K.R. MANGALAM UNIVERSITY

THE COMPLETE WORLD OF EDUCATION

SCHOOL OF BASIC AND APPLIED SCIENCES (SBAS)

Master of Science- Mathematics
M.Sc. (Mathematics)
Programme Code: 60
2019-21

Approved in the 20th Meeting of Academic Council Held on 16 July 2019

Academic Council
Member Secretary
K.R. Mangalam University

Registrar
K.R. Mangalam University
Sohna Road, Gurugram, (Haryana)

SCHOOL OF BASIC AND APPLIED SCIENCES (SBAS)

Master of Science- Mathematics

M.Sc. (Mathematics)

Programme Code: 60

2019-21

Approved in the 20th Meeting of Academic Council Held on 16 July 2019

PREAMBLE

The objective of any programme at Higher Education Institute is to prepare their students for the society at large. The K. R. Mangalam University visualizes all its programmes in the best interest of their students and in this endeavour; it offers a new vision to all its Postgraduate courses. The credit system to be implemented through this curriculum, would allow students to develop a strong footing in the fundamentals and specialize in the disciplines of his/her liking and abilities. The students pursuing this course would have to develop in depth understanding of various aspects of the subject. The conceptual understanding, development of experimental skills, designing and implementation of novel synthetic methods, developing the aptitude for academic and professional skills, research skills, acquiring basic concepts for structural elucidation with hyphenated techniques, understanding the fundamental biological processes and rationale towards computer assisted drug designing are among such important aspects.

Prepared by:

Dr. Yogendra Kumar Rajoria
Assistant Professor (Mathematics)
School of Basic and Applied Sciences

Dr. Rahul Boadh
Assistant Professor (Mathematics)
School of Basic and Applied Sciences

Dr. Mina Yadav
Assistant Professor (Mathematics)
School of Basic and Applied Sciences

Dr. Pooja Vats
Assistant Professor
(Mathematics)

Dr. Ravendra Singh
Assistant Professor (Mathematics)
School of Basic and Applied Sciences

Approved by:
Vice-Chancellor
K.R.Mangalam University

Verified by
Dr. Meena Bhandari
Associate Professor and Dean
School of Basic and Applied Sciences

1. Introduction

K.R. Mangalam University located on Sohna Road, Gurugram, is one of the fastest growing and most promising upcoming universities in India. It is a State Private University established in 2013 by an act of the legislature of the Haryana Government under Haryana Private Universities Act (Amendment) 8 of 2013.It is recognized by the UGC under Section 2f of the UGC Act, 1956. The primary aim of the University is to promote excellence in basic and professional education while upholding moral values.

KRMU offers various Undergraduate, Postgraduate and Doctoral Degree programs across different disciplines. The group of educational units in the University promote education in the areas of Engineering & Technology, Legal Studies, Basic and Applied Sciences, Management Sciences, Commerce, Journalism and Mass Communication, Hotel Management and Catering Technology, Medical and Allied Sciences, Architecture and Planning, Agriculture, Fashion Designing, Humanities and Education. All the disciplines follow a well-defined curriculum design keeping in view the guidelines of UGC/AICTE and appropriate regulatory bodies like Council of Architecture (COA), Bar Council of India (BCI), Pharmacy Council of India (PCI), National Council for Teachers Education (NCTE) etc., wherever applicable. All courses are semester and credit based.

K. R. Mangalam University is unique because of its

- An enduring legacy of providing education to high achievers who demonstrate leadership in diverse fields.
- Protective and nurturing environment for teaching, research, creativity, scholarship, social and economic justice.

Objectives

i. To impart undergraduate, post-graduate and Doctoral education in identified areas of higher education.
ii. To undertake research programmes with industrial interface.
iii. To integrate its growth with the global needs and expectations of the major stake holders through teaching, research, exchange & collaborative programmes with foreign, Indian Universities/Institutions and MNCs.
iv. To act as a nodal center for transfer of technology to the industry
v. To provide job oriented professional education to the pecia student community with particular focus on Haryana.

2. About School

The school imparts both teaching and research through its various science disciplines viz Mathematics, Chemistry and Physics.
School of Basic and Applied Sciences imparts students disciplinary knowledge, enhances their skills and ability, motivating them to think ingeniously, helping them to act independently and take decisions accordingly in all their scientific pursuits and other endeavours. It strives to empower its students and faculty members to contribute for the development of society and Nation.
The faculty is in constant touch with various experts in the relevant fields and is willing to experiment with latest ideas in teaching and research.

VISION

School of Basic and Applied Sciences intends for continuum growth as centre of advanced learning, research and innovation by disseminating analytical and scientific knowledge in the areas of basic and applied sciences by promoting interdisciplinary research and scientific acumen.

MISSION

M1: Enable students to be scientists/ academicians /entrepreneurs by accomplishing fundamental and advanced research in diverse areas of basic and applied sciences.

M2: Build strong associations with academic organizations/industries for knowledge creation, advancement, and application of scientific fervor.

M3: Create conducive environment for lifelong learning.

M4: Empower students to be socially responsible and ethically strong individuals through value-based science education.

3. Programmes offered by the School

School offers undergraduate B.Sc. (Hons) Programmes, postgraduate M.Sc. Programmes, and Doctoral Programmes. All these programmes are designed to impart scientific knowledge to the students and are aimed to provide theoretical as well as practical training in their respective fields.
School offers postgraduate M.Sc. Mathematics. This school established in 2013. This course emphasized on hands on practice, innovative thought process and project-based learning.

4. M.Sc. Mathematics

The M.Sc. in Mathematics provides a broad and flexible training in variety of courses tailored to your own interests and needs, ranging from pure mathematics to mathematical modelling, computational mathematics, and applications of mathematics to many research areas.

The programme offers a substantial opportunity for independent study and research in the form of a dissertation. The dissertation is undertaken under the guidance of a supervisor and will typically involve investigating and writing in a particular area of mathematical sciences. A dissertation gives students the opportunity to develop broader transferable skills in the processes of organizing, communicating, and presenting their work, and will equip students well for further research or for a wide variety of other careers.

Eligibility Criteria: - He/ She should have passed the B.Sc. (Hons) Mathematics / B.Sc. with Mathematics as a major subject, from a recognized University or equivalent with a minimum of 50% marks in aggregate.

Course Outline: - Real Analysis/ Complex Analysis/ Functional Analysis/ Topology/ Advanced Algebra/ Measure and Integration/ Industrial & Applied Mathematics/ Numerical Analysis & Scientific Computing.

Career Options: - Opportunities exist in researchers, teachers, or even work in many branches of Engineering, Finance, Physics, Chemistry, Medicine and more.

5. Programme Duration

The minimum period required for the M.Sc. Programme offered by the University shall extend over a period of two Academic Years.
The maximum period for the completion of the M.Sc. Programme offered by the University shall be four years.

6. Class Timings

The classes will be held from Monday to Friday from 09:10 am to 04:10 pm.

7. Scheme of Studies and Syllabi

The syllabi of M.Sc. Mathematics offered by School of Basic and Applied Sciences with scheme of studies are given in the following pages.

M.Sc. Mathematics Two Years Postgraduate Programme
Scheme of Studies as per the CBCS

SEMESTER	I	II	III	IV	TOTAL
COURSES	7	7	5	5	24
CREDITS	20	22	22	22	86

SEMESTER - I

SN	Course Code	Course Title	C
1	BSMA701A	Linear Algebra	4
2	BSMA703A	Real Analysis	4
3	BSMA705A	Probability and Statistics	5
4	BSMA707A	Integral Equations and Calculus of Variations	4
5	BSMA811A	Advanced MATLAB Programming	3
TOTAL			**20**

BSMA701A	LINEAR ALGEBRA	C
		4

Vector spaces over fields, subspaces, bases and dimension. Systems of linear equations, matrices, rank, Gaussian elimination.

