibrations.

   External Flow: Fluid Dynamic Forces Acting on Moving Bodies.
Flying and Swimming.


Micro- and Macrocirculation.

Respiratory Gas Flow.


Description of Internal Deformation and Forces.

Stress, Strain, and Stability of Organs.

Strength, Trauma, and Tolerance.


Recommended Text


M.A./M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)

38. Global Differential Geometry

(Duration: Two Semesters / One Year)

(For those who have not studied MM 405 (iii) Differential Geometry of Manifolds)

Differential manifolds; examples of differential manifolds; differential maps between differential manifolds; partition of unity and its application in extending a differential function; tangent vector, tangent spaces and differential of a differentiable mapping; tangent Birkhauser and contangent bundles.

Immersion, embedding, submanifolds and their examples; regular/critical points, regular values, Sards theorem, transversality of map, inverse image of a transverse submanifold, statement of Thom's transversality theorem and Whitney embedding theorem and their illustrations.

Vector fields; Lie bracket; integral curve of a vector field, existence of integral curves and 1-parameter family of transformation for a vector field; vector fields related by a differentiable map; distributions; integral manifolds; involutive distributions; the Frobenius theorem (statement and illustration only); maximal integral manifolds.

Tensor and exterior algebras; multilinear and alternating forms; relationship between exterior products and alternating forms; the non-singular pairing; tensor fields and differential forms; exterior differentiation; Lie derivative; orientation of a vector space; *-operators in multilinear algebra.
Orientation of a manifold; orientability and existence of a nowhere vanishing differential form; integration of n-forms in \(\mathbb{R}^n\); integration over chains; stokes theorem – first version; integration of an oriented manifold; Stokes theorem – second version; integration on a Riemannian manifold.

Riemannian metric on a differential manifold, coordinate representation, isometry and examples, Lie groups as Riemannian manifolds, existence of Riemannian metric on a differential manifold, affine connection, covariant derivative, parallel vector fields, Riemannian connections, Levi-Civita theorem on affine connection.

Geodesic, geodesic field, geodesic flow of geodesic field and its existence, homogeneity of geodesic, exponential map, minimizing properties of geodesic, symmetric connections, Gauss lemma; normal, totally normal and convex neighbourhood.

Curvature of a connection and its properties, sectional curvature, Ricci curvature, scalar curvature and their relationship, tensors on Riemannian manifolds, covariant and contravariant tensors in reference to Riemannian and non-Riemannian manifolds.

Jacobi equation, Jacobi field, Jacobi field on manifold of constant curvature, conjugate points and their multiplicity, singularities of the exponential map and their relationship, properties of Jacobi field, existence and uniqueness of Jacobi field along a geodesic.

Second fundamental form, Gauss spherical map, principal directions, Gauss-Kronecker curvature of an immersion, calculation of curvature, geodesic and totally geodesic immersions, minimal immersions, mean curvature, fundamental equation, Gauss equation, Ricci equation, Flat immersion, Codazzi's equation.

References

M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)

39. Analytic Number Theory
(Duration: Two Semesters / One Year)
(Prerequisite: Elementary Number Theory and Complex Analysis)
Riemann zeta function, functional equation, prime number theorem, arithmetical functions, mobious inversion, introduction to modular forms.

References
M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)

40. **Algebraic Number Theory**

(Prerequisite: Elementary Algebra & Number Theory)

Algebraic number fields and their rings of integers; calculations for quadratic and cubic cases. Localization, Galois extensions, Dedekind rings, discrete valuation rings, completion, unramified and ramified extensions, different, discriminant, cyclotomic fields, roots of unity. Class group and the finiteness of the class number. Dirichlet unit theorem, Pell's equation, Dedekind and Riemann zeta functions, analytic class number formula.

**References**


M.A/M.Sc. Mathematics (Final)

Optional Papers MM 503 (a & b), MM 504 (a & b), and MM 505 (a & b)

41. **Algebraic Curves**

(Duration: Two Semesters/One Year)

Affine algebraic sets, affine varieties, local properties of plane curves, projective varieties, projective plane curves, varieties, morphisms, rational maps. Resolution of singularities, Riemann-Roch Theorem.

