जम्मू केंद्रीय विश्वविद्यालय
Central University of Jammu
राया–सूचानी; बागला, जिला सांबा – 181143 जम्मू, जम्मू एवं कश्मीर
Rahya- Suchani (Bagla), District Samba-181143, Jammu (J&K)

No. CUJ/ACAD/4-2/Math/CUJ/Reg/2013/458 29th October, 2018

NOTIFICATION No. 59 /2018

Sub: Course Scheme and Syllabus of 1st and 2nd **Semesters** of M.A / M.Sc. Mathematics w.e.f. Academic Session **2018-19** – Reg.

Ref: Notification No. 4-2/Math/CUJ/Reg/2013/569 dated 09.09.2015

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It is hereby notified for the information of all concerned that on the recommendation of the Board of Studies, Department of Mathematics and School Board, School of Basic and Applied Sciences, the Academic Council has approved the following **Course Scheme** and **Syllabus** of 1st and 2nd **semesters** of M.A / M.Sc. Mathematics w.e.f. Academic Session **2018-19**:

Semester - I

Course Code	Course Title	Credit	CIA	MSE	ESE	Max. Marks
	Core courses					
PGMAT1C001T	Real Analysis	4	25	25	50	100
PGMAT1C002T	Abstract Algebra	4	25	25	50	100
PGMAT1C003T	Number Theory	4	-	-	-	100
PGMAT1C004T	Ordinary differential equations with Applications	4	25	25	50	100
	Elective Course					
PGMAT1E001T	Introduction to Computer Programming	4	25	25	50	100
	Foundation Course					
PGMAT1F001T	Introduction to Set Theory	2	12.5	12.5	25	50
	Total	22	-	-	-	550

Semester - II

Course Code	Course Title	Credit	CIA	MSE	ESE	Max. Marks
	Core Courses					
PGMAT2C001T	Linear Algebra	4	25	25	50	100
PGMAT2C002T	Topology	4	25	25	50	100
PGMAT2C003T	Complex Analysis	4	25	25	50	100
PGMAT2C004T	Optimization Techniques	4	25	25	50	100
	Elective Course					
PGMAT2E001T	Partial Differential Equations	4	25	25	50	100
	Foundation Course					
PGMAT2F001T	Introduction to Measure Theory	2	12.5	12.5	25	50
	Total	22	-	-	-	550

29/10/18
Deputy Registrar
(Admin – HR)

Encl: Syllabus of 1st and 2nd Semester

To:

Head, Department of Mathematics

Copy to:

OSD (Exam)

जम्मू केंद्रीय विश्वविद्यालय

Central University of Jammu

राया–सूचानी; बागला, जिला सांबा – 181143 जम्मू; जम्मू एवं कश्मीर

Rahya- Suchani (Bagla), District **Samba-181143, Jammu (J&K)**

No. CUJ/ACAD/ November, 2019

NOTIFICATION No. / 2019

Sub: Course Scheme and Syllabus of 3rd and 4th **Semesters** of M.A / M.Sc. Mathematics w.e.f. Academic Session **2019-20** – Reg.

Ref: 4-2/Math/CUJ/Reg/2013/1619 dated 24.06.2016

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It is hereby notified for the information of all concerned that on the recommendation of the Board of Studies, Department of Mathematics and School Board, School of Basic and Applied Sciences, the Academic Council has approved the following **Course Scheme** and **Syllabus** of **1st** and **2nd semesters** of M.A / M.Sc. Mathematics w.e.f. Academic Session **2019-20**:

Semester - III

Course Code	Course Title	Credit	CIA	MSE	ESE	Max. Marks
	Core courses					
PGMAT3C004T	Fields and Galios Theory	4	25	25	50	100
PGMAT3C005T	Functional Analysis	4	25	25	50	100
PGMAT3C006T	Differential Geometry of Curves and Surfaces	4	25	25	50	100
	Elective Course – III (Discipline) (Any One)					
PGMAT3E005T	Advanced Measure Theory	4	25	25	50	100
PGMAT3E006T	Finite Fields and Coding Theory					
	Foundation Elective – II (Skill Based)					
PGMAT3F006T	Probability and Statistics	4	25	25	50	100
	Minor Project					
PGMAT3C007P	To be completed in two semesters i.e. Semester III and IV and Project Report shall be evaluated at the end of Semester – IV	8	-	-	-	200
	Elective Course (Interdisciplinary)					
	Electives offered by other Departments	4	25	25	50	100
	Total	**32**	-	-	-	**800**

Semester - IV

Course Code	Course Title	Credit	CIA	MSE	ESE	Max. Marks
	Core courses					
PGMAT4C004T	Discrete Mathematics	4	25	25	50	100
PGMAT4C005T	Introduction to Cryptography	4	25	25	50	100
PGMAT4C006T	Operator Theory	4	25	25	50	100
	Elective Course – IV (Discipline) (Any One)					
PGMAT4E005T	Topological Vector Spaces	4	25	25	50	100
PGMAT4E006T	Fourier Analysis					
	Foundation Elective – II (Compulsory)					
PGMAT4F006T	Stochastic Processes	4	25	25	50	100

Minor Project				
PGMAT4C007P	Work already done in Semester – III to be continued and Project Report will be submitted at the end of this Semester	8	-	-
Elective Course (Interdisciplinary)				
	Electives offered by other Departments	4	25	25
Total		**32**	-	-

150 Dissertation
50 - Viva

Encl: Syllabus of 3rd and 4th Semesters

To:

Head, Department of Mathematics

Copy to:

OSD (Exam)

Draft for Approval

Head, Dept. of Mathematics

Approved

Afreena
03/12/19

M-AL-372
03/12/19

Programme out comes (Pos)

1. Demonstrate in depth knowledge of mathematics, both in theory and application.
2. To analyse complex problems in Mathematics and propose solutions using research based knowledge.
3. To Know the various specialised areas of advanced mathematics and its applications
4. To know the use of computers both as an aid and as a tool to study problems in Mathematics.
5. To obtain the accurate solutions for the community oriented problems via various mathematical models.
6. To attain the ability to identify, formulate and solve changing problems in Mathematics.
7. To work individually or as a team member or leader in uniform and multidisciplinary settings.
8. To inculcate the knowledge of formulation and apply the mathematical concepts which are suitable for real life applications.

Athaema

Programme Specific Outcomes (PSOs)

1. To communicate concepts of Mathematics and its applications.
2. To acquire analytical and logical thinking through various mathematical tools and techniques.
3. To investigate real life problems and learn to solve them through formulating mathematical models.
4. To motivate and prepare the students for research in various areas of mathematics.
5. To provide quality education and strong foundation in different areas of mathematics.

Objectives of Courses of M.A/M.Sc Mathematics I semester (2018-19)

1. **Real Analysis:** This course is to introduce the students to the Euclidean space R, Properties of functions on Rn, Riemann Stieltjies integral, sequences and series of functions, functions of bounded variation and properties of several variables.
2. **Ordinary Differential Equations with Applications:** The Course is the source of most of ideas and theories which constitute higher analysis. The aim is to develop a strong background on finding solutions to linear differential equations with constant and variable coefficients with singular points, and to study the existence and uniqueness of the solutions of first order differential equations.

A pre requisite for this course is course on calcus and differential equations at undergraduate level.

3. **Introduction to Set Theory:** Set Theory is a foundation course in Mathematics useful for everybody working in any area of Mathematics. Pre-requisite for this course is under graduate elementary logic and Set theory
4. **Abstract Algebra:** To provide a first approach to the subject of Algebra, which is one of the pillars of modern mathematics and to study of certain structures called Groups, rings, fields and some relates structures.
5. **Number Theory:** This is an introductory course for students interested in mathematics and the teaching of mathematics. The course begins with the basic notions if integers and sequences, divisibility, and mathematical induction. It also covers standards topics such as Prime Numbers, the Fundamental Theorem of Arithmetic's, Euclidean Algorithm, Congruence Equations and their applications (eg. Fermat's little theorem) Multiplicative Functions (eg. Euler's Phi Function).

6. **Introduction to Computer Programming:** The core of computer science is programming. Other areas of the subject are either side issues or specializations from the main programming. Machines, computer applications, and even the role of computers in society are all considerably different today than they were ten, twenty, or thirty years ago, and we can be confident that they will be different again in ten, twenty, or thirty years. Moreover, programming softwares like MATLAB, LAEX etc. are important and integral part in many research areas of Mathematics such as cryptography, modeling, queueing theory, differential equations etc.

Objectives of Courses of M.A/M.Sc Mathematics II semester (2018-19)

1. **Introduction to Measure Theory:** The aim of this course is to study general theory of measure and integration. The theory of measure has its origin in the idea of length, volume in Euclidean space. It is a pre-requisite course for Fourier Analysis and Wavelets and has lots of applications in Functional Analysis, Operator Theory, Integral Equations, Probability theory and several branches of Physics.

2. **Topology:** This course is aim at familiarizing the students with the basic concept of Topology. A preliminary knowledge of real and complex analysis is essential.

3. **Complex Analysis:** The course's main objective is to lay the groundwork for complex analysis field of mathematics. The goal is to introduce the fundamental concepts, methods, and applications of complex analysis. The majority of the topics taught can be used in Mathematics and Engineering

4. **Optimization Techniques:** The goal of this course is to cover the fundamentals of linear programming, nonlinear programming, dynamic programming problems, and classical optimization techniques, numerical methods of optimization, the basics of different evolutionary algorithms, explain integer programming techniques, and apply different optimization techniques to solve models.