Linear transformations, representation of linear transformations by matrices, rank-nullity theorem, duality and transpose. Determinants, Laplace expansions, cofactors, adjoint, Cramer's Rule.

Eigen values and Eigen vectors, characteristic polynomials, minimal polynomials, Cayley-Hamilton Theorem, triangulation, diagonalization, rational canonical form, Jordan canonical form.

Inner product spaces, Gram-Schmidt orthonormalization, orthogonal projections, linear functionals and adjoints, Hermitian, self-adjoint, unitary and normal operators, Spectral Theorem for normal operators, Rayleigh quotient, Min-Max Principle.

Bilinear forms, symmetric and skew-symmetric bilinear forms, real quadratic forms, Sylvester's law of inertia, positive definiteness.

REFERENCE BOOKS:

1. K. Hoffman and R. Kunze; *Linear Algebra*, Pearson Education (India).
2. M. Artin; *Algebra*, Prentice Hall of India.
3. S. Lang; Linear *Algebra: Undergraduate Texts in Mathematical*, Springer-Verlag, New York.
4. P. Lax; *Linear Algebra*, John Wiley & Sons, New York, Indian Ed.
5. H.E. Rose; *Linear Algebra*, Birkhauser.

BSMA703A	REAL ANALYSIS	C
		4

Review of basic concepts of real numbers: Archimedean property, Completeness. Metric spaces, compactness, connectedness, (with emphasis on R^n).

Definition and existence of Riemann Stieltjes integral, properties of the integral, integration and differentiation, the fundamental theorem of integral calculus, integration by parts, integration of vector-valued functions, Rectifiable curves.

Functions of several variables: linear transformations, Derivative in an open subset of R^n, Chain rule, Partial derivatives, directional derivatives, the contraction principle, Banach fixed point theorem. Taylor's theorem for a function of several variables, Directional derivative.

Inverse function theorem, Implicit function theorem, Jacobians, extremum problems with constraints, Lagrange's multiplier method, Derivatives of higher order, mean value theorem for real functions of two variables, interchange of the order of differentiation, Differentiation of integrals.

REFERENCE BOOKS:

1. Walter Rudin; *Principles of Mathematical Analysis*, McGraw-Hill.
2. T. Apostol; *Mathematical Analysis*, Narosa Publishers.
3. K. Ross; *Elementary Analysis: The Theory of Calculus*, Springer Int. Edition.

BSMA705A	PROBABILITY AND STATISTICS	C
		5

Measures of central tendency, measures of dispersion, confidence interval, estimating a population proportion, estimating a population mean, estimating a population standard deviation or variance,

Steps in hypothesis testing, P-value method for hypothesis testing, Hypothesis test- t, Z and chi-square, analysis of variance (ANOVA)

Sample spaces and probability, conditional probability and Bayes' theorem, discrete and continuous probability distributions, The Central Limit Theorem

REFERENCE BOOKS:

1. W.W. Hines, D.C. Montgomery, D.M. Goldsman, and C.M. Borror; *Probability and Statistics in Engineering*; John Wiley & Sons.
2. E.J. Dudewicz & S.N. Mishra; *Modern Mathematical Statistics*, John Wiley &. Sons.
3. J.S. Milton and J.C. Arnold; *Introduction to Probability and Statistics*, McGraw-Hill.
4. H.J. Larsen; *Introduction to Probability Theory and Statistical Inference*, John Wiley &. Sons.

PRACTICAL/ LAB WORK

List of Practicals

1. Graphical representation of data.
2. Problems based on measures of central tendency.
3. Problems based on measures of dispersion.
4. Problems based on combined mean and variance and coefficient of variation.
5. Problems based on moments, skewness and kurtosis.
6. Fitting of polynomials, exponential curves.
7. Testing of significance and confidence intervals for single proportion and difference of two proportions
8. Fitting of binomial distributions for n and p = q = ½.
9. Fitting of binomial distributions for given n and p.
10. Fitting of binomial distributions after computing mean and variance.
11. Fitting of Poisson distributions for given value of lambda.
12. Fitting of Poisson distributions after computing mean.
13. Fitting of negative binomial.
14. Application problems based on binomial distribution.
15. Application problems based on Poisson distribution.
16. Application problems based on negative binomial distribution.
17. Problems based on area property of normal distribution.
18. To find the ordinate for a given area for normal distribution.
19. Application based problems using normal distribution.
20. Fitting of normal distribution when parameters are given.
21. Fitting of normal distribution when parameters are not given.
22. Fitting of Binomial, Poisson distribution and apply Chi-square test for goodness of fit

BSMA707A	INTEGRAL EQUATIONS AND CALCULUS OF VARIATIONS	C
		4

Linear integral equations, Some basic identities, Initial value problems reduced to Volterra integral equations, Methods of successive substitution and successive approximation to solve Volterra integral equations of second kind, Iterated kernels and Neumann series for Volterra equations. Resolvent kernel as a series in λ, Laplace transform method for a difference kernel, Solution of a Volterra integral equation of the first kind.

Boundary value problems reduced to Fredholm integral equations, Methods of successive approximation and successive substitution to solve Fredholm integral equations of second kind, Iterated kernels and Neumann series for Fredholm integral equations. Resolvent kernel as a sum of series, Fredholm resolvent kernel as a ratio of two series, Fredholm equations with separable kernels, Approximation of a kernel by a separable kernel, Non homogenous Fredholm equations with degenerate kernels.

Green's function, Use of method of variation of parameters to construct the Green's function for a non-homogeneous linear second order boundary value problem, Basic four properties of the Green's function, Orthogonal series representation of Green's function, Alternate procedure for construction of the Green's function by using its basic four properties. Reduction of a boundary value problem to a Fredholm integral equation with kernel as Green's function, Hilbert-Schmidt theory for symmetric kernels.

Motivating problems of calculus of variations, Shortest distance, Minimum surface of revolution, Brnchistochrone problem, Isoperimetric problem, Geodesic. Fundamental lemma of calculus of variations, Euler's equation for one dependant function and its generalization to 'n' dependant functions and to higher order derivatives, Conditional extremum under geometric constraints and under integral constraints.

REFERENCE BOOKS:

1. M D Raisinghania; *Linear Integral Equations*, S. Chand Publication
2. A.S. Gupta; *Calculus of Variations*, Narosa Publication.
3. J. Jerri; *Introduction to Integral Equations with Applications*, Wiley-Interscience Pub.
4. Shanti Swarup; *Linear Integral Equations*, Krishna Prakashan Media.
5. J. M. Gelfand and S.V. Fomin; *Calculus of Variations*, Prentice Hall, New Jersy.
6. Weinstock; *Calculus of Variations*, McGraw Hall.
7. Abdul-Majid wazwaz; *A first course in Integral Equations,*World Scientific Pub.
8. P. David and S. G. David Stirling; *Integral Equations*, Cambridge University Press.

BSMA811A	ADVANCED MATLAB PROGRAMMING	C
		3

Introduction to MATLAB: Starting and ending MATLAB session, MATLAB environment, MATLAB help, types of files, search path, some useful MATLAB commands, data types, constant and variables, Arithmetic, Relational and Logical Operators, built-in functions, Import and export of data, Working with files and directories.

Polynomials: Entering a polynomial, polynomial evaluation, and roots of polynomial, polynomial operations - addition and subtraction, multiplication, division, formulation of polynomial equation, characteristic polynomial of a matrix, polynomial differentiation, integration and curve fitting, evaluation of polynomial with matrix arguments, Interpolation.

Vectors and Matrix Computations: Scalars and vectors, entering data in matrices, line continuation, matrix subscripts/indices, Transpose, dot product, matrix multiplication, matrix powers, matrix inverse, determinants, Matrix manipulation, special Matrices: identity matrix, diagonal matrices, Matrix functions, Eigen values and Eigen vectors. Solutions to systems of linear equations: matrix inverse and matrix left division.

