SYLLABUS

OF

COURSE

M.A. / M.SC. IN MATHEMATICS

FOR THE SESSION

2021–22

PRIVATE EXAMINATION CELL

SAMBALPUR UNIVERSITY

JYOTI VIHAR, BURLA,

SAMBALPUR, ODISHA – 768019

SAMBALPUR UNIVERSITY
COURSE STRUCTURE AND DETAIL SYLLABUS
FOR M.A./M.SC. MATHEMATICS PROGRAM,
2021-23

	Semester-I	
MAT 411	Real Analysis	4 Credits
MAT 412	Complex Analysis	4 Credits
MAT 413	Algebra-1	4 Credits
MAT 414	Probability	4 Credits
MAT 415	Topology	4 Credits
MAT 416	Programming Laboratory-1 (python programming)	2 Credits
	TOTAL	**22 Credits**
	Semester-II	
MAT 421	Measure Theory and Integration	4 Credits
MAT 422	Ordinary Differential Equations	4 Credits
MAT 423	Algebra-II	4 Credits
MAT 424	Numerical Analysis	4 Credits
MAT 425	Programming languages (C++)	4 Credits
MAT 426	Programming Laboratory-II (C- programming)	2 Credits
	TOTAL	**22 Credits**
	Semester-III	
MAT 531	Optimization techniques	4 Credits
MAT 532	Functional analysis	4 Credits
MAT 533	Partial differential equation	4 Credits
MAT 534	Elective-1	4 Credits
MAT 535	Elective-2	4 Credits
MAT 536	Programming Laboratory-III	2 Credits
	TOTAL	**22 Credits**
	Semester-IV	
MAT 541	Differential geometry	4 Credits
MAT 542	Mathematical methods	4 Credits
MAT 543	Elective-3	4 Credits
MAT 544	Elective-4	4 Credits
MAT 545	Elective-5	4 Credits
MAT 546	Project/dissertation (With Viva voce)	4 Credits
	TOTAL	**24 Credits**
	GRAND TOTAL	**90 Credits**

*The electives number will be chosen from the list given in the schedule A. The electives are chosen in such a way that they are not repeated.

LIST OF ELECTIVES

SCHEDULE = A

(Each Elective is of 4 Credits)

The Department will offer elective in Semester-III and Semester-IV from the following list avoiding repetitions.

1. ANALYTICAL NUMBER THEORY
2. ALGEBRAIC TOPOLOGY
3. ADVANCED COMPLEX ANALYSIS
4. ADVANCED LINEAR ALGEBRA
5. APPLIED STATISTICAL METHODS
6. ALGEBRAIC GEOMETRY
7. COMBINATORICS
8. COMPUTER AIDED GEOMETRIC DESIGN
9. CRYPTOGRAPHY
10. DATA STRUCTURE
11. DATA BASE MANAGEMENT
12. DATA ANALYTICS-I
13. DATA ANALYTICS=II
14. DISCRETE DYNAMICAL SYSTEMS
15. FOURIER ANALYSIS
16. GRAPH THEORY
17. MECHANICS
18. MATHEMATICAL MODELLING
19. METHODS IN SCINTIFIC COMPUTING
20. NON LINEAR PARTIAL DIFFERENTIAL EQUATION
21. OPERATOR THEORY
22. OPTIMISATION TECHNIQUES-II
23. QUEUEING THEORY
24. STOCHASTIC MODELLING
25. THEORY OF COMPUTATIONS
26. WAVELET ANALYSIS
27. GEOMETRIC FUNCTION THEORY

However if necessary and as per the availability of expertise the teacher council can frame a new course and offer it and it will be ratified in the next academic committee.

Semester -I

REAL ANALYSIS
Course No: MAT-411

Objective: Every other branch of mathematics depends deeply on the understanding of the structure and topology of real number system and handling series, sequence of real numbers, single valued, multivalued functions on R and their continuity, differentiation and integration on R. The objective of this course is to illustrate these basic materials to students and to add to their strength of solving problems.

Expected Outcomes: Every student is expected to earn enough maturity to handle real number system which is basic to all other subjects in mathematics. This is prerequisite for all other analysis courses such as Functional analysis, Operator theory, Differential equations, etc..