5. **Partial Differential Equations:** This course is an important part of mathematics for understanding the physical sciences, engineering and technology, a large number of physical phenomena occurring in physics and engineering can be formulated mathematically in the form of partial differential equations.

6. **Linear Algebra:** The aim of this course is to teach the student how to solve the linear system of equation using gause elimination, introduce the notion of vector space and classify the finite dimensional vector spaces, matrix representation of a linear transformation , characterstics of a linear operator, diagonalzation of a linear operator, bilinear forms: symmetric forms.

Objectives of Courses of M.A/M.Sc Mathematics III semester

1. **Functional Analysis:** Functional Analysis plays an increasing role in the Sciences as well as in Mathematics itself. Consequently, it becomes more and more desirable to introduce the student to the field at an early stage of study.

2. **Finite Fields and Coding Theory:** The objective of this course is to equip the students with fundamental knowledge and problem solving skills in finite Fields. Field extension, polynomials with finite Fields, Coding scheme and Decoding scheme. It helps the students to master mathematical techniques and concepts used to analyse and understand the finite Fields and coding theory. The students will also learn to interpret the real-world meanings and implications of the mathematical results. Students learn to discover and derive.

3. **Probability and Statistics:** The goal of the course is to acquaint students with various probability distributions as well as to improve their abilities and understanding of sampling distributions and hypothesis testing.

4. **Differential Geometry of Curves and Surfaces:** The goal of this course is to offer students with a foundation in differential geometry of curves and surfaces in space, with a focus on geometric aspects, as a foundation for further study or applications. Students will be introduced to the fundamental concepts of classical differential geometry before being shown how to apply characteristic classes, connections, and curvature tensors to Riemannian manifolds in detail.

5. Fields and Galois Theory: To provides a connection between these two theories. The galois theory allows reducing certain problems in field theory to group theory, which makes them simpler and easier to understand.

Objectives of Courses of M.A/M.Sc Mathematics IV semester

1. **Operator Theory:** The course's main goal is to study the fundamentals of operator theory. It is a field that has great importance for other areas of mathematics and physics, such as algebraic topology, differential geometry, and quantum mechanics.The classical areas of operator theory are the spectral theory of linear operators, distribution theory, operator algebra theory,the geometry of Banach spaces etc.

2. **Introduction to Cryptography:** To make the student learn different encryption techniques along with hash functions, Mac, digital signatures and their use in various protocols for network security and system security.

3. **Stochastic Processes:** The goal of the course is to give students a fundamental understanding of stochastic processes, particularly Markov processes, as well as a foundation for using stochastic processes as models in a wide range of applications, including queueing theory, Markov chain Monte Carlo, and their applications in modern engineering problems.

4. **Discrete Mathematics:** The aim of the course is to make students to understand the basic concepts in Discrete Mathematics such as some counting principles, Boolean Algebras and its applications, Basic Graph theory and some of its applications.

5. **Fourier Analysis:** Fourier series is used to describe a periodic signal in terms of cosine and sine waves. In other words, it allows us to model any arbitrary periodic signal with a combination of sines and cosines

Course Title: Real Analysis | **Course Code: PGMAT1C001T**

Duration of Examination: 3 hours | **Maximum marks: 100**

Unit -1

- Euclidean Space $\mathbf{R}^n$, Open ball and open set in $\mathbf{R}^n$, Structures of open sets in R, Closed sets, Adherent and accumulation points, Closure of a set, Derived set
- Bolzano's Weierstrass theorem, Cantor Intersection theorem, Lindeloff covering theorem, Heine-Borel theorem, Compactness in $\mathbf{R}^n$.

Unit-2

- Definition and existence of Reimann-Stieltjies intergral, conditions for R-S integrability, properties of the R-S intergral, Integration and differentiation.
- Fundamental theorem of calculus, Integration of vector valued functions, Rectifiable curves

Unit-3

- Sequences and series of functions, Point-wise and uniform convergence, Cauchy's criterion for uniform convergence.
- Weierstrass M-test, Abel's and Dirichlet's tests for uniform convergence, uniform convergence and continuity.

Unit -4

- Uniform convergence and Reimann-Stieltjies integration, uniform convergence and differentiation, Weierstrass approximation theorem
- Power series, uniqueness theorem for power series, Abel's and Tauber's theorems
- Functions of bounded variation, continuous functions of bounded variation

ourse code: PGMAT1C002T

Course title: Abstract Algebra

Course credits: 4

Unit-1

- Groups, Matrix and Permutation groups, subgroups, normal subgroups, Quotient group, group homomorphism, fundamental isomorphism theorems
- Group action on a set, Orbit-Stablizer formula, Conjugation, Automorphism, Computation of automorphism groups of $\mathbb{Z}_n$, $\mathbb{Z}$ and $\mathfrak{S}_3$

Unit-2

- Class equation and its Applications, Cauchy Theorem
- Sylow theorems for finite groups, Simple groups, Simplicity of A_n; $n \geq 5$

Unit-3

- Direct sums, Structure theorem for finite Abelian groups and its applications
- Composition series, Jordan-Hölder theorem, Solvable groups

Unit-4

- Rings, subrings, Ideals, Quotient rings, ring homomorphism, Isomorphism theorems, Matrix and Polynomial rings, prime and maximal ideals
- Integral domain, Field of fractions of an integral Domain, prime and irreducible elements Unique factorization domains

Unit-5

- Principal ideal domains and Euclidean Domains
- Polynomial rings over unique factorization domain: Gauss Lemma and Gauss theorem. Eisenstein crietria of irreducibility of polynomials

Recommened Texts

1. N. Jacobson, Basis Algebra, Vol. I, second edition, Dover Publications, 2012.
2. I. N Herstein, Topics in Algebra, Wiley Eastern Ltd., Second Edition, New Delhi, 2011.

References

1. M. Artin, Algebra, Prentice-Hall of India, Second Edition, 2011.
2. N. S. Gopalakrishnan, University Algebra, New Age International(P) Ltd., Publishers. Second Edition: 1986, (Reprint: 2004).
3. I. S. Luther and I. B. S. Passi, Algebra, Vol 1-Groups, Vol II-Rings, Narosa Publishing House (Vol. I-1996, Vol. II-1999).
4. W. A. Adkins and S. H. Weintraub, Algebra An approach by module theory, Springer. 1992.

Course Title: Number Theory
Course Type: P.G. Course

Course Code: PGMAT1C0031
Credits: 04

Unit I

Number theory- Divisibility, Euclidean algorithm, Linear Diophantine equations, Prime numbers, The series of reciprocals of primes, The Euclidean algorithm, Congruences, Residue classes, Solutions of linear congruences, The fundamental theorem of Arithmetic.

Unit-II

Fermat and Mersenne numbers. Farey series, Farey dissection of the continuum, Chinese Remainder Theorem, Euler's totient function, Euler's theorem, Fermat theorem, Wilson's theorem, Non-linear congruences.

Unit-III

Hensel's lemma, primitive roots and power residues, Quadratic residues and the law of quadratic reciprocity, the Jacobi symbols, The greatest integer function. Arithmetic functions-Mobius function and Mobius inversion formula, The Euler' function and Sigma function, The Dirichlet product of Arithmetical functions, Multiplicative functions.

Unit-IV

Irrational numbers- Irrationality of mth root of N, e and π, Approximation of irrational numbers, Hurwitz's Theorem, Representation of a number by two or four squares, Perfect numbers. The series of Fibonacci and Lucas.

Unit-V

Continued fractions - Finite continued fractions, Infinite continued fractions, Convergent of a continued fraction, Continued fractions with positive quotients, Simple continued fractions. The continued fraction algorithm and Euclid's algorithm, the representation of an irrational number by an infinite continued fraction.

Books for Reference:

1. G. H. Hardy and E. M. Wright – An Introduction to Theory of Numbers. Oxford University Press, 2008, 6th Ed.,
2. I. Niven, H. S. Zuckerman and H. L. Montgomery – An Introduction to the Theory of Numbers, New York, John Wiley and Sons, Inc., 2004, 5th Ed.,
3. Bruce C. Berndt – Ramanujan's Note Books Volume-1 to 5, Springer.
4. G. E. Andrews – Number Theory, Dover Books, 1995.
5. T. M. Apostol – Introduction to Analytic Number Theory, Narosa Publishing House, New Delhi.

Kamlesh Kumar

e Title: Ordinary differential equations with Applications **Course Code:** PG MAT1C004T

uration of Examination: 3 hours

Maximum Marks: 100

Objective: This course is the source of most of ideas and theories which constitute higher analysis. The aim is to develop a strong background on finding solutions to linear differential equations with constant and variable coefficients with singular points, and to study the existence and uniqueness of the solutions of first order differential equations.

A pre-requisite for this course is course on Calculus and differential equations at undergraduate level.

Unit-1

- Mathematical modeling by means of ordinary differential equations, Existence and uniqeness of solutions of initial value problems for first order differential equations, Picard's theorem(statement only), Picards Method of Succcessive Approximations, Singular solutions of first order ODEs, Lipschitz condition

- Linear systems, Gronwall's Lemma, Linear dependence and independence of solutions, Wronskian

Unit-2

- Solutions of homogeneous linear system of first order ODEs with constant coefficients

- General theory of homogeneous and non-homogeneous linear ODEs, The General solution of the Homogeneous equation, The use of known solution to find another, Homogeneous equation with constant coefficients, Method of undetermined coefficients.