MATLAB Programming: Function files, sub functions, global variations, loops, branches and control flow.

MATLAB Graphics: Two-dimensional plots, multiple plots, style options, legend command, subplots , three-dimensional plots, Mesh and surface plots.

Advanced Functions: Differentiation, Integration, Double integration, First and second order ODE, Publishing a report.

Symbolic Processing With MATLAB: Symbolic Expressions and Algebra, Algebraic and Transcendental Equations, Calculus, Symbolic Linear Algebra, ordinary and partial differential equation, Symbolic Tutors.

REFERENCE BOOKS:

1. L.F. Shampine, I Gladwell, S. Thompson; *Solving ODE's with MATLAB*, Cambridge University Press.
2. Rudra Pratap; *Getting Started with MATLAB 7*, Oxford Press.
3. S.R. Otto and J.P. Denier, *An Introduction to Programming and Numerical Methods in MATLAB*, Springer.
4. Won Young Yang, Tae-Sang-Chung, John Morris; *Applied numerical Methods using MATLAB*, John Wiley and Sons.

SEMESTER - II

SN	Course Code	Course Title	C
1	BSMA702A	Abstract Algebra-I	4
2	BSMA704A	Topology	4
3	BSMA706A	Complex Analysis	4
4	BSMA708A	Advanced Ordinary Differential Equations	4
5	BSMA710A	Numerical Analysis	5
6	BSMA714A	LaTeX Lab	1
TOTAL			**22**

BSMA702A	ABSTRACT ALGEBRA - I	C
		4

Groups : Zassenhaus lemma, Normal and subnormal series, Composition series, Jordan-Holder theorem, Solvable series, Derived series, Solvable groups, Solvability of Sn – the symmetric group of degree $n \geq 2$.

Nilpotent group: Central series, Nilpotent groups and their properties, Equivalent conditions for a finite group to be nilpotent, Upper and lower central series, Sylow-p sub groups, Sylow theorems with simple applications. Description of group of order p2 and pq, where p and q are distinct primes (In general survey of groups upto order 15).

Field theory, Extension of fields, algebraic and transcendental extensions. Splitting fields, Separable and inseparable extensions, Algebraically closed fields, Perfect fields.

Finite fields, Automorphism of extensions, Fixed fields, Galois extensions, Normal extensions and their properties, Fundamental theorem of Galois theory, Insolvability of the general polynomial of degree $n \geq 5$ by radicals.

REFERENCE BOOKS:

1. P. B. Bhattacharya, S.K. Jain and S.R. Nagpaul; *Basic Abstract Algebra*, Cambridge University Press, Indian Edition.
2. P. M. Cohn, *Algebra*, Vols. I, II & III, John Wiley & Sons.
3. S. Lang, *Algebra*, 3rd edition, Addison-Wesley.
4. I.S. Luther and I. B. S. Passi, *Algebra*, Vol. I-Groups, Vol. II-Rings, Narosa Publishing House.
5. Vivek Sahai and Vikas Bist, *Algebra*, Narosa Publishing House.
6. I. N. Herstein; *Topics in Algebra*, Wiley Eastern Ltd., New Delhi.
7. David S. Dummit, Richard M. Foote; *Abstract Algebra*, John Wiley.

BSMA704A	TOPOLOGY	C
		4

Definition and examples of topological spaces. Closed sets. Closure. Dense sets. neighborhoods, interior, exterior, and boundary. Accumulation points and derived sets. Bases and sub-bases. Subspaces and relative topology. Alternative methods of defining a topology in terms of Kuratowski closure operator and neighborhood systems.

Continuous functions and homeomorphism. First and second countable space. Lindelöf spaces. Separable spaces.

The separation axioms T_0, T_1, T_2, $T_{3½}$, T_4; their characterizations and basic properties. Urysohn's lemma. Tietze extension theorem.

Compactness. Basic properties of compactness. Compactness and finite intersection property. Sequential, countable, and B-W compactness. Local compactness. One-point compactification.

Connected spaces and their basic properties. Connectedness of the real line. Components. Locally connected spaces.

Nets and filters, their convergence, and interrelation. Hausdorffness and compactness in terms of net/filter convergence.

REFERENCE BOOKS:

1. J. L. Kelley, *General Topology*, Van Nostrand,
2. K. D. Joshi, *Introduction to General Topology*, Wiley Eastern.
3. James R. Munkres, *Topology*, 2nd Edition, Pearson International.
4. J. Dugundji, *Topology*, Prentice-Hall of India, 1966.
5. N. Bourbaki, *General Topology*, Part I, Addison-Wesley.
6. S. Willard, *General Topology*, Addison-Wesley.
7. George F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw-Hill.

BSMA706A	COMPLEX ANALYSIS	C
		4

Function of a complex variable, continuity, differentiability. Analytic functions and their properties, Cauchy-Riemann equations in Cartesian and polar coordinates. Power series, Radius of convergence, Differentiability of sum function of a power series.

Path in a region, smooth path, p.w. smooth path, contour, simply connected region, multiply connected region, bounded variation, total variation, complex integration, Cauchy-Goursat theorem, Cauchy theorem for simply and multiply connected domains.

Cauchy integral formula. Extension of Cauchy integral formula for multiple connected domain. Higher order derivative of Cauchy integral formula. Gauss mean value theorem Morera's theorem. Cauchy's inequality. Zeros of an analytic function, entire function, radius of convergence of an entire function, Liouville's theorem, Fundamental theorem of algebra, Taylor's theorem.

Maximum modulus principle, Minimum modulus principle. Schwarz Lemma. Singularity, their classification, pole of a function and its order. Laurent series, Cassorati – Weiertrass theorem Meromorphic functions, Poles and zeros of Meromorphic functions. The argument principle, Rouche's theorem, inverse function theorem

Residue at a singularity, residue at a simple pole, residue at infinity. Cauchy residue theorem and its use to calculate certain integrals.

Bilinear transformation, their properties and classification, cross ratio, preservance of cross ratio under bilinear transformation, preservance of circle and straight line under bilinear transformation, fixed point bilinear transformation, normal form of a bilinear transformation. Definition and examples of conformal mapping, critical points.

REFERENCE BOOKS:

1. J. B. Conway, *Functions of One Complex Variable*, 2nd ed., Narosa, New Delhi.
2. T.W. Gamelin, *Complex Analysis*, Springer International Edition.
3. R. Remmert, *Theory of Complex Functions*, Springer Verlag.
4. A.R. Shastri, *An Introduction to Complex Analysis*, Macmilan India, New Delhi.
5. Shanti Narayan; *Theory of Functions of a complex variable*, S. Chand & Co.

BSMA708A	ADVANCED ORDINARY DIFFERENTIAL EQUATIONS	C
		4

Review of solution methods for first order as well as second order equations, Power Series methods with properties of Bessel functions and Legendre polynomials.

Existence and Uniqueness of Initial Value Problems: Picard's and Peano's Theorems, Gronwall's inequality, continuation of solutions and maximal interval of existence, continuous dependence.

Higher Order Linear Equations and linear Systems: fundamental solutions, Wronskian, variation of constants, matrix exponential solution, behaviour of solutions.

Two Dimensional Autonomous Systems and Phase Space Analysis: critical points, proper and improper nodes, spiral points and saddle points.

Asymptotic Behavior: stability (linearized stability and Lyapunov methods).

Boundary Value Problems for Second Order Equations: Green's function, Sturm comparision theorems and oscillations, eigenvalue problems.