**References**

1. W. Fulton, Algebraic Curves, W.A. Benjamin, Inc.
2. A. Seidenberg, Elements of the theory of Algebraic Curves, Addison-Wesley.
M.Sc. TECH (INDUSTRIAL MATHEMATICS WITH COMPUTER APPLICATIONS)

COURSE STRUCTURE

(Duration: Six Semesters /Three Years)

Pre-requisite for the Course: Mathematics Courses of the B.A./ B.Sc. first two years/ Engineering Mathematics Courses of B.E./ B.Tech./ B.Sc.(Engg.) as taught in the Indian Universities.

M.Sc. Tech Part I (Industrial Mathematics with Computer Applications)

(Duration: Two Semesters/One Year)

MIM 401 (a & b) Real and Complex Analysis
MIM 402 (a & b) Algebra
MIM 403 (a & b) Discrete Mathematical Structures
MIM 404 (a & b) Programming in C with ANSI features
MIM 405 (a & b) Computer Architecture, and Data Structures using C
MIM 406 (a & b) Practicals related to Papers MIM 404 (a & b) and Data Structures (MIM 405)

M.Sc. Tech Part II (Industrial Mathematics with Computer Applications)

(Duration: Two Semesters/One Year)

MIM 501 (a & b) Topology and Functional Analysis
MIM 502 (a & b) Operations Research
MIM 503 (a & b) Object Oriented Programming with C++
MIM 504 (a & b) Operating Systems
MIM 505 (a & b) Design and Analysis of Algorithms
MIM 506 (a & b) Practicals related to Papers MIM 502, 503, 504.
M.Sc. Tech Part III (Industrial Mathematics with Computer Applications)

(Duration: Two Semesters/One Year)

MIM 601 (a & b) Probability and Measure
MIM 602 (a & b) Software Engineering
MIM 603 (a & b) Compiler Techniques and Computer Networks
MIM 604 (a & b) Computer Graphics
MIM 605 (a & b) Data Base Systems and Artificial Intelligence
MIM 606 (a & b) Practicals related to Papers Computer Networks (MIM 603), MIM 604 and MIM 605
MIM 607 (a & b) One Project work related to the Courses in all the three years as given above/or Real Industrial Problems/or One of the following Papers:

(i) Performance modeling of communication networks
(ii) Modeling, Simulation and Monte Carlo Methods
(iii) Computational Biology
(iv) Mathematics of Finance and Insurance.
(v) Computational Fluid Dynamics
(vi) Chemometrics and Quality Control in Industry
(vii) Industrial Processes
Practicals related to the above papers (vi) and (vii).
(viii) Wavelets
(ix) Biomechanics
(x) Fuzzy Sets and Their Applications
(xi) Any other topic according to the availability of Subject expert.

Additional Recommended References
Avner Friedman, Mathematics in Industrial Problems (All volumes of the series), Springer-Verlag, New York, Inc.
DETAILS OF SYLLABI

M.Sc. Tech (Industrial Mathematics with Computer Applications) Part I
(Duration: Two Semesters/One Year)

MIM 401 (a & b) Real and Complex Analysis

Real Analysis

Metric spaces and its topology. Weierstrass’ theorem.


Functions of several variables—Young and Schwarz theorems on the inversion of order of partial derivatives. Jacobians. Implicit function theorem.


Complex Analysis


References

4. Gabriel Klambauer, Mathematical Analysis, Marcel Dekkar, Inc. New York, 1975
23. Inder K. Rana, An Introduction to Measure and Integration, Narosa
M.Sc. Tech (Industrial Mathematics with Computer Applications) Part I

(Duration: Two Semesters/One Year)

**MIM 402 (a & b) Algebra**

Groups, subgroups, cosets, Lagrange's theorem, normal subgroups, quotient groups, homomorphisms, isomorphism theorems, Cayley's theorem, permutation groups, conjugacy, class equation, simple groups, simplicity of $A_n$ ($n > 5$), Sylow theorems, direct sums, structure theorem for finite abelian groups. Normal and subnormal series, composition series, Jordan-Hölder theorem, solvable groups.


Modules, Submodules. Quotient modules. Homomorphism and Isomorphism theorems.

Galois Theory—Extension fields, algebraic and transcendental extensions, separable and inseparable extensions, normal extensions, perfect fields, finite fields, primitive elements and theorem on primitive elements, algebraically closed fields, automorphisms of extensions. Galois extensions, fundamental theorem of Galois theory, solution of polynomial equations by radicals, insolvability of the general equation of degree 5 by radicals.