Unit-3

- Method of Variation of Parameters, Green's function

- Qualitative properties of solutions: Oscillations and the Sturm Sepration Theorem, Sturm-Liouville boundary value problem, Sturm-Liouville equations, Eigen value problems

Unit-4

- Series solutions of non-autonomous systems: Second order Linear Equations, Ordinary points, Regular Singular points, Legendre and Bessel series, Frobenius method.

Unit-5

Discrete dynamical systems, Stability of dynamical systems, Lyapunov exponential and asymptotic stability and their characterization

Textbooks:

1. G F Simmons, Differential equations with applications and historical notes, Tata McGraw-Hill Edition, 2003.

Reference books:

1. S L Ross, Differential equations, Blaisdell publishing company, First Edition, 1964.

2. G Birkhoff and G C Rota, Ordinary differential equations, Boston, 1962.

3. E A Coddington and N Levinson, Theory of Ordinary differential equations, McGraw-Hill, New York, 1955.

4. Saber N Elaydi, An introduction to Differential Equations, Springer-verlag, Second edition, 1995. 5. V I Arnold, Ordinary Differential equations, PHI, New Delhi, 1998.

Course Title: Introduction to Computer Programming Course Code: PGMAT4EC01T

Course Type: P.G. Course Credits: 04

Unit-I

Review-basic Computer Fundamentals, Introduction to computer systems: Number system. Integer, Signed integer, Fixed and floating point representations, IEEE standards. Integer and floating point arithmetic, CPU organization, ALU, Registers, Memory, The idea of program execution at micro level.

Introduction to Programming- Input/output; Constants, Variables, Expressions and operators: Naming conventions and styles,

UNIT II

What is C? Background concept of algorithms, Flow charts, Data flow diagrams. Data types variables, Sample program, Components of a program in C, Naming conventions for C. Variables printing and initializing, Variables array, Exercises based on above topics.

UNIT III

Programming using C- C data types, int, char, float etc., C expressions, arithmetic operation. relational and logic operations, C assignment statements, extension of assignment of the operations. C primitive input and output using getchar and putchar, Exposure to the scanf and printf functions, Compiling and executing a Program in C, Conditional execution using if and else.

UNIT IV

Iterations and Subprograms- Concept of loops, Example of loops in C using for, while and do-while, One dimensional and two dimensional arrays, Exercise on iterative programs using arrays, Matrix computations using array. Concept of sub-programming, Design of functions. void and value returning functions, parameters, Passing by value. Passing by reference.

UNIT V

Pointers and Strings- Pointers, Relationship between arrays and pointers, Argument passing using pointers, Structure and unions, Defining C structures, Passing strings as arguments. Exercises based on above topics.

Text books: 1. Yashawant Kanetkar, —Let us C, 6th edition, BPB Publications, 2004.

2. Sinha P.K. and Sinha P., Computer Fundamentals, BPB Publications. 2004

Reference Books:-

1. Deitel H.M. and Deitel P.J., C++ How to Program. Prentice Hall, 8th edition.
2. Mullis Cooper, Spirit of C, Jacob Publications.
3. Kerninghan B.W. and Ritchie D.M., The C Programming Language, PHI Publications.
4. Yashwant Kanetkar, Pointers in C, BPB Publications.
5. Gotterfied B., Programming in C, Tata McGraw Hill Publications.

...troduction to Set Theory
...e: Foundation Compulsory
...n of Examination: 2 Hours

Course No: PGMAT1F001T

Maximum Marks: 50

Objective: This is a foundation course in Mathematics useful for everybody working in any area of Mathematics. Pre-requisite for this course is under-graduate elementary logic and set theory.

Unit-1

The Axiom of Choice and some of its equivalent forms: Motivation and historical remarks, family of sets and Cartesian product of family sets, partial ordered sets, Hausdorff Maximality Principle, fixed point theorem (statement only), Zorn's lemma, applications of Zorn's lemma, well-ordering principle, equivalence of the above three concepts, Principle of transfinite induction.

Unit-2

Denumerable and non-denumerable sets: finite and infinite sets, equipotent of sets, examples and properties of denumerable and non-denumerable sets, cardinal numbers, ordering of the cardinal numbers, cardinal number of a power set, Cantor theorem, Schroder Berstein Theorem (statement only), addition and multiplication of cardinal numbers, exponential of cardinal numbers, the continuum hypothesis and its generalization.

Unit-3

Ordinal Numbers, ordering of the ordinal numbers, addition and multiplication of ordinal numbers, set of ordinal numbers is well ordered, non-existence of a set of all ordinals, problems and exercises based on these concepts.

Text Books:

1. Shwu-Yeng T Lin, Set Theory with Applications, Mariner Pub. Co.: Enlarged 2nd Edition (1981)

Reference Books:

1. Paul R Halmos, Naive Set Theory, Springer-Verley New York Inc, 1974
2. Robert R. Stoll, Set Theory and Logic, W.H. Freeman and Co. 1963.

Course Title: Introduction to Measure Theory Course No.: PGMAT2F0

Course Type: Elective (Disciplinary)

Duration of Examination: 2 Hours Maximum Marks: 50

Objective: The aim of this course is to study general theory of measure and integration. The theory of measure has its origin in the idea of length, area and volume in Euclidean spaces. It is a pre-requisite course for Fourier Analysis and Wavelets and has lots of applications in functional analysis, Operator theory, integral equations, Probability theory and several branches of Physics.

Unit-1

- σ -algebra of sets, limits of sequences of sets, Generation of σ-algebras, Borel σ-algebras, Measure on a σ-algebra, Measurable spaces and measure spaces, Outer measures, construction of Measure by means of outer measure (statement only), Construction of outer measures by means of sequential covering class (statement only).

Unit-2

- Lebesgue measure on ***R***, some properties of Lebesgue measure, Translation invariance o Lebesgue measure, Existence of non-Lebesgue measurable sets, Measurable functions Operations with measurable functions (without proof), Equality almost everywhere Sequence of measurable functions

Unit-3

- Lebesgue Integration, Integration of step functions, Approximation theorem (statemer only), Lebesgue integral of non-negative functions, Lebesgue integral of measurab functions, Convergence a.e., Almost uniform convergence, Convergence in measu Convergence in mean, Cauchy sequence in measure (only definitions).
- Statements of following theorems :
  Fatous Lemma, Lebesgue monotone convergence theorem, Lebesgue dominat convergence theorem.

Text book:

1. J. Yeh, Lectures on Real Analysis, World Scientific, 2000.

Reference books:

1. M E Munroe, Measure and Integration, 2nd edition, Addison Wesley, 1971
2. G De Barra, Measure theory and Integration, Wiley Eastern Ltd., 1987
3. H L Royden, Real Analysis, 3rd edition, Macmillan, New York, 1988.

Course code: PGMAT2C001T

Course title: Linear Algebra

Course Credits: 4

Unit-1

- Matrix, Operations on Matrices, Special types of Matrices, Elementary Matrices, Vectors in $\mathbb{R}^n$ and $\mathbb{C}^n$
- Row reduction, Rank of a matrix, Solution of Matrix equation $AX = B$, Determinants, Cramer's Rule

Unit-2

- Vector spaces, Subspaces, Quotient Spaces, Linear span, Linear independence and dependence, Basis and Dimension, Finite dimensional vector spaces, Existence of basis, Computations with a basis

Unit-3

- Linear Transformation, The Matrix of Linear Transformation, Rank-nullity theorem, Effect of change of basis on Matrix of a linear transformation,
- Linear Operator, Eigenvalues and eigenvectors, characteristic polynomial of a linear operator, Diagonalization

Unit-4

- Orthogonal matrices and rotations
- Bilinear forms: Symmetric forms, Hermitian forms, Orthogonality, Orthogonal Projection, Euclidean and Hermitian Spaces

Unit-5

- The Spectral Theorem, Classificaion of conics
- Modules, Submodules, Structure theorem for finitely generated modules over a Principal ideal Domain (statement only), Rational and Jordan Canonical forms

Recommended Text

1. M Artin, Algebra, Second edition, PHI Learning Private Limited, New Delhi, 2012.

References

1. I N Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
2. K Hoffman and R Kunze, Linear Algebra, 2nd Edition, Prentice Hall, Englewood Cliffs, New Jersey, 1971.
3. S K Jain, A Gunawardena & P B Bhattacharya, Basic Linear Algebra with Matlab, Key College Publishing (Springer-Verlag) 2001.
4. S Kumaresan, Linear Algebra, A Geometric Approach, Prentice Hall of India, 2000.

Course Title: Topology **Course Code:** PGMAT2C002T

Duration of Examination 3 hours **Maximum Marks: 100**

Objective:

This course is aims at familiarizing the students with the basic concepts of Topology. A preliminary knowledge of real and complex analysis is essential.