REFERENCE BOOKS:

1. M. Hirsch, S. Smale and R. Deveney; *Differential Equations, Dynamical Systems and Introduction to Chaos*, Academic Press.
2. L. Perko; *Differential Equations and Dynamical Systems, Texts in Applied Mathematics*, Vol. 7, 2nd ed., Springer Verlag, New York.
3. M. Rama Mohana Rao; *Ordinary Differential Equations: Theory and Applications*, Affiliated East-West Press Pvt. Ltd., New Delhi.
4. D. A. Sanchez; *Ordinary Differential Equations and Stability Theory: An Introduction*, Dover Publ. Inc., New York, 1968.

BSMA710A	NUMERICAL ANALYSIS	C
		5

Solution of Algebraic and Transcendental Equations: Iterative Methods, Bisection Method, Method of false position, Secant Method, Newton-Raphson Method, Muller's Method, Horner's Method, Lin-Bairstow's Method and Graeffe's Root squaring Method.

Solution of Simultaneous Algebraic Equations: Direction methods, Matrix inversion method, Guass elimination, Gauss-Jordan method, Factorization method; Iterative method-Jacobi and Seidal Methods, Relaxation Method.

Interpolation: Newton's Interpolation, Gauss's interpolation, Stirling's formula, Bessel's formula, Everett's formula, Lagranges's interpolation, Divided Differences and Newton's divided difference formula, Hermite's interpolation, Spline interpolation, Double interpolation, Inverse interpolation.

Numerical Differentiation and Integration: Formulae for derivatives, Maxima and Minima of a tabulated function, Newton-Cote's Quadrature Formula, Romberg's Method, Euler-Maclaurin formula, Gaussian integration, Numerical double integration.

Numerical Solution of Ordinary Differential Equations: Picard's Method, Taylor's series method, Euler's Method, Modified Euler's Method, Runge-Kutta Method, Milne's Predictor-Corrector Method, Adams-Bashforth method, Solving simultaneous first order differential equations and second order differential equations. Error analysis, Stability analysis, Boundary-value problems, Finite-difference method, Shooting method.

Numerical Solution of Partial Differential Equations: Finite – difference approximations to partial derivatives, Solutions of Laplace equation, Poisson's equation, Five point formulae for Laplacian, Concept of compatibility, convergence and stability, explicit, full implicit, Crank-Nicholson, du-Fort and Frankel scheme, ADI methods to solve two-dimensional equations with error analysis.

REFERENCE BOOKS:

1. M. K. Jain, S. R. K. Iyengar and R. K. Jain; *Numerical Methods for Scientific and Engineering Computation*, New age International Publisher, India.
2. Kresyzig; *Advanced Engineering Mathematics*, John Wiley and Sons.
3. Veerarajan and Ramachandran, Numerical Methods: With Programs In C, Tata McGraw-Hill Education.
4. B. S. Grewal, *Numerical Methods in Engineering and Science*, Khanna Publishers.

PRACTICAL/ LAB WORK

Modeling of the following problems using Matlab / Mathematica / Maple etc.

List of Practicals

1. Bisection Method.
2. Newton Raphson Method.
3. Secant Method.
4. Regulai Falsi Method.
5. LU decomposition Method.
6. Gauss-Jacobi Method.
7. SOR Method or Gauss-Siedel Method.
8. Lagrange Interpolation.
9. Newton Interpolation.
10. Trapezoidal rule.
11. Simpson's rule.
12. Modified Euler's Method.
13. Runge-Kutta Method.
14. Milne's Predictor-Corrector Method.
15. Poisson's equation
16. First-order quasi-linear PDEs.
17. 3-D Heat Equation
18. Laplace equation of heat equilibrium problem

BSMA714A	LaTeX Lab	C
		1

Advantages of LaTeX, distribution and installation of the software for different operating systems, writing a small LaTeX document

Utility of different document classes-article, book and beamer, add-on packages to provide additional typesetting, creating multiple equations, table and figures, PSTricks to draw figures

REFERENCE BOOKS:

1. Stefan Kottwitz, *LaTeX Beginner's Guide*, Packt Publishing Ltd., UK, 2011.
2. Stefan Kottwitz, *LaTeX Cookbook*, Packt Publishing Ltd., UK, 2015.
3. George Gratzer, *Practical LATeX*, Springer International Publishing Switzerland, 2014.

SEMESTER - III

SN	Course Code	Course Title	C
1	BSMA801A	Abstract Algebra-II	4
2	BSMA803A	Measure and Integration	4
3	BSMA805A	Advanced Partial Differential Equations	4
4		Discipline Elective - I	5
5		Discipline Elective - II	5
TOTAL			**22**

Discipline Elective I - II (Choose any two)						
SN	**COURSE CODE**	**COURSE TITLE**	**L**	**T**	**P**	**C**
1	BSMA821A	Mathematical Modelling	4	0	0	4
	BSMA871A	Mathematical Modelling Lab	0	0	2	1
2	BSMA823A	Operational Research	4	0	0	4
	BSMA873A	Operational Research Lab	0	0	2	1
3	BSMA825A	Basics of Statistical Inference	4	0	0	4
	BSMA875A	Basics of Statistical Inference Lab	0	0	2	1
4	BSMA827A	Stochastic Processes and Queuing Theory	4	0	0	4
	BSMA877A	Stochastic Processes and Queuing Theory Lab	0	0	2	1
5	BSCA 330A	Network Security & Cryptography	4	0	0	4
	BSCA 372A	Network Security & Cryptography Lab	0	0	2	1
6	BSCS401A	Artificial Intelligence	4	0	0	4
	BSCS 451A	Artificial Intelligence Lab	0	0	2	1

BSMA801A	**ABSTRACT ALGEBRA II**	**C**
		4

Modules, General properties of modules, sub modules, Quotient modules, Homomorphism of modules, simple and semi- simple modules, free modules

Cyclic modules, Schur's lemma, Free modules, Fundamental structure theorem of finitely generated modules over principal ideal domain and its applications to finitely generated abelian groups.

Neotherian and Artinian modules and rings with simple properties and examples, Nil and Nilpotent ideals in Neotherian and Artinian rings, Hilbert Basis theorem.

HomR(R,R), Opposite rings, Wedderburn – Artin theorem, Maschk's theorem, Equivalent statement for left Artinian rings having non-zero nilpotent ideals, Uniform modules, Primary modules and Neother- Lasker theorem.

Canonical forms : Similarity of linear transformations, Invariant subspaces, Reduction to triangular form, Nilpotent transformations, Index of nilpotency, Invariants of nilpotent transformations, The primary decomposition theorem, Rational canonical forms, Jordan blocks and Jordan forms.

REFERENCE BOOKS:

1. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul; *Basic Abstract Algebra*, Cambridge University Press, Indian Edition.
2. M. Artin; *Algebra*, Prentice-Hall of India.
3. P.M. Cohn; *Algebra*, Vols. I, II & III, John Wiley & Sons.
4. I.S. Luther and I. B. S. Passi; *Algebra*, Vol. I-Groups, Vol. II-Rings, NarosaPublishing House.
5. K.B. Datta; *Matrix and Linear Algebra*, Prentice Hall of India Pvt., New Delhi.
6. Vivek Sahai and VikasBist; *Algebra*, Narosa Publishing House.
7. I.N.Herstein; *Topics in Algebra*, Wiley Eastern Ltd., New Delhi.

BSMA803A	MEASURE AND INTEGRATION	C
		4

Riemann integral: scope and limitations, Null sets, Outer measure, Lebesgue measurable sets and Lebesgue measure, Basic properties of Lebesgue measure

Borel sets, Probability space, Definition, examples and properties of Lebesgue-measurable functions, Random variables, Sigma fields generated by random variables

Definition of the integral, Integrable functions, Monotone Convergence Theorems, The Dominated Convergence Theorem, Approximation of measurable functions

REFERENCE BOOKS:

1. P. R. Halmos; *Measure Theory*, Grand Text Mathematics, 14, Springer.
2. I. K. Rana; *An Introduction to Measure and Integration*, Narosa Publishing House, New Delhi.
3. E. Hewit and K. Stromberg; *Real and Abstract Analysis*, Springer, 1975.
4. H. L. Royden and P. M. Fitzpatrick, Real Analysis, (Fourth edition), P.H.l. New Delhi.