**References**


M.Sc. Tech (Industrial Mathematics with Computer Applications) Part I
(Duration: Two Semesters/One Year)

MIM 403 (a & b) Discrete Mathematical Structures


Lattices–Lattices as partially ordered sets. Their properties. Lattices as Algebraic systems. Sublattices, Direct products, and Homomorphisms. Some Special Lattices e.g., Complete, Complemented and Distributive Lattices.


Turing Machine and Partial Recursive Functions.


Notions of Syntax Analysis. Polish Notations. Conversion of Infix Expressions to Polish Notations. The Reverse Polish Notation.

References
7. N. Deo, Graph Theory with Applications to Engineering and Computer Sciences, Prentice Hall of India.

M.Sc. Tech (Industrial Mathematics with Computer Applications) Part I
(Duration: Two Semesters/One Year)

MIM 404 (a & b) Programming in C with ANSI features


Recommended Text

References

M.Sc. Tech (Industrial Mathematics with Computer Applications) Part I
(Duration: Two Semesters/One Year)

MIM 405 (a & b) Computer Architecture, and Data Structures using C

(a) Computer Architecture


Uniprocessors—Register machine. Stack machine. Language directed architecture.


(b) \textit{Data Structures Using C}

Introduction to the concepts of an abstract data structure and an implementation.

Stacks and their C implementation. Infix, Postfix, and Prefix notations.

Recursion, its applications, and its implementation. Queues, priority queues and linked lists and their implementation using an array of available nodes as well as dynamic storage.


Internal and external searching.

Graphs–A flow problem. Graph traversal and spanning forests.

\textbf{References}


\textbf{M.Sc. Tech (Industrial Mathematics with Computer Applications) Part I}

(Duration: Two Semesters/One Year)

\textbf{MIM 406 (a & b) Practical related to Papers MIM 404 (a & b) and Data Structures (MIM 405)}
M.Sc. Tech Part II (Industrial Mathematics with Computer Applications)

(Duration: Two Semesters/One Year)

MIM 501 (a & b) Topology and Functional Analysis


Alternate methods of defining a topology in terms of Kuratowski Closure Operator and Neighbourhood Systems.

Continuous functions and homeomorphism.


Separation axioms $T_0$, $T_1$, $T_2$, $T_{3\frac{1}{2}}$, $T_4$; their Characterizations and basic properties. Urysohn's lemma. Tietze extension theorem.


Functional Analysis


References
2. J. Dugundji, Topology, Allyn and Bacon, 1966 (Reprinted in India by Prentice Hall of India Pvt. Ltd.)
33. B.V. Limaye, Functional Analysis, Wiley Eastern Ltd.
M.Sc. Tech Part II (Industrial Mathematics with Computer Applications)

(Duration: Two Semesters/One Year)

**MIM 502 (a & b) Operations Research**


Transportation and Assignment Problems.


Integer Programming—Branch and Bound Technique.


**References**

   (i) LINDO (the linear programming solver)
   (ii) LINDO Callable Library (the premier optimization engine)
   (iii) LINGO (the linear, non-linear, and integer programming solver with mathematical modeling language)
   (iv) What's Best! (the spreadsheet add-in that solves linear, non-linear, and integer problems).
   All the above four products are bundled into one package to form the Solver Suite. For more details about any of the four products one has to click on its name.
   (v) Optimization Modeling with LINDO (5th edition) by Linus Schrage.
   (vi) Optimization Modeling with LINGO by Linus Schrage.

More details available on the Related Books page.

M.Sc. Tech Part II (Industrial Mathematics with Computer Applications)

(MIM 503 (a & b) Object Oriented Programming with C++)

(Duration: Two Semesters/One Year)

Introduction to Object-oriented programming paradigm and design.


Inheritance—Hierarchical. Multiple. Selective.


Programming—Introduction to OOP languages-Class concept in SIMULA. Pure object-oriented language like Smalltalk 80. Hybrid Object-oriented language like C++, etc. Details of C++.


Application—Use of OOP concepts in different areas:

(i) Object-oriented Software Engineering—Architecture of OOSE method. Reusability and OOP. Testing in OOSE. Case study in OOSE.


References
5. Timothy Budd, An Introduction to Object-Oriented Programming, Addison-Wesley.