Unit-1

• Topological Spaces: Definition and some examples, Interior, Closure, and Boundary of a set, Basis and Subbasis, First and second countable spaces, Continuous function, Open and Closed Functions, Homeomorphism, Subspaces

Unit-2

• Connectedness: Connected and disconnected Spaces, Results on Connectedness, Connected subsets of real Line, Applications of connectedness, Path Connected Spaces, Locally connected and Locally Path connected Spaces

Unit-3

• Compact Spaces and Subspaces, Compactness and Continuity, Properties related to Compactness, OnePoint Compactification, The Cantor Set

Unit-4

• Finite Products, Arbitrary Products, Comparison of Topologies, Quotient Spaces • Separation Axioms: T0, T1, and T2 Spaces

Unit-5

• Regular Spaces, Normal Spaces, Separation by Continuous functions: Uryshon's Lemma, Completely regular spaces, Tietze extension theorem

Text book:

1. F H Croom, Principles of Topology, Cengage Learning India Private Limited, New Delhi, First Indian Reprint 2008.

Reference books:

1. G F Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill

2. James R Munkeres, Topology, Afirst course, Prentice Hall of Indi Pvt. Ltd., New Delhi, 2000.

3. J Dugundji, Topology, Allyn and Bacon, 1966(reprinted in India by PHI Pvt. Ltd.)

4. K D Joshi, Introduction to general Topology, Wiley, Eastern Ltd. 1983.

5. S T Hu, Elements of General Topology, Holden-Day, Inc. 1965.

6. W J Pervin, Foundations of General Topology, Academic Press Inc., New York, 1964.

7. S Willard, General Topolgy, Addison - Wesley, Reading, 1970.

Kamlesh Kumar

Title: Complex Analysis Course Code: PGMAT2C003T

Duration of Examination: 3 hours Maximum-Marks: 100

Unit-1

Review of complex numbers, Stereographic projection, Chordal distance, Multi-valued functions, Branches of multi-valued functions, with special reference to *arg z*, exponential functions, Logarithm function, power functions and phase factors. Analytic functions: Limit and continuity of complex functions, complex derivative, Singularities, Cauchy- Reinmann equations, Cauchy-Reinmann equations in polar form, Harmonic functions, Harmonic conjugate.

Unit-2

Line integrals, Piecewise smooth path, Jordan curve, Green's theorem, Independence of path, Anti-derivative, fundamental theorem of calculus, Mean value property, Strict maximum principal (real and complex version), ML-estimate.

Unit-3

Complex integration and analyticity: Cauchy's theorem, Cauchy Integral formula, Cauchy integral formulae for higher order derivatives.

Liouville's theorem, Cauchy's inequality, Morera's theorem, Goursat's theorem, complex form of Cauchy-Riemann equations.

Unit-4

Power series, radius of convergence, power series expansion of an analytic function: Taylor's expansion, Isolated singularities, Laurent Series. The residue calculus, Cauchy residue theorem, fractional residues, Jordan's lemna, Evaluation of integrals using residue theorem.

Kamlesh Kumar

Conformal mappings, Mobius transformations, composition of two Mobius transformations Translations, Dilations, Inversion, The Schwarz lemma, Conformal Self-maps of the unit disk, Mappings of the unit disk and upper half plane, The Riemann Mapping theorem (Statement only).

Text-Books:

1. TW Gamelin, Complex Analysis, Springer–Verlag, New York Berlin Heidelberg 2001.

References:

1. Walter Rudin; Real & Complex Analysis, Tata Mc-Graw Hill,2006
2. S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House, 2005
3. J.W. Brown & R.V. Churchill, Complex variables and applications, Mc-Graw Hill International VIII-Edition, 2009
4. J.B. Conway, Function of One complex variable, Springer International Student Edition, 1980
5. L.V. Ahlfors, Complex Analysis, International Edition, McGraw Hill International Editions, 1979.

Course Title: Optimization Techniques | Course Code: PG/MAT2C004T

Duration of Examination: 3 hours | Maximum marks: 100

Unit-1

- Linear programming-I (Graphical method) Formulation of a linear programming problem with different types of constraints, requirements, assumptions, merits and demerits, applications of LP, Graphical analysis, Graphical solution, Multiple, unbounded solution and infeasible problems and its applications
- Linear programming-II (Simplex method (SM)) Simplex Method: Principle, Computational aspect, SM with several decision variables. Two phase LP problem, Big-M method, multiple, unbounded solution, infeasible problems, Sensitivity and duality analysis in LP.

Unit-2

- Assignment Problem (AP): Approach, procedure and maximization, unbalanced and crew assignment problems.
- Transportation Problem (TP): Structure and formulation of TP, Procedure for TP, Methods for finding initial solution and optimality, Unbalanced, maximization, degeneracy, transhipment in TP.

Unit-3

- Sequencing problems: Processing of n-jobs through two, three, M-machines, Processing of n-jobs through m-machines.
- Replacement Problems: Replacement of items that deteriorate with time (with and without change in money value), Staff replacement problem.

...se Title: Partial Differential Equations Course Code: PGMAT2E001T

Duration of Examination: 3 hours Maximum marks: 100

Objective: This course is an important part of applied Mathematics for understanding the physical sciences, Engineering and Technology. A large number of physical phenomena occurring in Physics and Engineering can be formulated mathematically in the form of Partial Differential equations.

A pre-requisite for this course is the course on Ordinary differential equations.

Unit-1

- Formulation of first order partial differential equations: Derivation of PDE by elimination method of arbitrary functions, Solution of linear first order partial differential equations (Lagrange method), Integral surfaces passing through a given curve, The Cauchy Problem for first order PDE, Lagranges linear PDE and non Linear PDE of first order

Unit-2

- Compatible systems of first order partial differential equations, Charpits method for solving first order non linear Partial differential equations
- Classification of second order Partial Differential Equations, Canonical form: Elliptic, Parabolic and Hyperabolic PDE

Unit-3

- Laplace Equation and its derivation, Boundary value Problems, Properties of Harmonic functions: Spherical mean, Mean Value theorem, Maximum-Minimum Principle and its applications, Separation of variables, Dirichlet and Neumann problem for a rectangle

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..it-4

• Heat Equation: Boundary equations, Fundamental solutions of Heat equation, Dirac Delta function, Separation of variables method

Unit-5

• Wave Equation: Derivation of one dimensional wave equation and its solution by canonical reduction, Initial value problem of Cauchy's type; D' Alembert's solution, Vibrating string-variables separable solution, Boundary and initial value problems for two-dimensional wave equations-Eigen function method, uniqueness of solution for the wave equation

Text book:

1. K Sankara Rao, Introduction to partial differential equations, Prentice Hall of India, 2nd Edition, New Delhi, 2007.

Reference books:

1. Renardy and Rogers, An introduction to PDEs, Springer-Verlag, 1999.
2. Smoller, Shock Waves and reaction-diffusion equations, second edition, 1994.
3. Kevorkian, Partial Differential equations, Wadsworth and Brooks/ cole
4. F John, Partial differential equations
5. L C Evans, Partial differntial equations, AMS, 1998.
6. B Folland, Introduction to partial differential equations.
7. D Gilbarg and N S Trudinger, Elliptic Partial differential equations of second order.
8. W A Strauss, Partial differential equations, An Introduction, Wiley, John and sons 1992.
9. B P Parashar, Differential and Integral equations, Oscar Publication

Kamlesh Kumar

Course code:

Course title: Fields and Galois Theory

Course Credits: 4

Unit 1

- Field: Definition and Examples, Types of fields, algebraic and transcendental elements, minimal polynomial of an algebraic element, simple extension
- Degree of a field extension, multiplicative property of degree, Classification of Quadratic extensions,

Unit 2

- Straight edge and compass constructions: constructible numbers, degree of a constructible number, trisection of an angle, Construction of regular polygon
- Splitting Field of a Polynomial, Existence and Uniqueness, Multiple Roots, Perfect Field

Unit 3

- Galois group, Examples, Artin Lemma, Separable and Normal extensions, Galois extension, Fundamental Theorem of Galois Theory
- Fundamental Theorem on symmetric polynomials, Symmetric rational functions

Unit 4

- Solvability by radicals, Galois group of a polynomial, Cyclotomic field and its Galois group
- Galois group as permutation group of the roots

Unit 5

- The general equation of the n^{th} degree, Abel-Ruffini Theorem, Equations with rational co-efficients and Symmetric group as Galois group
- Constructible regular n-gons, Cyclotomic fields over $\mathbb{Q}$.

Recommended Texts.

1. N Jacobson, Basic Algebra, Vol.- I, second edition, Dover Publications, 2012
2. P B Bhattacharya, S K Jain, S R Nagpaul, Basic Abstract Algebra, Second edition, Cambridge University Press, 1994.
3. M Artin, Algebra, Second edition, PHI Learning Private Limited, New Delhi, 2012.
4. I N Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.

P. Singh Kamlesh Kumar

Course Title: Functional Analysis
Course Code:

Duration of Examination: 3 hours
Maximum Marks: 100

Objective: Functional Analysis plays an increasing role in the Applied Sciences as well as in Mathematics itself. Consequently, it becomes more and more desirable to introduce the student to the field at an early stage of study.

Unit-I

Normed linear spaces, Banach Spaces and examples, subspace of Banach space, Completion theorem, properties of finite dimensional normed linear spaces and subspaces, equivalent norms, compactness, F. Riesz's Lemma, linear operators and examples, Inverse operator.

Unit-II

Bounded and continuous linear operators and examples, properties of bounded linear operators, relations between bounded and continuous linear operators, linear functionals and their properties, dual spaces. Find duals of R, c, l , 0 < p < infinity.