BSMA805A	ADVANCED PARTIAL DIFFERENTIAL EQUATIONS	C
		4

Cauchy Problems for First Order Hyperbolic Equations: method of characteristics, Monge cone. Classification of Second Order Partial Differential Equations: normal forms and characteristics.

Initial and Boundary Value Problems: Lagrange-Green's identity and uniqueness by energy methods.

Stability theory, energy conservation and dispersion.

Laplace equation: mean value property, weak and strong maximum principle, Green's function, Poisson's formula, Dirichlet's principle, existence of solution using Perron's method (without proof).

Heat equation: initial value problem, fundamental solution, weak and strong maximum principle and uniqueness results.

Wave equation: uniqueness, D'Alembert's method, method of spherical means and Duhamel's principle.

Methods of separation of variables for heat, Laplace and wave equations.

REFERENCE BOOKS:

1. F. John; *Partial Differential Equations*, 3rd ed., Narosa Publ. Co., New Delhi.
2. E. Zauderer; *Partial Differential Equations of Applied Mathematics*, 2nd ed., John Wiley and Sons, New York.
3. E. DiBenedetto; *Partial Differential Equations*, Birkhauser, Boston.
4. L.C. Evans; *Partial Differential Equations, Graduate Studies in Mathematics*, Vol. 19, AMS, Providence.

---BSMA821A	MATHEMATICAL MODELLING	4	0	0	4

UNIT-I

Modelling through ODE of First order

Need, Techniques, Classifications, Characteristic and Limitations of Mathematical Models. Modelling through Ordinary Differential Equation of First Order and systems of Ordinary Differential Equation of First Order: Linear and Non – Linear Growth and Decay Models, Compartment Models.

UNIT-II

Modelling through Difference Equation

Modelling through Ordinary Differential Equation of Second Order: Planetary Motion, Motion of Satellites, Electrical Circuits.

Modelling through Difference Equations: Basic Theory of Linear Difference equations with constant coefficient, Models used in Economics and Finance, Population dynamics and genetics.

UNIT-III

Modelling through Graphs

Modelling through Graphs: Directed and Signed graphs, Weighted Di-graphs, Eulerian and Hamiltonian graphs, Applications to route problems, network flow and scheduling problems.

UNIT-IV

Simulation Modelling

Monte Carlo Simulation Modelling: simulating deterministic behaviour (area under a curve, volume under a surface). Forecasting: Time Series, Linear and Nonlinear Trend, seasonal Variations and Irregular Variations and their Measurements, Moving Averages, Single and Double exponential smoothing.

Reference Books/Materials

1. Reinhard Illner; *Mathematical Modelling*, A Case Studies Approach, Indian Editions of AMS (American Mathematical Society).
2. Rutherford Aris; *Mathematical Modelling Techniques*, Dover Publications Inc.
3. Frank R. Giordano , William P. Fox , Steven B. Horton; *A First Course in Mathematical Modeling*, Brooks Pub Co.
4. Edward A. Bender; *An Introduction to Mathematical Modeling*, John Wiley & Sons.
5. Mark M. Meerschaert; *Mathematical Modeling*, Academic Press Inc.
6. J. Caldwell and Y. M. Ram; *Mathematical Modelling*; Concepts and Case Studies, Springer.
7. S.C. Gupta and V.K. Kapoor, *Fundamentals of Applied Statistics*, Sultan Chand & Sons.
8. J. N. Kapur; *Mathematical Modelling*, New Age International Publishers.
9. John E. Hanke, Dean Wichern and Arthur G. Reitch, *Business Forecasting*, 7th Ed., Pearson.

---BSMA871A	MATHEMATICAL MODELLING LAB	1

Course Content

Modeling of the following problems using Matlab / Mathematica / Maple etc.

List of Practicals

1. Plotting of second & third order solution family of differential equations.
2. Growth & Decay model (exponential case only).
3. Lake pollution model (with constant/seasonal flow and pollution concentration)
4. Case of single cold pill and a course of cold pills.
5. Limited growth of population (with and without harvesting).
6. Predatory-prey model (basic volterra model, with density dependence, effect of DDT, two prey one predator).
7. Epidemic model of influenza (basic epidemic model, contagious for life, disease with carriers).
8. Battle model (basic battle model, jungle warfare, long range weapons).
9. Sketching the Phase Plane for the system
10. Coupled Mass-Spring Systems
11. Second Order RLC electrical circuits
12. Shortest Path Graph Algorithms (Dijkstra's/ Floyd Warshall's/ Bellman Ford's).
13. Minimum Spanning Tree Algorithms (Kruskal's/Prim's).
14. Traffic Flow Analysis Model.
15. Fitting of trend by Moving Average Method
16. Forecasting by exponential smoothing

Reference Books/Materials

1. J. Sinha Roy and S Padhy: A course of Ordinary and Partial differential equation Kalyani Publishers,New Delhi.
2. Belinda Barnes and Glenn R. Fulford, Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab,2ndEd.,Taylor and Francis group, London and New York,2009.
3. Simmons G F, Differential equation, Tata Mc GrawHill, 1991.
4. Martin Braun, Differential Equations and their Applications, Springer International, Student Ed.
5. S. L. Ross, Differential Equations, 3rd Edition, John Wiley and Sons, India. 4. C.Y. Lin, Theory and Examples of Ordinary Differential Equations, World Scientific, 2011.

BSMA823A	OPERATIONAL RESEARCH	C
		4

Introduction: Origin, definition, methodology and scope. Linear Programming: Formulation and solution of linear programming problems by graphical and simplex methods, Big - M and two phase methods, Degeneracy, Duality in linear programming.

Transportation Problems: Basic feasible solutions, optimum solution by stepping stone and modified distribution methods, unbalanced and degenerate problems, transhipment problem.

Assignment problems: Solution by Hungarian method, unbalanced problem, case of maximization, travelling salesman and crew assignment problems.

Queuing models: Basic components of a queuing system, General birth-death equations, steady-state solution of Markovian queuing models with single and multiple servers (M/M/1. M/M/C, M/M/1/k, M/MC/k)

Inventory control models: Economic order quantity(EOQ) model with uniform demand and with different rates of demands in different cycles, EOQ when shortages are allowed, EOQ with uniform replenishment, Inventory control with price breaks.

Game Theory: Two person zero sum game, Game with saddle points, the rule of dominance; Algebraic, graphical and linear programming methods for solving mixed strategy games.

Sequencing problems: Processing of n jobs through 2 machines, n jobs through 3 machines, 2 jobs through m machines, n jobs through m machines.

RFERENCE BOOKS:

1. Taha, H.A., Operation Research-An introducton, Printice Hall of India.
2. Gupta, P.K. and Hira, D.S., Operations Research, S. Chand & Co.
3. Sharma, S.D., Operation Research, Kedar Nath Ram Nath Publications
4. Kanti Swarup, P.K. Gupta and Manmohan, Operations Research,Sultan Chand & Sons.

BSMA871A	OPERATIONAL RESEARCH LAB	C
		1

PRACTICAL/ LAB WORK

List of Practicals

1. Mathematical formulation of L.P.P and solving the problem using graphical method, Simplex technique and Charne's Big M method involving artificial variables.