M.Sc. Tech Part II (Industrial Mathematics with Computer Applications)
(Duration: Two Semesters/One Year)

MIM 504 (a & b) Operating Systems


References
1. P.B. Hansen, Operating System Principles, PHI.
5. Manuals of DOS, UNIX and NetWare.
M.Sc. Tech Part II (Industrial Mathematics with Computer Applications)

(Duration: Two Semesters/One Year)

MIM 505 (a & b) Design and Analysis of Algorithms

Mathematical Foundations—Growth functions, summations, and recurrences-substitution, iteration, and master methods, counting, and probability, amortized analysis.

Sorting—Heap sort, quick sort, merge sort, sorting in linear time, median, and order statistics.

Advanced Data Structures—B-trees, red-black trees, hashing, dynamic order statistics, binomial and fibonacci heap, disjoint sets.

Dynamic Programming—Matrix chain multiplication, longest common subsequence, optimal polygon triangulation.

Greedy Algorithms—Huffman coding and task scheduling problems.

Graphs—Traversal, topological sort, minimum spanning trees, single source shortest paths-Dijkstra’s and Bellman Ford Algorithms, all-pairs shortest path, maximum flow problems.

Sorting Networks—Comparison networks, bitonic sort and merge-sort networks.

Arithmetic circuits—Combinational circuits, addition, multiplication, and clocked circuits.

Parallel Algorithms—CRCW, EREW algorithms, efficiency, sorting linear systems problems.

Matrix Operations—Strassen’s algorithm, matrix inversion.

FFT—Polynomial representation, DFT, FFT.

Number-Theoretic Algorithms—Modular arithmetic, Chinese remainder theorem, RSA Codes.

String Matching—Rabin-Karp, KMP, Boyer-Moore algorithms.


NP-completeness—P and NP classes, NP-completeness and reducibility, NP-completeness proofs.

Approximation Algorithms—Vertex cover, travelling salesman, set-covering, and subset-sum problems.

References

M.Sc. Tech Part II (Industrial Mathematics with Computer Applications)

(Duration: Two Semesters/One Year)

MIM 506 (a & b) Practicals related to Papers MIM 502, 503, 504.
M.Sc. Tech Part III (Industrial Mathematics with Computer Applications)  
(Duration: Two Semesters/One Year)

*MIM 601 (a & b) Probability and Measure*

Classes of sets. Measures and Probability Spaces.

- Distribution and Characteristic Functions.
- Central Limit Theorems.

*Recommended Text*


*References*


M.Sc. Tech Part III (Industrial Mathematics with Computer Applications)  
(Duration: Two Semesters/One Year)

*MIM 602 (a & b) Software Engineering*

Introduction–Evolution & Scope of Software.

- Software Product & Process.


Software Testing Methods & Strategies—Structural, functional, unit, integration, validation, system testing.

Software Metrics—Quality Metrics & Metrics for analysis, design, coding, testing & maintenance.

Software Reliability & Software Quality Assurance.

References

M.Sc. Tech Part III (Industrial Mathematics with Computer Applications)
(Duration: Two Semesters/One Year)

MIM 603 (a & b) Compiler Techniques and Computer Networks

Compiler Techniques
Overview of the Compiling Process. Some Typical Compiler Structures.


Symbol Table Organization—Data Structures for Symbol Table (ST). Design of a ST. ST for Block Structured Language.


Computer Networks

Elements of data communication—Concepts and terminology, analog and digital data transmission, signals, attenuation, delay distortion, noise, channel capacity, transmission media, data encoding, asynchronous and synchronous transmission, multiplexing.


Network Architecture and Distributed Processing—OSI reference model, layered and hierarchical approaches, network interface, principles or inter-networking.

TCP/IP reference model. Internet protocols and standards. Network services, virtual terminal protocol, and file transfer protocol, electronic mail. Distributed processing—Definition, logical aspect of application design, case studies.

References

3. W.A. Barrett el al., Compiler Construction Theory & Practice, Galgotia.

M.Sc. Tech Part III (Industrial Mathematics with Computer Applications)

(Duration: Two Semesters/One Year)

MIM 604 (a & b) Computer Graphics


Line Generation and Area Filling algorithms—Bresenham line generation algorithm. Scan line, Flood-fill and boundary-fill algorithms for polygonal domains.


Transformations in 2D—Translation, rotation, scaling and shearing transformations. Reflection about any arbitrary line, Homogeneous Coordinates.


Hidden line/surface elimination algorithms—Z-buffer algorithms, depth-sort algorithm, area-subdivision method, floating horizon algorithm.