Unit-III

Hahn-Banach Theorem for real linear spaces, Complex linear spaces and normed linear spaces, Adjoint operator, Reflexive spaces, Uniform Boundedness Theorem, Baire's Category Theorem(statement), Strong and weak convergence, convergence of sequences of operators and functionals, Open mapping Theorem, Closed Graph Theorem with examples and counter examples.

Unit-IV

Inner product spaces, Hilbert space, parallelogram Law, Orthogonal Complements and Direct Sums, orthonormal sets and Sequences, Pythagorean Relation, Bessel's inequality, series related to orthonormal sequences and sets, Total orthonormal sets and sequences, Separable Hilbert spaces.

Unit-V

Legendre, Hermite and Laguerre Polynomials, Riesz's Representation Theorem, Hilbert adjoint operator, properties of Hilbert adjoint operator, Reflexive spaces, Self-adjoint, unitary and normal operators.

Text book:

- Erwin Kreyszig, Introductory Functional Analysis with Applications, John Wiley & Sons, USA, 1989.

Reference books:

- George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill International editions.
- Martin Schechter, Principles of Functional Analysis, AMS, second edition, 2002.
- John B. Conway, A course in Operator Theory, AMS, 2000.
- Balmohan V. Limaye, Functional Analysis, New age International (P) Limited, Publishers, second edition, 1996.

Course code:

Course Title: Differential Geometry of Curves and Surfaces

Course Credits: 4

Unit-1

- Curves in the plane, arc length, reparametrization, plane curvature, Euler Theorem for plane curves, oriented curvature, Fundamental Theorem for curves in $\mathbb{R}^2$.
- Cuves in space, curvature and torsion, Serret-Frenet formulae, Fundamental Theorem for curves in $\mathbb{R}^3$.

Unit-2

- Surfaces in $\mathbb{R}^3$(2-manifolds), Regular surface, change of coordinates, Tangent plane, The first Fundamental form and its applications

Unit-3

- Normal curvature, principal curvatures, The Gauss map, Second Fundamental form, Gaussian curvature, Mean Curvature

Unit-4

- Equivalence of Surfaces, Isometrics, Christoffel symbols, Theorema Egregium, Gauss Equations, Mainardi-Codazzi Equations, Fundamental Theorem for Regular Surfaces

Unit-5

- Geodesics: geodesic curvature, geodesic, Clairaut's Relation, exponental map, Hopf-Rinow Theorem, The Gauss-Bonnet Theorem.

Recommended Text

1. John McCleary, Geometry from a Differentiable viewpoint, Second edition, Cambridge University Press, 2012.

References

1. A. Pressley, Elementary Differential Geometry, Springer, Indian Reprint, 2004
2. Manfredo P. do Carmo, Differential Geometry of Curves and Surfaces, Prentice Hall, 1976.
3. D. J. Struik, Lectures on Differential Geometry, Dover, 1988.
4. Barett O'Neill, Elementary Differential Geometry, Second edition, Academic Press(Elsevier), 2006.

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Advanced Measure Theory

UNIT-1

Topological Preliminaries: Urhyson's Lemma (Statement Only), Finite Partation of Unity, Definition of $C_C(X)$, Linear Functional on $C_C(X)$, Reisz Representation Theorem (Statement Only), Borel Measure, Definition and examples. Regularity and other properties of Borel Measures, Lusin's Theorem.

UNIT-2

L^P-spaces: Convex functions and inequalities, Jensen's inequality, Definition of L^P-spaces, Holder's inequality, Minkowski's inequality, Completeness of L^P-spaces. Simple functions, Denseness of $C_C(X)$ in L^P-spaces.

UNIT-3

Complex Measures: Definition and examples, Total variation of complex measures, Absolute countinity and Mutually singular. A theorem of Raydon and Nikodym, Hahn decomposition theorem.

UNIT-4

Differentiation of measure: Derivative of measure. Weak L^1 function, Lebeasgue points, Nicely shrinking sets and their properties. Fundamental theorem of calculus.

UNIT-5

Measurability of Product spaces: The functions fx and fy. The class Ω of sets in $s \times \tau$ and its properties. Definition of product measure. Fubini theorem, Examples of Fubini's theorem, Convolution of functions, Convolution theorem.

Books:

1. **Rudin, Walter**, Real & Complex analysis, ,McGraw-Hill,2000
2. **J.Yeh**. Real analysis: theory of Maesure and Integration 3rd Edition, World Scientific. 2000.

Course Title; **Finite Fields & Coding theory** **Course Code**

Duration of Examination: 3 hours **Maximum-Marks: 100**

Unit-1

- Field Extensions: Field, Prime Field, Algebraic extension, simple extension, minimal polynomial of an algebraic element, Finite extension, Transitivity of Finite extensions, Simple algebraic extension, Splitting field,

- Characterization of finite Fields: Finite fields, Number of elements in a finite field, Existence and uniqueness of finite fields, Subfields of a finite field

Unit-2

- Roots of an irreducible polynomials over finite fields: Nature of roots, Relation between splitting fields of two irreducible polynomials of same degree, Automorphisms of a finite field

- Trace: Definition and its basic properties, Relation between trace and linear transformations, Transitivity of Trace, Norm: Definition and its basic properties, Transitivity of Norm, Bases: Dual bases, normal basis, Artin lemma, Normal Basis Theorem,

Unit-3

- Roots of unity and Cyclotomic polynomials: Cyclotomic field, Primitive *nth* root of unity, Cyclotomic polynomial, Cyclotomic field as simple algebraic extension, Finite fields as Cyclotomic fields

- Representation of elements of finite fields: Some different ways of writing the elements of a finite field

- Irreducible Polynomials: Moebius function μ, Moebius Inversion formula, Number of monic irreducible polynomials of a given degree over a finite field, Product of all monic irreducible polynomials of a given degree over a finite field

Unit-4

- Linear Codes: Definition of Code Coding scheme and Decoding scheme, Linear Codes, Hamming distance and weight, *t*-error-correcting codes, Decoding of linear codes, Hamming Bound, Poltkin Bound, Gilbert-Varshamov Bound, Dual code

Unit-5

Cyclic Codes: Definition, Characterization of cyclic code in terms of an ideal, Generator polynomial of cyclic code, Parity-check polynomial of cyclic code, Relation between code polynomial and the roots of generator polynomial, BCH code, Minimum distance of BCH codes, Decoding algorithm for BCH codes

Textbooks:

1. R Lidl and H Niederreiter, Introduction to finite fields and Applications, Revised Edition, Cambridge University Press, 1992.

Reference books:

1. R Hill, A first course in Coding theory, Oxford Appl. Math and Comp. Sci. Series., Clarendon Press, Oxford, 1986.
2. R Lidl and H Niederreiter, Finite fields, Revised Edition, Cambridge University Press, 1997.
3. Gary L. Mullen and C. Mummert, Finite fields and Applications, American Mathematical Society, Indian Edition 2012.

Name of the course: Probability and Statistics **Course Credits: 4**

Course Code:

Unit-1

Review of probability theory including conditional probability, Some important theorems on probability, Exercise on probability and conditional probability, Independent Events, Total probability theorem and Bayes' Theorem, Addition and multiplication theorems of probability

Unit-2

Random Variables and Distribution function: discrete and continuous, Exercise on distribution functions, Two dimensional random variables: joint distribution function and marginal distribution, Expectation and moments about mean and origin, Covariance and conditional expectation and examples, Moment inequalities- Tchebyshef, Markov, Jensen, Moment generating function and characteristic function with their properties.

Unit-3

Standard discrete probability distributions: Discrete uniform distribution, Bernoulli distribution, Binomial distribution, Poisson distribution, Geometric distribution, Negative binomial distribution with their properties and examples. Some important theorems based on these distributions.

Unit-4

Standard continuous probability distributions: Continuous uniform distribution, Normal distribution, Exponential distribution, Gamma distribution or Erlang distribution, Weibull distribution, Triangular distribution, Standard Laplace (Double exponential) distribution, Cauchy distribution, with their properties and examples. Some important theorems based on these distributions.

Unit-5

More on two dimensional random variables: probability and distributions and examples. Transformation of random variables with examples, Central limit theorem and its applications, Large sample theory: types, parameter and statistics, test of significance.

Reference books:

1. **S. C. Gupta and V. K. Kapoor**: Fundamentals of Mathematical Statistics, Sultan Chand and Sons, New Delhi.

2. **S. Palaniammal,** "Probability and Queueing Theory", PHI Learning Private Limited, Delhi.

Kamleshkumar Kamleshkumar 01-05-2019

Sem. IV

Course code:

Course title: Discrete Mathematics

Course Credits: 4

Unit-1

- Set, Relation, Well-ordering principle, Poset, Lattices, trees, Boolean Algebra, Boolean functions, disjunctive and conjunctive normal form. Representation theorem for Boolean Algebra, Representation of relations as digraphs and Boolean matrices.

Unit-2

- Combinations, Counting Principles, Binomial Coefficients, Set-partitons and Stirling number of first and second kinds, Number partitions, Ferrers diagram

Unit-3

- Inclusion-Exclusion Principle and its Applications
- Generating function, Solving Recurrence relations, Convolution, Exponential generating function, Dirichlet generating function.