UNIT-I

Review of sets , Relation ,Functions and Basics of calculus, Countability, axiom of choice and equivalents (without proof),Metric space, examples, limit points, open sets , closed sets, R as a metric space, sequences of real numbers, Cauchy sequence, completeness ,Bolzano Weierstrass theorem, Heine Borel theorem, Series , convergence, tests of convergence

UNIT-II

Continuous functions, Definition and general properties, Uniform continuity, power series, uniform convergence, Weierstrass M Test, Weierstrass approximation theorem, Functions of bounded variation, Differentiation, properties , Mean value theorems, Taylor's theorem

UNIT-III

Functions of several variables, Differentiation in Rn, Partial derivatives, Directional deriva- tives, Jacobians, Contraction mapping principle, inverse function theorem, implicit function theorem, Riemann integrals, Properties and techniques, Riemann Stieltjes Integrals, proper- ties and techniques, Imroper Integrals, multiple integrals

UNIT-IV

Lebesgue measure on the line, Outer measure, measurable sets, Properties of measurable sets, non measurable sets, measurable functions, simple functions, Lebesgue integration of simple and measurable functions, convergence theorems

Books for Reference:

1. Rudin-Principles of Mathematical analysis-Mc Graw Hill, 3rd Ed, 1976.

2. Royden-Real Analysis-Pearson, 4th Ed., 2010.
3. Apostol-Mathematical Analysis- Pearson; 2nd edition, 1974.
4. Debarra- Measure theory and Integration-New Age, 1981.
5. Hewitt and Stromberg-Real analysis-Springer, 1975.
6. Das and Pattanayak- Fundamentals of Real analysis-Tata Mc GrawHill, 1987.

COMPLEX ANALYSIS
Course No: MAT-412

Objective: This course is aimed to provide an introduction to the theories for functions of a complex variable. It begins with quick review on the exploration of the algebraic, geometric and topological structures of the complex number field. The concepts of analyticity and mapping properties of function of a complex variable will be illustrated. The notion of the Riemann sheet is presented to help student visualize multi-valued complex functions. Complex integration and complex power series are presented. We then discuss the classification of isolated singularities and examine the theory and illustrate the applications of the calculus of residues in the evaluation of integrals.

Expected Outcomes: After completing this course, students are expected to be able to work with functions (polynomials, reciprocals, exponential, trigonometric, hyperbolic,etc) of single complex variable and describe mappings in the complex plane; work with multi-valued functions (logarithmic, complex power) and determine branches of these functions; evaluate a contour integral using parameterization, fundamental theorem of calculus and Cauchy‟s integral formula; find the Taylor series of a function and determine its circle or annulus of convergence; compute the residue of a function and use the residue theory to evaluate a contour integral; determine the number of zeros of a polynomial in the unit disk and in the right half plane; explain the concepts, state and prove theorems and properties involving the above topics. For example, able to recognize and apply the Liouville‟s theorem, the mean-value property of a function and the maximum modulus principle, Rouche‟s theorem, Argument principle, fundamental theorem of algebra.

Unit-I

The complex number system, The spherical representation, Analytic functions, Exponential and trigonometric functions, The Cauchy-Riemann equations, Power series, Functions defined by power series as holomorphic functions, The linear fractional transformations, Cross ratios and Conformal mappings.

Unit-II

Complex line integrals and Cauchy's theorem, Cauchy's integral formula, The index of a closed curve, Cauchy's theorem for rectangle, Cauchy's theorem for disc, General form of Cauchy's theorem, Harmonic functions, Fundamental theorem of algebra, Morera's theorem, Open map- ping theorem a Zeros of complex functions.

Unit-III

Taylor’s series, Laurent’s series, Types of singularities, Calculus of residues, Evaluation of definite integrals, The argument principle, Rouche’s theorem, The maximum modulus theorem and Schwarz’s lemma.

Unit-IV

Normal families, Arzela’s theorem, Product developments, Hadamard’s theorem Riemann zeta functions, Riemann mapping theorem and Weriestrass’ theorem.

Books for References:

1. L. V. Ahlfors - Complex Analysis, McGraw Hill, 3rd Ed.,1979.
2. Brown and Churchill - Complex Variables and Appl., McGraw Hill, 9th Ed., 2013.
3. J. B. Conway - Functions of one Complex Variable, Springer; 2nd ed. 1978, 7th printing 1995 edition

ALGEBRA - I
Course No: MAT-413

Objective: The concept of groups, rings, fields and vector spaces are essential building blocks of Modern algebra and are an integral part of any post graduate course. The objective of the present course Algebra-I is to deal with groups and rings only and students are encouraged to solve many problems here as this is necessary for any course they take later. This course not only play a fundamental role in mathematics but also has applications to other areas of science and engineering.