References

M.Sc. Tech Part III (Industrial Mathematics with Computer Applications)
(Duration: Two Semesters/One Year)

MIM 605 (a & b) Data Base Systems and Artificial Intelligence

Data Base Systems

Data Models—Data modeling using entity relationship.

Hierarchical and Network Model—DBTG proposals, data manipulation languages.


Artificial Intelligence
Definition and Introduction to AI & AI Techniques. Problem Definition—Problem Definition as a State space search. Production System. Control Strategies. Problem characteristics.


Knowledge Representation—Knowledge Representation in Predicate and Propositional Logic. Resolution in Predicate and Propositional Logic. Deduction and Theorem Proving. Question


Introduction to Expert Systems.

References
2. C.J. Date, An Introduction to Database Systems, Vols. I & II, Addison-Wesley.
3. P.H. Winston, Artificial Intelligence, Addison-Wesley.
6. N.C. Rowe, Artificial Intelligence through PROLOG, Prentice-Hall of India.
7. A. Bonnet, Artificial Intelligence: Promise and Performance, Prentice Hall.

M.Sc. Tech Part III (Industrial Mathematics with Computer Applications)

(Duration: Two Semesters/One Year)

MIM 606 (a & b) Practicals related to Papers Computer Networks (MIM 603), MIM 604 and MIM 605

MIM 607 (a & b) One Project work related to the Courses in all the three years as mentioned above/Real Industrial Problems/or One of the following Papers:

(i) Performance modeling of computer communication networks


Queuing Systems–(case studies involving queuing theory).

Simple queuing systems (Poisson process, M/M/1 queue, extended models such as Erlang B and C, Transient effects, M/G/1 queue).

Network of queues (Product form solutions, recursive non-product form solutions, negative customer queuing models).

Numerical solutions of Models (Convolution and mean value analysis algorithms with worked out examples, PANACEA, Norton’s equivalent theorem for queuing networks, simulation).

Stochastic petri networks (The model, SPN’s with and without product form solution).

Discrete time queuing systems (arrival process, Geom./Geom/m and Geom/Geom/1 discrete time queues, three industrial case studies involving discrete time queuing system).
Network traffic models (Continuous and discrete time models of recent interest, burstiness, self-similar traffic, solution techniques).

Performance analysis of multiple access protocols. Performance issues in mobile communication.

References

(ii) Modeling, Simulation and Monte Carlo Methods


Language for discrete system simulation—Language characteristics. Use of multipurpose language. Example: Simulation of queuing system. Simulation languages—GPSS, Special-purpose languages—SIMSCRIPT II.5, GASP IV.

References
(iii) Computational Biology

Basic concepts of molecular biology. DNA and Proteins. The Central Dogma. Gene and Genome Sequences.

- Sequence Assembly–Sequencing strategies. Assembly in practices fragment overlap statistics, fragment alignment, sequence accuracy.
- Sequence comparisons Methods–Local and global alignment. Dynamic programming method. Multiple sequence alignment.
- Probability and Statistics for sequence alignment and sequence patterns – Hidden Markov models for biological sequences.

References

(iv) Mathematics of Finance and Insurance.

Prerequisite–Application of Mathematics and Finance (Optional Paper BMH 305 (a &b) and 306 (a &b))

- Financial Derivatives–An Introduction; Types of Financial Derivatives-Forwards and Futures; Options and its kinds; and SWAPS.
- The Arbitrage Theorem and Introduction to Portfolio Selection and Capital Market Theory: Static and Continuous-Time Model.
- Pricing by Arbitrage–A Single-Period option Pricing Model; Multi-Period Pricing Model-Cox-Ross-Rubinstein Model; Bounds on Option Prices.
- The Ito’s Lemma and the Ito’s Integral.
- The Dynamics of Derivative Prices–Stochastic Differential Equations (SDEs)-Major Models of SDEs: Linear Constant Coefficient SDEs; Geometric SDEs; Square Root Process; Mean Reverting Process and Omstein -Uhlenbeck Process.
- Martingale Measures and Risk-Neutral Probabilities: Pricing of Binomial Options with equivalent martingale measures.
- The Black-Scholes Option Pricing Model–using no arbitrage approach, limiting case of Binomial Option Pricing and risk-Neutral probabilities.
Concepts from Insurance-Introduction; The Claim Number Process; The Claim Size Process; Solvability of the Portfolio; Reinsurance and Ruin Problem.