Unit-4

- Graph Theory: Graphs, subgraphs, Isomorphism of graphs, Adjacency and Incidence matrices; Trees, Forests, Counting labeled trees, Spanning subgraphs, Kruskal's algorithm
- Matching theory, Hall's Marriage Theorem

Unit-5

- Planar graphs, Euler's formula, Five colour theorem, Chromatic polynomial of a graph, Edge colourings, Hamiltonian Cycles, Ramsey Theory, Diameter and eigenvalues of a graphs.

Recommended Texts.

1. Richard A. Brualdi, Introductory Combinatorics, 5th edition, Pearson Education.
2. Ralph P. Grimaldi, Discrete and Combinatorial Mathematics: An Applied Introduction, 5th edition, Pearson Education, 2003.
3. Sebastian M. Cioaba and M. Ram Murty, A first Course in Graph Theory and Combinatorics(Texts and Readings in Mathematics), Hindustan Book Agency, 2009.
4. C L Liu and D P Mohapatra, Elements of Discrete Mathematics, McGraw Hill, 1985.

2

Semester-4

Course Title: Introduction to Cryptography **Course Code: ....**

Duration of Examination: 3 hours **Credits: 04** **Maximum Marks: 100**

Prerequisite: Some basic knowledge of Number Theory, Set Theory and Lattice Theory will help to understand the course.

Unit-1

Introduction to cryptography: Private and Public key Cryptosystems, Classical Cryptography, Simple Substitution Ciphers, Cryptanalysis of Simple Substitution Ciphers, Cryptography before the Computer Age, Symmetric and Asymmetric Ciphers, An Encoding Scheme and an Encryption Scheme, Symmetric Encryption of Encoded blocks, Examples of Symmetric Ciphers, Random bit sequence and symmetric ciphers.

Unit-2

Introduction to asymmetric ciphers, Origin of Public Key Cryptography, The Discrete Logarithm Problem, Diffie-Hellman Key Exchange Algorithm, The ElGamal Public Key Cryptosystem, Hardness of the Discrete Logarithm Problem, Order Notation, A Collision Algorithm for Discrete Logarithm Problem.

Unit-3

Integer factorization and the RSA cryptosystem: Euler's formula, Roots modulo pq with p & q as distinct primes, The RSA public key cryptosystem, It's implementation and security issues, Primality testing, Miller-Rabin test for composite numbers, The prime number theorem (statement only), Riemann zeta function, Riemann hypothesis, AKS primality test (statement only), Pollard's $p-1$ factorization algorithm.

Unit-4

Legendre's symbol, quadratic reciprocity, Jacobi symbol, Probabilistic encryption and the Goldwasser-Micali cryptosystem. Information theory: Perfect secrecy, Conditions for perfect secrecy, Entropy, Redundancy and the entropy of natural language, The algebra of secrecy systems, Complexity theory and *P* versus *NP*.

Unit-5

Digital signatures: Definition, Components of a digital signature scheme, RSA digital signatures, ElGamal digital signatures digital signature algorithm (DSA), GGH lattice based digital signature scheme, NTRU digital signature scheme.

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Textbook: J Hoffstein, J Pipher & J H Silverman, An introduction to mathematical cryptography, Springer (India) Pvt. Ltd., 2011

Reference Books:

1. V V Yaschenko, Cryptography: An introduction, American Mathematical Society, 2009
2. G. H. Hardy and E. M. Wright – An Introduction to Theory of Numbers, Oxford University Press, 2008, 6th Ed.,
3. J Talbot and D Welsh, Complexity and Cryptography: An Introduction, Cambridge University Press, 2006

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Sem-IV 4

Course Title: Operator Theory
Course Code:
Course Credits: 4

Duration of Examination: 3 hours
Maximum Marks: 100

Unit-1

• Spectral Theory in Finite normed spaces: Definition of eigenvalues, eigenvectors, eigenspaces, spectrum, resolvent set of a matrix, eigen values of an operator, Existence Theorem for eigenvalues, spectral theory for infinite dimensional normed linear spaces, resolvent of an operator, spectrum of a bounded linear operator on a complex Banach space, Representation Theorem, Resolvent equation, commutative properties of resolvent, Spectral Mapping Theorem for Polynomials, definition of local holomorphy, holomorphy of resolvent operator, Spectral radius of a bounded linear operator.

Unit-2

• Definition of normed algebra, Banach Algebra and examples, invertible elements, Banach-Alaoglu theorem (statement only), multiplicative linear functional, definition of spectrum, resolvent set, spectral radius, division algebra, Gelfand Mazur Theorem, Spectral Mapping Theorem.

Unit-3

• Definition of compact linear operator on normed spaces, examples, compactness criterion, uniform limit of a sequence of compact operators, finite rank operator, eigenvalues and eigenspaces for compact operators.

Unit-4

• Unbounded Linear Operators: Hellinger-Toeplitz Theorem, Densely defined operators, Hilbert-Adjoint operators, Inverse of the Hilbert-adjoint operator, Symmetric linear operator, closed linear operator, definition of closable operator, closure, spectrum of self-adjoint linear operator.

Unit-5

• Multiplication operator and Differentiation operator, self-adjoint multiplication operator, spectrum of multiplication operator, definitions of States, Observables, Position operator and Moment operator, Heisenberg Uncertainty Principle.

Textbook:

1. Erwin Kreyszig, Introductory Functional Analysis with Applications, John Wiley & Sons, USA, 1989.

Reference books:

1. Ronald G. Douglas, Banach Algebra Techniques in Operator Theory, Springer-Verlag, New York, 1998.
2. John B. Conway, A course in Functional Analysis, Second Edition, Springer, 1990.
3. Arch W. Naylor and George R. Sell, Linear Operator Theory in Engineering and Sciences, Springer-Verlag, New York, 2000.

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01/05/2019

TOPOLOGICAL VECTOR SPACE

UNIT-1

Semi norm, Topological vector space, Convex set, Balanced set, Absorbing set, Minkow ski functional (Gauge),Topology in a semi- norm, Linear space, Semi normed linear space, Locally convex space.

UNIT-2

Linear Transformation, Linear functional, Maximal subspace, Linear variety, Hyper plane, Geometric form of Hahn Banach theorem.

UNIT-3

Reflexive Banach space, Cannonical embedding, Milman's theorem, Weak Topology, Basic neighbourhoods, Weak*-topology, F-topology, The Banach Alaoglu theorem, Extreme Points, Extremal Subset.

UNIT-4

Krein-Milman theorem, Baire's Category theorem, Closed Graph theorem, Application of Closed Graph theorem, Frechet space, Open Mapping theorem for Frechet space.

UNIT-5

Absolutely convex set, Duality, Linear form, Weak topology, Polar of a set, Bipolar theorem, Barrelled Space, Bornivorous or Bornivorne, Bornological Space.

Books:

1. **Larsen, R.,** *Functional Analysis: an introduction*, M. Dekker 1973.
2. **Schaefer, H.H.** ,*Topological Vector Spaces*, Springer 1999.
3. **Rudin, walter,**Functional Analysis (2nd edition),McGraw-Hill,1991

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Course Title: Fourier Analysis **Course Code:**

Duration of Examination: 3 hours **Maximum-Marks: 100**

Unit-1

- Lp- spaces. Holder's inequality and Minkowki's inequality (statements only), completeness OF Lp –spaces, Approximations by continuous functions. Fourier series, Fourier sine series and Fourier cosine series, Smoothness, the Riemann-Lebesgue Lemma, the Dirichelt and the Fourier Kernels, Area under Dirichlet Kernel on $[0, \pi]$, the Riemann- Labesgue property of the Dirichelet Kernal , Continuous and Discrete Fourier Kernal.

Unit-2

- Pointwise convergence of Fourier Series, criterion for pointwise convergence, Dini's test Lipschitz's test, Selector property of $[\sin(n + \frac{1}{2}u/u)]$, Dirichlet point-wise convergence theorem, the Gregory series, Selector property of $(\sin w)/t$, point-wise convergence for B V, uniformly convergent trigonometric series and Fourier series, Absolutely convergent coefficients, Uniform convergence for piecewise smooth functions.

Unit-3

- The Gibb's phenomenon, the Gibb's phenomenon for a step function, Divergent Fourier series, Term-wise integration and term-wise differentiation, Trigonometric vs. Fourier series , Smoothness and speed of convergence, Dido's Lemma, other kinds of summability, Toeplitz summability, Toeplitz summability , abel summability.

Unit-4

- Fejer Kernal, Properties of Fejer Kernal, Fejer's Theorem, Lebesge pointwise Convergence Theorem. The finite Fourier Transform, convolution on the circle groupT.

Unit-5

- The exponential form of Lebesgue theorem, Labesgue's pointwise convergence Therom -II, the Fouier transform and residue , the Fourier map, Convolution on R, Inversion, Exponential form and Trigonometric form.

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Textbooks:

1. George Bachman, Lawrence Narici and Edward Beckenstein Fourier and Wavelet Analysis, Springer – Verlag, New York, 2005

Reference books:

1. C S Rees, S M Shah, C V Stanojevic: Theory and applications of Fourier Analysis, Marcel Dekkar Inc., New York
2. Rajendra Bhatia, Fourier Series, Hindustan Book Agency, Delhi.
3. N. K. Bary, A Treatise on Trigonometric Series, Pergamon Press., A. Zygmund, Trigonometric Series, Cambridge Press.
4. H P Hsu, H B Jovanovich, Applied Fourier Analysis, New York.
5. K G Beauchhamp, Walsh Functions and their applications, Academic Press.
6. E O Brigham, The Fast Fourier Transform, Prentice Hall of India.