Expected Outcomes: Students will observe how so much theory can be developed from just a few simple axioms that define group and ring. They will understand the importance of algebraic properties with regard to working within various areas like number systems, matrices, class of functions etc. Knowledge of this course can help students to read field theory, another basic concept of Modern algebra, in the next semester.

Unit - I

Groups, Subgroups, Permutation group, Dihedral group, Caylay’s Theorem, Direct product of groups, Cyclic group, Normal subgroup, Quotient group, Homomorphism, Isomorphism.

Unit-II

Finitely generated abelian group, free abelian groups, Commutator group, Simple group, Series of groups, Group action on a set, Sylow theorems and applications.

Unit - III

Ring, Integral domain, Characteristic of an Integral domain, Homomorphism, Isomorphism, Ideals, Maximal ideal, Prime ideal, Quotient rings.

Unit – IV

Euclidean rings, Gaussian integers, Polynomial rings, Principal ideal domain, Unique factorization domain.

Books for reference

1. I. N. Herstein - Topics in Algebra , John Wiley and Sons; 2nd Revised edition edition, 1975.
2. J. B. Fraleigh-A first Course in Algebra, Pearson, 7th Ed., 2013.
3. J. Gallian - Contemporary Abstract algebra, Brooks/Cole Pub Co; 8 edition, 2012.
4. David S. Dummit and Richard M. Foote, Abstract Algebra, Wiley,3ed, 2011

PROBABILITY
Course No: MAT-414

Objective: Analysis of the outcome a random experiment and numerical probability of happening of an event is the contents of a first course in probability at undergraduate level. As a second course in probability, this post graduate course aims at developing measure theoretic method based on work of Kolmogorov and his school to study the outcome of stochastic phenomena in all spheres of life.

Expected Outcomes: This measure theoretic probability course will prepare a student far a vats range of courses such as stochastic process, Brownian motion, Martingle theory, Markov chains, queuing and inference, Time series analysis, Mathematical finance and computer applications.

Unit-I

Algebra of sets, Fields and Sigma fields, limits of sequence of subsets, Sigma field generated by a class of subsets, Borel fields. Probability space, continuity of probability measure.

Unit-II

Sample space, Probability axioms, Conditional probability, Independence of events. Bayes' theorem, Real and vector valued random variables, Distribution function, Discrete and continuous random variables, Distribution of L.V.S. Marginal and conditional distribution. Independence of random variables.

Unit-III

Poisson theorem, Interchangeable events and their limiting properties, Expectation of a ran- dom variable. Linear properties of expectations.

Conditional expectation, Moment generating function. Moment inequalities. Characteristic function and its properties.

Unit-IV

Convergence of a sequence of random variables, Convergence in distribution, Convergence in probability, Almost sure convergence and Convergence in quadratic mean and their interrela- tions. Monotone and dominated convergence theorem, Central limit theorem: Lindberg-Levy and Demoivre-Lapalce theorem.

Books for reference

1. Bhat, B.R. (1985): Modern probability theory (Wiley).
2. Billingsley, P. (1986): Probability and measure (Wiley).
3. Feller, W. (1969): Introduction to probability theory and applications, Vol . II (Wiley)
4. Rohatgi, V.K. (1976): Introduction to theory of probability and mathematical Statistics (Wiley).
5. H.G.Tucker(1967) : A graduate course in probability theory (AP)
6. Y.S.Chow and H Teicher(1979) : Probability theory (Springer-Verlag)

TOPOLOGY
Course No: MAT-415

Objective: This is an introductory course in topology, or the study of shape. The objective of this course is to have knowledge on point set topology, topological spaces, Quotient spaces, Product spaces and metric spaces, sequences, continuity of functions, connectedness and compactness, homotopy and covering spaces.

Expected Outcomes: On successful completion of the course students will learn to work with abstract topological spaces, both the concrete and the very formal, the non-intuitive and the geometric. They will develop qualitative tools to characterize them (e.g., connectedness, compactness, second countable, Hausdorff...), and develop tools to identify when two are equivalent (homeomorphic).