2. Identifying Special cases by Graphical and Simplex method and interpretation
    a. Degenerate solution
    b. Unbounded solution
    c. Alternate solution
    d. Infeasible solution
3. Post-optimality
    a. Addition of constraint
    b. Change in requirement vector
    c. Addition of new activity
    d. Change in cost vector
4. Allocation problem using Transportation model

5. Allocation problem using Assignment model

6. Networking problem
    a. Minimal spanning tree problem
    b. Shortest route problem

7. Problems based on game matrix
    a. Graphical solution to mx2 / 2xn rectangular game
    b. Mixed strategy

8. To find optimal inventory policy for EOQ models and its variations

9. To solve all-units quantity discounts model

BSMA825A	BASICS OF STATISTICAL INFERENCE	C
		4

Estimation of population mean, confidence intervals for the parameters of a normal distribution (one sample and two sample problems). The basic idea of significance test. Null and alternative hypothesis. Type I & Type II errors, level of significance, concept of p-value. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).

Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chi-square test, Yates' correction.

Tests for the significance of correlation coefficient. Sign test for median, Sign test for symmetry, Wilcoxon two-sample test.

Analysis of variance, one-way and two-way classification. Brief exposure of three basic principles of design of experiments, treatment, plot and block. Analysis of completely randomized design, randomized complete block design. Bioassay.

RFERENCE BOOKS:

1. Daniel, Wayne W., Bio-statistics: A Foundation for Analysis in the Health Sciences. John Wiley.
2. Goon, A.M., Gupta M.K. & Das Gupta, Fundamentals of statistics, Vol.-I & II.
3. Dass, M. N. &Giri, N. C.: Design and analysis of experiments. John Wiley.
4. Dunn, O.J Basic Statistics: A primer for the Biomedical Sciences by John Wiley.
5. Bancroft, Holdon Introduction to Bio-Statistics , P.B. Hoebar New York.
6. Goldstein, A Biostatistics-An introductory text, The Macmillion New York.

BSMA875A	BASICS OF STATISTICAL INFERENCE LAB	C
		1

PRACTICAL/LAB WORK

List of Practicals

1. Estimators of population mean.
2. Confidence interval for the parameters of a normal distribution (one sample and two sample problems).
3. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).
4. Chi-square test of proportions.
5. Chi-square tests of association.
6. Chi-square test of goodness-of-fit.
7. Test for correlation coefficient.
8. Sign test for median.
9. Sign test for symmetry.
10. Wilcoxon two-sample test.
11. Analysis of Variance of a one way classified data
12. Analysis of Variance of a two way classified data.
13. Analysis of a CRD.
14. Analysis of an RBD.

BSMA827A	STOCHASTIC PROCESSES AND QUEUING THEORY	C
		4

Probability Distributions: Generating functions, Bivariate probability generating function. Stochastic Process: Introduction, Stationary Process.

Markov Chains: Definition of Markov Chain, transition probability matrix, order of Markov chain, Markov chain as graphs, higher transition probabilities. Generalization of independent Bernoulli trials, classification of states and chains, stability of Markov system, graph theoretic approach.

Poisson Process: postulates of Poisson process, properties of Poisson process, inter-arrival time, pure birth process, Yule Furry process, birth and death process, pure death process.

Queuing System: General concept, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution (without proof). Gambler's Ruin Problem: Classical ruin problem, expected duration of the game.

RFERENCE BOOKS:

1. Medhi, J. (2009): Stochastic Processes, New Age International Publishers.
2. Basu, A.K. (2005): Introduction to Stochastic Processes, Narosa Publishing.
3. Bhat,B.R.(2000): Stochastic Models: Analysis and Applications, New Age International Publishers.
4. Taha, H. (1995): Operations Research: An Introduction, Prentice- Hall India.
5. Feller, William (1968): Introduction to probability Theory and Its Applications, Wiley International.

BSMA877A	**STOCHASTIC PROCESSES AND QUEUING THEORY LAB**	**C**
		1

PRACTICAL/LAB WORK

List of Practicals

1. Calculation of transition probability matrix
2. Identification of characteristics of reducible and irreducible chains.
3. Identification of types of classes
4. Identification of ergodic transition probability matrix
5. Stationarity of Markov chain and graphical representation of Markov chain
6. Computation of probabilities in case of generalizations of independent Bernoulli trials
7. Calculation of probabilities for given birth and death rates and vice versa
8. Calculation of probabilities for Birth and Death Process
9. Calculation of probabilities for Yule Furry Process
10. Computation of inter-arrival time for a Poisson process.
11. Calculation of Probability and parameters for (M/M/1) model and change in behaviour of queue as N tends to infinity.
12. Calculation of generating function and expected duration for different amounts of stake.
13. Computation of probabilities and expected duration between players.

BSCA330A	NETWORK SECURITY AND CRYPTOGRAPHY	C
		4

Introduction: Plain text and cipher text, substitution techniques, transposition techniques, encryption and decryption, symmetric and asymmetric key cryptography.

Symmetric key algorithms: introduction, algorithms types and modes, DES, AES.
Asymmetric key algorithms: introduction, history of asymmetric key cryptography, RSA symmetric and asymmetric key cryptography together, Digital signature.

Internet security protocols: basic concepts, Secure Socket Layer (SSL), Transport Layer Security (TLS), Secure HyperText Transfer protocol (SHTTP), Time Stamping Protocol (TSP), Secure Electronic Transaction (SET), SSL versus SET, Electronic Money, Email Security.

User Authentication and Kerberos: Introduction, Authentication basics, Passwords, authentication tokens, certificate based authentication, biometric based authentication, Kerberos, key distribution center (KDC), Security handshake pitfalls, single sign on(SSO) approach.

TEXT BOOKS:
1. Atul Kahate, “Cryptography and Network Security”, TMH
2. Mani Subramaniam , “Network Management Principles & Practices” AWL

BSCA372A	NETWORK SECURITY AND CRYPTOGRAPHY LAB	C
		1

PRACTICAL/ LAB WORK

List of Practicals

Understanding types of Network Attacks:

1. Case study of different types of passive and active attacks (2 each).
2. To study Symmetric key encryption principles.
3. Write a program to implement DES algorithm or use existing library programs to test it.
4. Examine different techniques for authentication. Study examples of each type.
5. Examine how PGP works.
6. Use the tools available at gnupg.org, study the commands and use it.
7. To study MD5 algorithm. Use existing implementations in your own code to generate and verify MD5 hashes for files.
8. To study RSA algorithm.
9. Study of Secure Socket Layer (SSL).
10. To study security requirements for websites
11. To study Wireless Network security.
12. Examine how firewalls work.

BSCS401A	ARTIFICIAL INTELLIGENCE	C
		4

Scope of AI: Games, theorem proving, natural language processing, vision and speech processing, robotics, expert systems, AI techniques-search knowledge, abstraction.
Problem Solving (Blind): State space search; production systems, search space control; depth-first, breadth-first search.
Heuristic Based Search: Heuristic search, Hill climbing, best-first search, A* Algorithm, Problem Reduction, Constraint Satisfaction.

Knowledge Representation: Predicate Logic: Unification, Modus Ponens, Modus Tokens, Resolution in Predicate Logic, Conflict Resolution Forward Chaining, Backward Chaining, Declarative and Procedural Representation, Rule based Systems.
Structured Knowledge Representation: Semantic Nets: Slots, exceptions and default frames, conceptual dependency.

Handling Uncertainty: Non-Monotonic Reasoning, Probabilistic reasoning: Bayesian Inference, use of uncertainty factors.
Natural Language Processing: Introduction, Syntactic Processing, Semantic Processing, Pragmatic Processing.

Learning: Concept of learning, learning automation, genetic algorithm, learning by inductions, neural nets.
Expert Systems: Need and justification for expert systems, knowledge acquisition, Case Studies: MYCIN, RI.

REFERENCES BOOKS:

1. Artificial Intelligence, P. H. Winston,Pearson Education.
2. Introduction to AI and Expert Systems, D. W. Patterson, PHI.
3. Principles of AI, N. J. Nilsson, Narosa Publishing House.
4. Artificial Intelligence, E. Rich and K. Knight, TMH.