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Name of the Course: Stochastic Processes **Course Credits: 4**

Course No.:

Unit-I

Stochastic or random processes definitions, applications and examples, continuous and discrete stochastic processes,. Stationary and Evolutionary stochastic processes, Distribution and density functions, mean, correlation, covariance and auto-covariance functions, Probability generating function (pgf) method, some elementary exercises.

Unit-II

Markov processes and Markov chain, Homogeneous Markov chain, Transition probability matrix, one step and *n*-step transition probability, steady state condition on Markov chain, Classification of Markov chain, Some Markov chain models, Chapman-Kolmogorov theorem, Regular Markov chain, Irreducible Markov chain, Periodicity, Ergodicity.

Unit-III

Poisson Processes, Poisson distribution, Distribution associated with the Poisson Processes, Properties of Poisson processes, The Law of Rare Events and the Poisson Process, Pure Birth Processes, Pure Death Processes, Distribution of inter arrivals and departures, Yule-Furry process, Simple Birth and Death Processes.

Unit-IV

Queueing Processes, Basic Queueing characteristics, Kendall's Notation, Steady state distribution, Poisson arrivals, Exponential service times, Little's formula, M/M/1: ∞ queueing model, M/M/c: ∞ queueing model, M/M/1: K queueing model and their performance measures, M/M/c: K queueing model, Examples based on these models.

Unit-V

M/M/1: ∞ queueing model with state dependent service rates, Finite population M/M/c/K/K queueing model, Transient behavior of M/M/1/1 model, Non-Markovian queueing models as M/G/1 and various performance measures, Queue Networks, Series queues with blocking and their performance measures,

Reference Books:

1. **Howard M. Taylor and Samuel Karlin**, "An Introduction to Stochastic Modeling", Third Edition, Academic Press, London.
2. **B. R. Bhat,** "Stochastic Models: Analysis and Applications", First Edition, (Reprinted on Jan, 2000), ISBN No.: 978-81-224-1228-4, New Age International, Delhi.
3. **J. Medhi,** "Stochastic Processes", Third Edition, New Age International, Delhi.
4. **S. Palaniammal,** "Probability and Queueing Theory", PHI Learning Private Limited, Delhi.

Kamlesh Kumar
01-05-2019

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Course Code: PGMAT1C002T
Course Title: Abstract Algebra

Objectives: To provide a first approach to the subject of Algebra, which is one of the basic pillars of modern mathematics and to study of certain structures called Groups, rings, fields and some related structures.

Learning outcomes:

1. Students will be able to understand the set relation by demonstrating Venn diagrams
2. Students will be able to understand the concept of equivalence relation by applying different examples to the definition
3. Students will be able to prove a statement by mathematical induction by using sequence of consecutive integers
4. Students will be able to understand the concept of binary operations by definition and examples
5. Students will be able to determine whether a given binary operation on the given set gives a group structure by applying the axioms
6. Students will be able to determine whether a given group is Abelian by checking the properties
7. Students will be able to prove that a given subset of a group is a subgroup by applying the properties.
8. Students will be able to describe all elements in a cyclic subgroup by using generators.
9. Students will be able to compute the expression of permutation groups by using permutation multiplication
10. Students will be able to understand the homomorphism by using the relationship between groups
11. Students will be able to understand the isomorphism by using the relationship between groups

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Course Code: PGMAT1F006T

Course Title: INTRODUCTION TO SET THEORY

OBJECTIVES: Set theory is a branch of mathematical logic where students learn sets and their properties.Set theory is commonly employed as a foundational system for the whole of mathematics. Besides its foundational role, set theory also provides the framework to develop a mathematical theory of infinity, and has various applications in other fields. Set theis a branch of mathematical logic where students learn sets and their properties.

LEARNING OUTCOMES: After completion of the course, students will be able to do the following:

- understanding of limit points and what is meant by the continuity of a function are based on set theory.
- Students who successfully complete the course will be able to understand and apply the basic axioms and concepts of set theory.
- They will be able to read, write and present theorems and proofs in higher mathematics.
- Demonstrate an understanding of set theory as a sub-area of logic and contrast it with other areas of logic.
- Describe the various types of set theoretical objects that can be constructed using the different axioms, with a special focus on the axiom of choice.
- Formulate, derive and apply basic arithmetic for cardinal and ordinal numbers.
- Formulate and present set theoretical constructions of number systems including the natural and real numbers, as well as verify their most central properties using the axioms of set theory.

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Course Code: PGMAT1C003T
Course Title: Number Theory

OBJECTIVES: This is an introductory course in Number Theory for students interested in mathematics and the teaching of mathematics. The course begins with the basic notions of integers and sequences, divisibility, and mathematical induction. It also covers standard topics such as Prime Numbers; the Fundamental Theorem of Arithmetic; Euclidean Algorithm, Congruence Equations and their Applications (e.g. Fermat's Little Theorem); Multiplicative Functions (e.g. Euler's Phi Function).

LEARNING OUTCOMES:

- Effectively express the concepts and results of Number Theory
- Revising basic notions of Integers, sequences and divisibility.
- Understand various algorithms and theorems related to numbers, prime numbers.
- Understanding concept of Modulus and related results.
- Construct Mathematical proofs of statements and find counter example to false the statement.
- Collect and use numerical data to form conjectures about integers.
- Understand the logics and methods behind the major proofs in number theory .
- Work effectively as part of a group to solve challenging problem in number theory .

Course Code: PGMAT1E001T

Course Title: INTRODUCTION TO COMPUTER PROGRAMMING

Objectives: The core of computer science is programming. Other areas of the subject are either side issues or specializations from the main programming. Machines, computer applications, and even the role of computers in society are all considerably different today than they were ten, twenty, or thirty years ago, and we can be confident that they will be different again in ten, twenty, or thirty years. Moreover, programming softwares like MATLAB, LaTeX etc. are important and integral part in many research areas of Mathematics such as cryptography, modeling, queueing theory, differential equations etc.

Learning Outcomes: After course completion the students will have the following learning outcomes:

- understanding foundation concepts of information and information processing in computer systems: a matter of information, data representation, coding systems;
- understanding of an algorithm and its definition;
- understanding of a programming language syntax and its definition by example of C language;
- knowledge of basic principles of imperative and structural programming;
- ability to write simple programs in C language by using basic control structures (conditional statements, loops, switches, branching, etc.);
- ability to create a programmable model for a problem given;
- understanding a function concept and how to deal with function arguments and parameters;
- ability to use pointers and pointer arithmetic in the simple cases;
- basic knowledge of working with arrays in C language;
- understanding a defensive programming concept.Ability to handle possible errors during program execution;
- elementary knowledge of programming code style.

Athaema

P. Singh

Kamlesh Kumar

Sanjay K.

Course Code: PGMAT1C004T

Course Title: ORDINARY DIFFERENTIAL EQUATIONS WITH APPLICATIONS.

OBJECTIVES: The objective of this course is to equip the students with fundamental knowledge and problem solving skills in Power series methods of solution of ODE, Existence and Uniqueness theory of Initial Value Problems and Solution of system of differential equations. It helps the students to master mathematical techniques and concepts used to analyze and understand differential equations.The students will also learn to interpret the real-world meanings and implications of the mathematical results.Students learn to discover and derive.

LEARNING OUTCOMES:

The main purpose of the course is to introduce students to the theory and methods of ordinary differential equations.

- Students will know that the subject of differential equations has two parts, namely first order differential equations and higher order differential equations.
- Students will also study the various methods of solving several types of differential equations. Some applications for first order and second order differential equations are also included.
- Classify first order differential equations according to type, order, degree and linearity.
- Identify the type of first order differential equations as separable, linear, homogeneous, exact or Bernoulli and then solve the equations.
- Solve second order homogeneous and non-homogeneous.
- Solve application problems of first and second order differential equations.
- The main purpose of the course is to introduce students to the theory and methods of ordinary differential equations.

Course Code: PGMAT2C001T

Course Title: LINEAR ALGEBRA

Learning Outcomes:

- Solve systems of linear equations using multiple methods, including Gaussian elimination and mtrix inversion.
- Carry out matrix operations, including inverse and determinants.
- Demonstrate understanding of linear independence, span and basis.
- Determine eigenvalues and eigen vectors and solve eigen problems.
- Apply principal of matrix algebra to linear transformation.

Course Outcomes:

- To use mathematically correct language and notation for linear algebra.
- To become computational proficiency involving procedures in linear algebra.
- To understand the axiomatic structure of modern mathematical subject and learn to construct simple proofs.
- To solve problems that apply linear Algebra to Chemistry, Economics and Engineering.

Kamlesh Kumar

Course Code: PGMAT2C003T

Course Title: Complex Analysis:

Objectives: The course's main objective is to lay the groundwork for complex analysis field of mathematics. The goal is to introduce the fundamental concepts, methods, and applications of complex analysis. The majority of the topics taught can be used in Applied Mathematics and Engineering.