Unit-I

Basic concepts of Topology, Examples, Bases, Subbases, closed sets, Limit Points, Continuous functions. - Subspace topology, Product topology, and Quotient topology.

Unit-II

Connectedness, Local connectedness, Path-connectedness, compact Spaces, compactness in metric spaces, locally compacts spaces, compact open topology

Unit-III

Countability axioms Separation axioms Regular & completely regular space, normal spaces, Urysohn Lemma, Urysohn metrization theorem

Unit-IV

Tychonoff Theorem, Homotopy, Homotopy equivalences, path homotopy Fundamen- tal Group, covering space fundamental Group of S1.

Books for reference

1. J.R. Munkres-Topology - A First Course in Topology, Pearson; 2 edition, 2000.
2. Dugundji - Topology, McGraw-Hill Inc.,US (1 April 1988)
3. Hu- Elements of General Topology, Holden-Day, 1964.

PROGRAMMING LABORATORY - I
Course No: M-416

The candidates should be able to do the following programmes by using Python Languages.

1. Write a program to find the solutions of a Quadratic equation.
2. Write a program to find the addition of two matrices.
3. Write a program to find the Fibonacci series.
4. Write a program to find the GCD and LCM of two numbers.
5. Write a program to test a number is prime or not.
6. Write a program to find the transpose of a matrix.
7. Write a program to find the area of a circle.
8. Write a program to find the area of an ellipse.
9. Write a program to arrange some numbers in ascending order.
10. Write a program to multiply two matrices.
11. Write a program to find the sum of diagonal elements of a matrix.
12. Write a program to find the Factorial of a number.
13. Write a program to find the Surface area of a sphere.
14. Write a program to find the sum of digits of a number.
15. Write a program to find the Volume of a Cone.
16. Write a program to find the Volume of a Sphere.
17. Write a program to check a number is a palindrome or not.
18. Write a program to find Surface area of a Prism.
19. Write a program to calculate the Product of two complex numbers.
20. Write a program to find the Exponential series.
21. Write a program to find the Pascal Triangle.
22. Write a program to find the Sine series and Cosine series.
23. Write a program to find all factors of a number.
24. Write a program to generate a list of primes between 1 and n. Find the twin primes and count no of primes of the form 4n+1 and 4n-3.

Semester - II

MEASURE THEORY AND INTEGRATION
Course No: MAT-421

Objectives: Measure Theory formalises and generalises the notion of integration. It is fundamental to many areas of mathematics and probability and has applications in other fields such as physics and economics. Students will be introduced to Lebesgue measure and integration, signed measures, the Hahn-Jordan decomposition, the Radon-Nikodym derivative, conditional expectation, Borel sets and standard Borel spaces, product measures, and the Riesz representation theorem.

Expected Outcomes: After completing this subject, students will understand the fundamentals of measure theory and be acquainted with the proofs of the fundamental theorems underlying the theory of integration. They will also have an understanding of how these underpin the use of mathematical concepts such as volume, area, and integration and they will develop a perspective on the broader impact of measure theory in Ergodic theory and have the ability to pursue further studies in this and related areas.

Unit-I

Abstract measure spaces, measurable sets, Examples, Extension uniqueness and completion of a measure, Integration with respect to a measure, properties, Monotone convergence theorem, Fatou's Lemma, and Dominated convergence theorem, Lebegsue measure and properties

Unit-II

Modes of convergence, Point wise convergence and convergence in Measure, convergence dia- grams and counter examples, Egorov‟s theorem, Differentiation of monotone functions, Lebesgue Differentiation theorem, Absolute continuity.

Unit-III

Complex and signed measure, Hahn decompositions, Jordan decomposition, Radon-Nikodym theorem ,Product measure, Fubini Theorem.

Unit-IV

Lp-spaces, Inequalities in Lp-spaces, Jensen Inequality, Holder Inequality, Minkowskiinequality Completeness of *Lp*.