BSCS451A	ARTIFICIAL INTELLIGENCE	C
		1

PRACTICAL/ LAB WORK

List of Practicals

Write the following programs using PROLOG.

1. Write a program to solve 8 queens problem.
2. Solve any problem using depth first search.
3. Solve any problem using best first search.
4. Solve 8-puzzle problem using best first search
5. Solve Robot (traversal) problem using means EndAnalysis.
6. Solve traveling salesman problem.

SEMESTER - IV

SN	Course Code	Course Title	C
1	BSMA802A	Functional Analysis	4
2	BSMA804A	Mathematical Programming	4
3		Discipline Elective - III	4
4		Discipline Elective - IV	4
5	BSMA852A	Dissertation	6
TOTAL			**22**

Discipline Electives III - IV (Choose any two courses from one group)			
Group A			
1	BSMA828A	Number Theory	4
2	BSMA830A	Advanced Measure Theory	4
3	BSMA832A	Theory of Bounded Operators	4
4	BSMA834A	Harmonic Analysis	4
Group B			
1	BSMA806A	Fuzzy Sets and Applications	4
2	BSMA809A	Fluid Dynamics	4
3	BSMA812A	Mathematical Biology	4
4	BSMA818A	Discrete Mathematics	4

BSMA802A	**FUNCTIONAL ANALYSIS**	**C**
		4

Review of metric spaces, normed spaces, Banach spaces, bounded linear operators and functionals, convergence

Inner product spaces, Hilbert spaces with example, projection theorem, othonormal sets and sequences, Riesz representation theorem, self-adjoint, unitary and normal operators, Hilbert-adjoint operator

Hahn Banach theorem, uniform boundedness theorem (Banach-Steinhaus theorem), open mapping theorem and closed graph theorem

REFERENCE BOOKS:

1. A. E. Taylor; *Introduction to Functional Analysis*, John Wiley.
2. B. V. Limaye; *Functional Analysis*, Wiley Eastern.
3. N. Dunford and J. T. Schwartz; *Linear Operators*, Part-I, Interscience.
4. R. E. Edwards; *Functional Analysis*, Holt Rinehart and Winston.
5. C. Goffman and G. Pedrick; *First Course in Functional Analysis*, Prentice- Hall of India.
6. K. K. Jha; *Functional Analysis and Its Applications*, Students' Friend.
7. Kreyszig; *Introductory Functional analysis with Applications,* Wiley India publication**.**
8. G. F. Simmons; *Introduction to Topology and Modern Analysis*, McGraw-Hill.

BSMA804A	MATHEMATICAL PROGRAMMING	C
		4

Existence theorems, First order optimality conditions and second order optimality conditions for unconstrained optimization problems

Convex functions, Differentiable convex functions, Optimization on convex sets, Karush Kuhn Tucker conditions in nonlinear programming, Second order conditions in nonlinear programming

Quadratic programming, Wolfe's method as application of Karush Kuhn Tucker conditions, convex simplex method, Penalty function methods.

Integer Linear Programming, Modeling using pure and mixed integer programming, Branch and Bound Technique, Gomory's Cutting Plane Algorithm.

REFERENCE BOOKS:

1. Jan Brinkhuis and Vladimir Tikhomirov; *Optimization : Insights and Applications*, Princeton University Press.
2. Kenneth Lange; *Optimization*, Springer.
3. Osman Gler; *Foundations of Optimization*, Springer.
4. David G. Luenberger and Yinyu Ye; *Linear and Nonlinear Programming*, Springer.
5. Mokhtar S. Bazaraa, Hanif D. Sherali and C.M. Shetty; *Nonlinear Programming: Theory and Algorithms*, John Wiley & Sons, 2006.

BSMA828A	NUMBER THEORY	C
		4

The equation ax+by = c, simultaneous linear equations, Pythagorean triangles, assorted examples, ternary quadratic forms, rational points on curves.

Elliptic curves, Factorization using elliptic curves, curves of genus greater than 1. Farey sequences, rational approximations, Hurwitz theorem, irrational numbers, Geometry of Numbers, Blichfeldt's principle, Minkowski's Convex body theorem Lagrange's four square theorem.

Euclidean algorithm, infinite continued fractions, irrational numbers, approximations to irrational numbers, Best possible approximations, Periodic continued fractions, Pell's equation. Partitions, Ferrers Graphs, Formal power series, generating functions and Euler's identity, Euler's formula, bounds on P(n), Jacobi's formula, a divisibility property.

REFERENCE BOOKS:

1. G.H. Hardy, and E.M. Wright; *An Introduction to the Theory of Numbers*, Oxford Science Publications
2. D.M. Burton; *Elementary Number Theory*, McGraw Hill
3. N.H. McCoy; *The Theory of Number*, McMillan.
4. Ivan Niven, Herbert S. Zuckerman, Hugh L. Montgomery; *An Introduction to the Theory of Number*s, John Wiley & Sons(Asia)Pte.Ltd.

BSMA830A	ADVANCED MEASURE THEORY	C
		4

Review of Lebesgue measure and integral, Signed measure, Complex measure Multi-dimensional Lebesgue measure, Construction of the product measure, Fubini's Theorem, L^p spaces, Riesz representation theorem for bounded linear functionals on L^p spaces, Convergence in measure

Singular measures, Lebesgue-Stieltjes measures, Hahn decomposition theorem, Jordan decomposition theorem, Radon-Nikodym theorem, Lebesgue decomposition theorem

REFERENCE BOOKS:

1. H. L. Royden, *Real Analysis*, 3rd Edition, Prentice Hall, 1988.
2. P. R. Halmos, *Measure Theory*, East-West Press Pvt. Ltd., 1978.
3. M. E. Taylor, *Measure Theory*, American Mathematical Society, 2006.

BSMA832A	THEORY OF BOUNDED OPERATORS	C
		4

Spectrum of a bounded operator, uniform, strong and weak operator convergence on the space of bounded linear operators, approximate point spectrum and compression spectrum, spectral mapping theorem for polynomials

Compact linear operators and their properties, adjoint of compact operators, the Fredholm alternative spectral properties of self-adjoint operators, positive operators and their properties, spectral representation of a self adjoint compact operator, spectral family of a self-adjoint operator and its properties, continuous functions of self-adjoint operators, polar decomposition, singular values, trace class operators, trace norm and trace, Hilbert-Schmidt operators

REFERENCE BOOKS:

1. J.E. Conway, *A course in Operator Theory*, Graduate Studies in Mathematics, Volume 21, AMS, 1999.
2. E. Kreyszig, *Introductory Functional Analysis with Applications*, John Wiley and Sons, 2001.
3. Martin Schechter, *Principles of Functional Analysis*, American Mathematical Society, 2004.

BSMA834A	HARMONIC ANALYSIS	C
		4

Cassical Fourier series on the unit circle, Fourier coefficients, Cesaro means of the Fourier series, Fourier series of square summable functions, Convergence of Fourier Series- Convergence in norm, Convergence and divergence at a point, Absolutely convergent Fourier series, classic kernels – Poisson, Fejer and Dirichlet

Basic properties of topological groups, Haar measure on topological groups with emphasis on R, Z and T, The Banach space $L^1(G)$, convolution with special emphasis on $L^1(R)$, $L^1(Z)$ and $L^1(T)$

Plancherel theorem on abelian groups, Plancherel measure on R, Z and T maximal ideal space of $L^1(G)$ (G an abelian topological group)

REFERENCE BOOKS:

1. Yitzhak Katznelson, *An Introduction to Harmonic Analysis*, Cambridge University Press, 2004.
2. Henry Helson, *Harmonic Analysis*, Addition-Wesley Publishing Company, 1983.
3. Elias M. Stein & Rami Shakarchi, *Fourier Analysis: An introduction*, Princeton University Press, 2003.