Learning Outcomes:

In this course, the students will master the algebra of complex numbers, mappings in the complex plane, the theory of multi-valued functions and the calculus of single complex variable functions.In particular, students should be able to do the following after completing this course:

- perform basic mathematical operations with complex numbers in Cartesian and polar forms;
- find the modulus of a Complex valued function and related results;
- determine the continuity, differentiability and analyticity of a function;
- find the Taylor series of a function and determine its radius of convergence;
- find the Laurant series of a function;
- to learn about the singularities of the function through Laurant series;
- learn to use Argument Principle;
- understand and develop skills in the use of Rouche's theorem;
- find the residue of a function and use the residue theory to evaluate an integral over some contour;
- to learn the conformal mappings, Mobius transformation and cross ratio;
- to learn about the open mapping theorem, maximum and minimum modulus principle.

Course Code: PGMAT2E001T

Course Title: PARTIAL DIFFERENTIAL EQUATIONS

OBJECTIVES: The goal of this course is to introduce partial differential equations to students. The goal of this project is to create analytical tools for solving partial differential equations. To have a better understanding of the properties of partial differential equation solutions. Following objectives are introduced:

1. Introduce partial differential equations to pupils.

2. Show pupils how to solve linear partial differential equations using various strategies.

3. In 2D and 3D, derive heat and wave equations.

4. Determine the solutions of PDEs based on conditions at the spatial domain's border and initial conditions at time zero.

5. Separation of variables technique for solving PDEs and analysing solution behaviour in terms of eigen function expansions.

LEARNING OUTCOMES:

On completion of the course the student should have the following learning outcomes. Students will be able to

1. Categorise partial differential equations and transform them into canonical form after completing the course.

2. Solve first- and second-order linear partial differential equations

3. Use partial derivative equations to forecast the behaviour of various phenomena.

4. Conduct research and generate creative results in the area of speciality using specialised procedures, techniques, and resources.

5. In order to interpret reality, extract information from partial derivative models.

6. Recognize real-world occurrences as partial derivative equation models.

Kamlesh Kumar

Course Code: PGMAT2C004T

Course Title: OPTIMIZATION TECHNIQUES

<u>OBJECTIVE</u>: The goal of this course is to cover the fundamentals of linear programming, nonlinear programming, dynamic programming problems, classical optimization techniques, numerical methods of optimization, the basics of different evolutionary algorithms, explain integer programming techniques, and apply different optimization techniques to solve models.

<u>LEARNING OUTCOMES</u>

Upon successful completion of this course, students will be:

- Able to explain the essential understanding of Linear Programming, Non-linear Programming, and Dynamic Programming problems after completing the topic.
- Able to formulate the LPP for a real-world situation and provide a solution utilising appropriate optimization approaches.
- Able to use the Graphical, Simplex, and Big-M methods to solve LPP.
- Able to complete the assignment and the problem of the travelling salesman.
- Able to use traditional optimization techniques as well as numerical optimization methods.

Course Code: PGMAT3C005T

Course Title: FUNCTIONAL ANALYSIS.

OBJECTIVE : The objective of this course is to introduce basic concepts, methods of Functional Analysis and its Applications. It is a first level course in Functional Analysis.It is a core course in any mathematics curriculum at the masters level. It has wide ranging applications in several areas of mathematics, especially in the modern approach to the study of partial differential equations.The proposed course will cover all the material usually dealt with in any basic course of Functional Analysis. Starting from normed linear spaces, it covers all the important theorems, with applications, in the theory of Banach and Hilbert spaces.

LEARNING OUTCOMES: After the completion of course the students will acquire knowledge on the following:

- They study vector spaces which are endowed with a topology, in particular infinite-dimensional spaces.
- They are able to know the extension of the theory of measure, integration, and probability to infinite dimensional spaces, also known as infinite dimensional analysis.
- They will be able to compare the differences between finite and infinite dimensional spaces.
- Also, they will know how to compare the differences between Banach and Hilbert spaces.
- Analyse the structure of the spectrum of certain operators.
- They will know how touse topology to work with infinite dimensional vector spaces.

Kamlesh Kumar

Course Code: PGMAT3E006T

Course Title: FINITE FIELDS AND CODING THEORY.

OBJECTIVE: The objective of this course is to equip the students withfundamental knowledge and problem solving skills in finite Fields, Field extension, polynomials with finite Fields, Coding scheme and Decoding scheme. It helps the students to master mathematical techniques and concepts used to analyse and understand the finite Fields and coding theory. The students will also learn to interpret the real-world meanings and implications of the mathematical results. Students learn todiscover and derive.

Learning Outcomes:

- This subject consists of two topics namely finite Fields and Coding theory.

- Students will also study the various methods of solving several types of problem related to finite Fields and Coding theory. Some applications for polynomials with finite Fields and coding are also included.
- Classify finite Field and Field extension according to type of the problem.

- Identify roots of irreducible polynomials over finite Field, roots of unity and Primitive roots of unity.

- To solve the problems related to Moebius function and Moebius Inversion Formula.

- The main purpose of the course is to introduce students to the theory and methods of finite Fields and Coding theory.

Kamlesh Kumar

Course Code: PGMAT3F006T

Course Title: Probability & Statistics

OBJECTIVES: The goal of the course is to acquaint students with various probability distributions as well as to improve their abilities and understanding of sampling distributions and hypothesis testing.

LEARNING OUTCOMES

Upon successful completion of this course, students will be:

- Able to comprehend the essential ideas of probability, such as random variables, event probability, additive rules, and conditional probability.
- able to comprehend Bayes' theorem notion
- Able to comprehend statistical ideas and measures at a basic level
- Able to construct the central limit theorem notion
- Understand Binomial, Geometrical, Negative Binomial, Pascal, Normal, and Exponential Distributions.
- Be able to comprehend the ideas of various parameter estimation approaches, such as the method of moments, maximum likelihood estimation, and confidence intervals.
- Possessing the ability to test hypotheses.

Kamlesh Kumar

Course Code: PGMAT3C006T

Course Title: DIFFERENTIAL GEOMETRY OF CURVES AND SURFACES

OBJECTIVES: The goal of this course is to offer students with a foundation in differential geometry of curves and surfaces in space, with a focus on geometric aspects, as a foundation for further study or applications. Students will be introduced to the fundamental concepts of classical differential geometry before being shown how to apply characteristic classes, connections, and curvature tensors to Riemannian manifolds in detail.

LEARNING OUTCOMES:

Students would get familiar with basic notions and instruments of differential geometry, would enhance their methods of solving mathematical problems in various fields. Students would be capable of solving basic problems on differential geometry structures and objects on manifolds. The course introduces the fundamentals of differential geometry primarily by focussing on the theory of curves and surfaces in three space.

On completion of the course the student should have the following learning outcomes:

1. Define the equivalence of two curves.
2. Find the derivative map of an isometry.
3. Explain differential maps between surfaces and find derivatives of such maps.
4. Express definition and parameterization of surfaces.
5. Defines surfaces and their properties.
6. Express tangent spaces of surfaces.
7. Integrate differential forms on surfaces.

Kamlesh Kumar

Course Code: PGMAT4C006T

Course Title: Operator Theory:

Objectives: The course's main goal is to study the fundamentals of operator theory. It is a field that has great importance for other areas of mathematics and physics, such as algebraic topology, differential geometry, and quantum mechanics.The classical areas of operator theory are the spectral theory of linear operators, distribution theory, operator algebra theory,the geometry of Banach spaces etc. It has numerous applications in differential equations, harmonic analysis, representation theory, geometry, topology, calculus of variations, optimization, quantum physics, etc. It assumes a basic knowledge in functional analysis but no prior acquaintance with operator theory is required.

Learning Outcomes :

The students will be introduced to topics of operator theory with an emphasis on spectral theory and to the fundamentals of Banach algebra theory.In particular, students should be able to do the following after completing this course:

- find the strong, uniform and weak convergences;
- prove the continuity of concrete linear operators between topological vector spaces;
- prove whether a linear operator is compact or not;
- find the essential spectra of linear operators;
- find the maximal spectra of concrete commutative Banach algebras;
- describe the functional calculi and the spectral decompositions of concrete self-adjoint operators;
- find the bounded operators on Hilbert spaces.

Athaeing
D. Vinyl
Kamlesh Kumar
Ranjeet K.

Course Code: PGMAT4F006T

Course Title: Stochastic Processes

OBJECTIVES: The goal of the course is to give students a fundamental understanding of stochastic processes, particularly Markov processes, as well as a foundation for using stochastic processes as models in a wide range of applications, including queueing theory, Markov chain Monte Carlo, and their applications in modern engineering problems.

Learning Outcomes

Upon successful completion of this course, students will be:

- Describe stochastic processes in detail, particularly Markov processes, after successfully completing this course.
- Able to define Markov chains in both discrete and continuous time.
- Able to establish a good understanding of discrete state Markov processes such as Markov chains, Poisson processes, and birth and death processes, as well as queueing systems.
- Able to formulate simple time-domain stochastic process models and perform qualitative and quantitative assessments on them.

Course Code: PGMAT4C005T
Course Title: INTRODUCTION TO CRYPTOGRAPHY

OBJECTIVES:

To make the student learn different encryption techniques along with hash functions, MAC, digital signatures and their use in various protocols for network security and system security.

LEARNING OUTCOMES

- Analyze and Design Classical encryption techniques and block Ciphers.
- Understand and analyze data encyption standards.
- Understand and analyze public-key Cryptography, RSA and other public-key cryptosystems.
- Understanding Protocols
- Analyze and design digital signatures.
- Design network application security schemes.