Books for Reference

1. Debarra. G. Measure Theory and Integration (New age International), 1981.
2. Royden-Real Analysis-Pearson, 4th Ed., 2010.
3. Rudin W Real and Complex Analysis.(Tata McGraw Hill of India), 3rd Ed,

1986.
4. Hewitt and Stromberg-Real analysis-Springer, 1975.
5. Rana. I.K. Measure Theory and Integration, (New Age Publication)

ORDINARY DIFFERNTIAL EQUATIONS
Course No: MAT-422

Objective: Differential Equations introduced by Leibnitz in 1676 models almost all physical, biological, Chemical, Socio-economic system in nature. The objective of this course is to familiarize the students with various methods of solving differential equations and to have a qualitative analysis of the behaviour of solutions along with existence and uniqueness problems. The students have to solve problems to understand the methods.

Expected Outcomes: A student completing the course is able to solve differential equations and is able to model problems in nature using ODE. This is also prerequisite for taking other core courses in partial differential equations, stability theory, oscillation problems, Evolution equations, Dyncmical system, Bifurcation theory, Mathematical modeling etc.

Unit- I

Second order Linear Differential Equations:- General solution, Using a known solution to find the other, Homogeneous equations with constant coefficients, Inverse operator method, Method of variation of parameters, Power series solution and special functions.

Unit- II

Oscillations of second Order Equations: Fundamental Results, Sturm"s Comparison theorem, Hille-wintner theorem, Oscillations of $x'' + a(t)x = 0$.

Boundary Value Problems: Introduction ; Strum Liouville Problem, Green"s functions, Picard"s throrem.

Unit- III

Existence and Uniqueness of Solutions: Successive approximations, Picard"s Theorem, Non Uniqueness of solutions, Continuation and dependence on initial conditions, Existence of solutions in the large, Existence and uniqueness of solution of systems.

Unit- IV

System of Linear Differential Equations: System of first order equations, Existence and Uniqueness theorems, Fundamental Matrix, Homogeneous and Non Homogeneous linear systems with constant Co-efficient, Linear system with periodic Co-efficient.

Books for Reference

1. G. F. Simmons, Differential Equations with Applications, McGraw Hill International Edition, 1991.
2. S. G. Deo and V. Raghavendra, Ordinary Differential Equa- tions and stability theory, TATA Mc Graw Hill Ltd, 1980. Chapter 2 (Quick Review) 4,5,6,7.
3. G. Birkhoff and G. C. Rota-Ordinary Differential Equations-John Wiley and Sons, N.Y., 1989.
4. Coddington and Levinson, Theory of Ordinary Differential Equations, Krieger Pub Co (June 1984)
5. Tyn-Myint-U Ordinary Differential Equations, Elsevier North-Holland, 1987.
6. S. Ahmed, A. Ambrosetti, A textbook on Ordinary Differential Equations Springer Publication, 201

ALGEBRA - II
Course No: MAT -423

Objective: As a second course in algebra the objective of this course is to have a complete understanding of fields and linear algebra. The concept of Galois theory in fields is central to theory of equations and is a must for all mathematics students. Understanding vector spaces and linear transformations in linear algebra pave the way for any advance course in linear algebra.

Expected Outcomes: The knowledge on this course will provide the basis for further studies in advanced algebra like commutative algebra, linear groups, modules etc., which forms the basics of higher mathematics.

Unit – I

Vector Spaces, Subspaces, Linear independence, bases, Dimension, Projection, Quotient spaces, Isomorphism of vector spaces, Algebra of matrices, Rank and Inverse of matrix, The Algebra of Linear transformation, Kernel, range, matrix representation of a linear transformation, Change of bases.

Unit – II

System of Linear equations, Characteristic roots and Vectors, eigen values, eigen vectors, Cayley-Hamilltorn theorem, Canonical Forms: Diagonal forms, triangular forms, Jordan form, Quadratic form, Inner Product spaces.

Unit – III

Extension fields, Transcedence of e and, Roots of Polynomials, Construction with straight edge and compass.

Unit – IV

More about roots, elements of Galois theory, solvability by radicals.

Books for Reference

1. A. Ramachandra Rao and P. Bhimsankaram. Linear Algebra, Hindustan Book Agency; 2nd Revised edition edition (15 May 2000.
2. S. Kumaresan-Linear Algebra, Prentice Hall India Learning Private Limited; New title edi- tion (2000).
3. P.P. Halmos - Finite Dimensional Vector Spaces, Springer; 1st ed. 1958. Corr. 2nd printing 1993 edition (August 20, 1993)
4. I. N. Herstein - Topics in Algebra, John Wiley and Sons; 2nd Revised edition edition, 1975.
5. J. B. Fraleigh-A first Course in Algebra, Pearson, 7th Ed., 2013.
6. J. Gallian - Contemporary Abstract algebra, Brooks/Cole Pub Co; 8 edition (13 July 2012).