Premium and Ordering of Risks—Premium Calculation Principles and Ordering Distributions. Distribution of Aggregate Claim Amount—Individual and Collective Model; Compound Distributions; Claim Number of Distributions; Recursive Computation Methods; Lundberg Bounds and Approximation by Compound Distributions.

Risk Processes—Time-Dependent Risk Models; Poisson Arrival Processes; Ruin Probabilities and Bounds Asymptotics and Approximation.

Time Dependent Risk Models—Ruin Problems and Computations of Ruin Functions; Dual Queuing Model; Risk Models in Continuous Time and Numerical Evaluation of Ruin Functions.

References
1. John C. Hull, Options, Futures, and Other Derivatives, Prentice-Hall of India Private Limited.
5. Robert C. Merton, Continuous-Time Finance, Basil Blackwell Inc.

(v) Computational Fluid Dynamics


Basic equations of Fluid Dynamics.

Analytic Aspects of PDE.

Finite Volume and Finite Difference Methods on Nonuniform Grids.

Stationary Convection—Diffusion Equation (Finite Volume Discretization, Schemes of Positive Type, Upwind Discretization).


Incompressible Navier-Stokes (NS) Equations—Boundary Conditions. Spatial and Temporal Discretization on Collocated and on Staggered Grids.


Shallow water Equations—one and Two Dimensional Cases.

Scalar Conservation Laws—Godunov's Order Barrier Theorem, Linear Schemes.

Discretization in General Domains—Boundary Fitted Grids. Equations of Motion in General Coordinates.

Numerical Solution of Euler Equation in General Coordinates.

Numerical Solution of NS Equations in General Domains.


**Recommended Text**


**References**


*Note:* This is a rapidly emerging area and books are being published at a very fast rate. Visit the website [www.cfd-online.com](http://www.cfd-online.com) for an up-to-date list.

**(vi) Chemometrics and Quality Control in Industry**


Regression analysis (least-squares methods) standard addition calibration method, normal error curve (Gaussian distribution) and its mathematical equation general treatment of equilibria (acid-base, complexations, redox) in Nater, calculation of pH and knowledge of good lab practice (GLP) and other requirements to generate data for qualitative and quantitative production from industry.

**References**

(vii) Industrial Processes


References

Practicals Related to the above papers (vi) & (vii)

Determination of accuracy. Precision. Mean deviation. Standard deviation. Coefficient of variation. Normal error curve and least square fitting of certain sets of data obtained from industrial quality control laboratory. Use of analytical instruments (HPLC, HPTLC, fluorimeter, polarized microscope etc.) and organization of results in terms of optimization, resolution, modeling, signal processing and pattern recognitions. Validation of methods. Data and computer modeling. Comparison of two sets of results in terms of significance by students’ t-test and F-test. Preparations of materials. Solutions and buffers for benchwork in an industry. Tests for purity of industrial chemicals

(viii) Wavelets

Preliminaries.

Characterizations in the theory of wavelets — The basic equations and some of its applications. Characterizations of MRA wavelets, low-pass filters and scaling functions. Non-existence of smooth wavelets in $H^2(R)$.

Frames — The reconstruction formula and the Balian-Low theorem for frames. Frames from translations and dilations. Smooth frames for $H^2(R)$.

Discrete transforms and algorithms — The discrete and the fast Fourier transforms. The discrete and the fast cosine transforms. The discrete version of the local sine and cosine bases. Decomposition and reconstruction algorithms for wavelets.

**Recommended Text**

**References**

(ix) **Biomechanics**
(Prerequisite: Fluid Mechanics (See MM 503, MM 504, MM 505-8))


Segmental Movement and Vibrations.

External Flow: Fluid Dynamic Forces Acting on Moving Bodies.

Flying and Swimming.


Micro- and Macrocirculation.

Respiratory Gas Flow.


Description of Internal Deformation and Forces.

Stress, Strain, and Stability of Organs.

Strength, Trauma, and Tolerance.

Recommended Text

(x) Fuzzy Sets and Their Applications


An Introduction to Fuzzy Control – Fuzzy controllers. Fuzzy rule base. Fuzzy inference engine. Fuzzification. Defuzzification and the various defuzzification methods (the centre of area, the centre of maxima, and the mean of maxima methods).


References