BSMA806A	FUZZY SETS AND APPLICATIONS	C
		4

Definition of a fuzzy set and membership function, representation of membership function, General definitions and properties of fuzzy sets, Support, height, equality of two fuzzy sets.

Union and Intersection of fuzzy sets, Complement of a fuzzy set, normal fuzzy set, α- cut set, strong α-cut, convex fuzzy set, Necessary and Sufficient condition for convexity of a fuzzy set, Decomposition of fuzzy sets, Level set of a fuzzy set, Cardinality, fuzzy cardinality, Product of fuzzy sets, Product of a fuzzy set with a crisp number, Power of a fuzzy set, Difference of fuzzy sets, Disjunctive sum of fuzzy sets.

General properties of operations on fuzzy sets, Commutativity, associativity, distributivity, Idempotent law, identities for operations, Transitivity, involution, Demorgans laws, proofs and examples, Some important theorems on fuzzy sets, set inclusion of fuzzy sets and corresponding α-cuts and strong α-cuts.

Comparison of α-cut and strong α-cut, Order relation of scalars α is inversely preserved by set inclusion of corresponding α-cuts and strong α-cuts, α-cut of union and intersection of two fuzzy sets, α-cut of complement of a fuzzy set, α-cuts and strong α-cuts of union and intersection of arbitrary collection of fuzzy sets.

REFERENCE BOOKS:

1. G.J. Klir, B.Yuan; *Fuzzy Sets and Fuzzy Logic: Theory and Applications*, Prentice Hall.
2. Hao Ying; *Fuzzy Control and Modeling: Analytical Foundations and Applications*, IEEE Press.
3. T.J. Ross; *Fuzzy Logic with Engineering Applications*, John Wiley & Sons.
4. H.J. Zimmermann; *Fuzzy set theory and its Applications*, Allied Publishers Ltd, New Delhi.
5. Pundir and Pundir; *Fuzzy Sets and their Applications*, PragatiPrakashan

BSMA809A	FLUID DYNAMICS	C
		4

Classification of fluid flows - viscous flow, compressible flow, steady flow, uniform flow, laminar flow, turbulent flow, Properties of fluids,

Fluid kinematics - Lagrangian and Eulerian Descriptions, Flow Patterns - streamlines and streamtubes, pathlines, streaklines, timelines, Vorticity and rotationality, The Reynolds Transport Theorem

Conservation of mass, Conservation of energy, Mass and volume flow rates, The Linear Momentum Equation, Bernoulli Equation, General Energy Equation

Laminar flow in pipes, Turbulent flow in pipes, Newtonian versus Non-Newtonian fluids, The Navier–Stokes Equation, Continuity and Navier–Stokes equations

RFERENCE BOOKS:

1. W. H. Besant and A.S. Ramsey; *A Treatise on Hydromechanics*, Part-II, CBS Publishers.
2. F. Chorlton; *Text-book of Fluid Dynamics*, C. B. S. Publishers, Delhi.
3. Michael E.O. Neill and F. Chorlton; *Ideal and Incompressible Fluid Dynamics*, John Wiley &Sons.
4. R.K. Rathy. *An Introduction to Fluid Dynamics*, Oxford and IBH Publishing Company.
5. A.J. Chorin and A. Marsden, *A Mathematical Introduction to Fluid Dynamics* Springer-Verlag, New York.
6. L.D. Landau and E.M. Lipschitz, *Fluid Mechanics*, Pergamon Press, London.
7. G. K. Batchelor; *An Introduciton to Fluid Mechanics*, Foundation Books, New Delhi.

BSMA812A	MATHEMATICAL BIOLOGY	C
		4

Mathematical Biology and the modeling process: an overview. Continuous models: Malthus model, logistic growth, Allee effect, Gompertz growth, Michaelis-Menten Kinetics, Holling type growth, Bacterial growth in a Chemostat, Harvesting a single natural population, Prey predator systems and Lotka Volterra equations, Populations in competitions, Epidemic Models (SI, SIR, SIRS, SIC), Activator-Inhibitor system, Insect Outbreak Model: Spruce Budworm, Numerical solution of the models and its graphical representation. Qualitative analysis of continuous models: Steady state solutions, stability and linearization, multiple species communities and Routh-Hurwitz Criteria, Phase plane methods and qualitative solutions, bifurcations and limit cycles with examples in the context of biological scenario. Spatial Models: One species model with diffusion, Two species model with diffusion, Conditions for diffusive instability, Spreading colonies of microorganisms, Blood flow in circulatory system, Travelling wave solutions, Spread of genes in a population. Discrete Models: Overview of difference equations, steady state solution and linear stability analysis, Introduction to Discrete Models, Linear Models, Growth models, Decay models, Drug Delivery Problem, Discrete Prey-Predator models, Density dependent growth models with harvesting, Host-Parasitoid systems (Nicholson-Bailey model), Numerical solution of the models and its graphical representation. Case Studies: Optimal Exploitation models, Models in Genetics, Stage Structure Models, Age Structure Models.

RFERENCE BOOKS:

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

BSMA818A	DISCRETE MATHEMATICS	C
		4

Counting: Basic counting principles, Permutations and Combinations, Binomial theorem, Multinomial theorem, Counting subsets, Set-partitions, Stirling numbers. Principle of Inclusion and Exclusion, Derangements, Inversion formulae.

Generating functions: Algebra of formal power series, Generating function models, Calculating generating functions, Exponential generating functions.

Boolean Algebra: Lattices, Complete lattices, Lattices as algebraic structures, Sublattices, Products and Homomorphisms, Modular and Distributive lattices, Boolean polynomials, minimal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, Switching circuits.

Graph theory: Directed graph, Euler graph, Hamiltonian graph, Matrix representation of graphs, Shortest path in a weighted graph, K- connected and K- edge connected graphs, Planar graphs, Coloring of graphs, Vizing's theorem.

Trees: Rooted trees, Spanning tree and Cut set, Minimum-spanning tree, Flow network in a graph, max-flow-min cut theorem.

REFERENCE BOOKS:

1. C.L. Liu & Mahopatra; *Elements of Discrete mathematics*, Tata McGraw Hill.
2. N. Deo, Graph Theory with Applications to Computer Science, Prentice-Hall of India.
3. T.H. Coremen, C.E. Leiserson, R. L. Rivest; *Introduction to algorithms*, Prentice Hall on India.
4. M. O. Albertson and J. P. Hutchinson; *Discrete Mathematics with Algorithms*, Johnwiley Publication.
5. J. L. Hein; *Discrete Structures, Logic, and Computability*, Jones and Bartlett Publishers.
6. Kenneth H. Rosen; *Discrete Mathematics and Its Applications*, McGraw-Hill Education.

BSMA852A **Dissertation** **(Credits 6)**

Dissertation based on Research project: Suitable Topics in Mathematical Sciences

Presentation & Viva-voce

1. Students will be divided among faculty members for the supervision of the research work.

2. In the first week of Semester III, each faculty member will assign a suitable research topic to the students from the selected topics in the areas of Mathematical Sciences.

3. The student will work on the assigned research topic during semesters III and IV in regular consultation with his/her assigned teacher.

4. The student will write a dissertation based on the research work carried out during Semesters III and IV and prepare two copies to be submitted to the office of the Dean of School duly signed by the student and the supervisor in the sixth week of IV semester or a date decided by the Dean of School.

5. Before preparing power point presentation and submission of dissertation, each student has to deliver a seminar talk on his/ her research project work on a date fixed by Dean of School necessary suggestions has to be incorporated in the final draft of dissertation.

6. The student will make a power point presentation based on the work carried out and mentioned in the dissertation to the board of examiners appointed by the University.