NUMERICAL ANALYSIS
Course No: MAT-424

Objective: Calculation of error and approximation is a necessity in all real life, industrial and scientific computing. The objective of this course is to acquaint students with various methods of finding solution of different type of problems such as locating roots of equations, finding solution of nonlinear equations, systems of linear equations, differential equations, Interpolation and approximation, differentiation, evaluating integration so as to minimize the error and time required to solve the problem and to evaluate approximate eigenavlues by using different methods.
Expected Outcome: After getting trained a student can opt for the courses like advanced Numerical analysis and numerical functional analysis. Use of good mathematical software will help in getting the accuracy one need from the computer and can assess the reliability of the numerical results, and determine the effect of round off error or loss of significance.

Unit-I

Errors: Root finding for non-linear equations: Bisection method, Iteration methods based on first degree equations (Secant method, Regula-Falsi method, Newton Raphson method), Iteration methods based on second degree equation(Muller method, Chebysev method), Rate of convergence , Iteration methods.

Unit-II

Interpolations: Lagrange and Newton interpolations, Finite differences, Interpolating polyno- mials using finite differences, Hermite interpolation, Piecewise and Spline interpolation. Approximations.

Unit-III

Differentiation: Methods based on Interpolation, Methods based on Finite Differentials, Methods based on undetermined coefficients, optimum choice of step length, Interpolation method. Integration: Methods based on Interpolation (Trapezoidal rule, Simpson"s rule), Method based on undetermined coefficiencts (Gausses Legendre Integration method, Lobatto integration method, Radon integration method, Gausschebysev Integration method (without derivation), Gauss Laguerre Integration method (without derivation), Gauss-Hermite Integration methods (without derivation), Composite integration methods.

Unit-IV

Numerical Solution of system of linear equations: Direct methods, Gauss Elimination meth- ods, Gauss-Jordan Elimination method, Triangularization method, Cholesky method, Iteration methods(Jacobi iteration method, Gauss-siedel iteration method, Iterative method for A^{-1}) Eigen value problems(Jacobi method for symmetric matrices) Givers Method for symmetric matrices, Rutishauser method for arbitrary matrices). Numerical solution of ordinary dif- ferential equation: Euler Method, Backward Euler method, Mid-point method, Single Step methods(Tayler series method, Range-kutta method(Second order, Fourth order method)

Books for Reference

1. M.K. Jain, S.R.K Iyengar, R.K. Jain: Numerical Methods for Scientific and Engineering Computation, Willey Eastern Ltd. New Delhi (1995)

   Unit-I : Chapt-I 1.3 ; Chapt-II 2.1,2.2,2.3,2.4,2.5,2.6.;
   Unit-II: Chapt-IV 4.1,4.2,4.3,4.4,4.5,4.6,4.8,4.9,4.10;
   Unit-III: Chapt-V 5.1,5.2,5.3,5.4,5.6,5.7,5.8,5.9;
   Unit-IV: Chapt-III- 3.1,3.2,3.4,3.5;Chapt-VI 6.1,6.2,6.3;

PROGRAMMING LANGUAGES (C++)
Course No: MAT-425

Objective: The course partially covers the basics of programming in the "C" programming language and demonstrates fundamental programming techniques, customs and vocabulary including the most common library functions and the usage of the preprocessor. The aim of the course is to familiarize the students with basic concepts of computer programming and developer tools and to present the syntax and semantics of the "C" language as well as data types offered by the language. In this course, students will also learn the basics about the concepts of Object oriented program, Basics in C++ programming, Constructors and destructors.

Expected Outcome:

At the end of the class, we expect students to have a good understanding about the concept of object oriented programming and they must write their own programs using standard language infrastructure regardless of the hardware or software platform.

UNIT-I

Fundamentals, Introduction to C, Data Type, Arrays, Computer Fundamentals, Evolution of Programming Languages, Structure of C program, writing a Simple C program, identifiers, basic data types, storage classes, Constants, variables, different types of operators, precedence of operators. Input-output statements, statements and blocks, if and switch statements, loops- while, do-while and for statements, break, continue. Arrays- con- cepts, declaration, definition, accessing elements, storing elements, multi-dimensional arrays, Strings

UNIT-II

Structure Pointers, Functions, C-Preprocessors Structures: declaration, definition and initialization of structures, accessing structures, nested structures, arrays of structures, self referential structures, unions. Pointers: concepts, initialization of pointer variables, concept of arrays and pointer, pointers of pointer, Character pointers, pointers to structures. Functions: basics, different types parameter passing, user defined functions, standard library functions, recursive functions, structures and functions. C-preprocessor and header files.

UNIT-III

Concept of Opps, Introduction to C++, Class and Objects, Principle of Object Oriented Programming language, Procedural vs Object Oriented Pro- gramming, Elements of Object Oriented Programming: Objects, Classes, Encapsulation and Data Hiding, Data Abstraction, Inheritance and reusability, Polymorphism, message passing. Introductions to C++: Basic I/Os (Cin, Cout), Literals, Constant Qualifiers, Keywords, Con- ditional statements, loops, structures, union, functions and types of parameters passing, inline functions, static members. Objects and Classes: Access Specifies (Private, Public, Protected), Defining class Member, Use of scope resolution operators to define member functions outside the class, static member functions.

UNIT-IV

Friend Function, Function Overloading, Constructors & Destructors, Operator Overloading, Inheritance Friend Function: Basics and examples Function Overloading: Basic and example Constructors and Destructors: Basic, Types (parameterized constructors, copy constructors, multiple constructors etc), Destructor. Operator Overloading: Basics, types of operator can be used for overloading, examples. In- heritance: Basics, types of inheritance, different types of data derivation, examples

Book for Reference:

1. E. Balaguruswami, The C Programming Language, TMH.
2. E. Balaguruswami, The C++ Programming Language, TMH.
3. B.W. Kernighan, Dennis M. Ritchie, The C Programming Language, PHI/Pearson Education, 2 edition (1990)
5. Bjarne Stroustrup, The C++ Programming Languages, Addison-Wesley Professional, 4th ed., 2013.

PROGRAMMING LAB-II

Course No: M-426

Following Advance Programs Should be Done in C

1. Test the truth of Bertrand conjecture (Bertrand conjecture is that there is at least one prime between n and 2n).
2. Write a program to multiply two numbers having more than 15 digits each.
3. Write a program to construct a magic square of dimension n × n (n odd).
4. Write a program to generate the Fibonacci sequence using recursion and find the number that are perfect square:
5. Write a program to determine the roots by using Bisection Method / Regula-Falsi Method / Newton Raphson Method.
6. Write a program to find f (x) by using Lagrange Interpolation/ Newtonian Interpolation.
7. Write a program to find the value of numerical integration by using/ Trapezoidal Rule/ Simpson‟s one-third rule/ Simpson‟s 3/8 rule
8. Write a program to find the numerical solution of Differential equations by using Runge-Kutta method/ Euler method
9. Write a program to find the matrix inversion by using Gauss-elimination method / Gauss-Seidal method
10. Write a program to evaluate the following limits:

$$a)\ \lim_{x\to\infty}(1+1/x)\quad b)\ \lim_{n\to\infty}(a^{1/n}-1)\quad c)\ \lim_{x\to 0}(1+x)^{1/x}$$

11. Write a program to find the summation of series

$a)\ \sum_{n=0}^{\infty} 1/\ n!$ b) Sine series c) Cosine series.

12. Write a program to trace the following curves, Circle, Ellipse, Parabola, Hyperbola, Sine

Curve, Cosine Curve.

13. Write programs to Data Handling by: Sorting : Bubble sort, Quick sort, Merge sort. Searching : Linear search, Binary search
14. Write a program for generation of random number.
15. Write a program to determine the rank of any nxm matrices.
16. To find eigenvalue and eigenvector of a matrix
17. To find inverse of a 3×3 matrix
18. To find determinant of 3×3 matrix

Beside all the above, the candidate will do other programmes assigned by concern teachers during practical classes.

Semester - III

OPTIMIZATION TECHNIQUES-I
Course No: MAT-531

Objective: Optimization Techniques (old name Operation Research) is developed during World-II as how to „minimize the war resources for maximum benefit‟. Now it is a well known technique in modern technology. The objective of this course is to familiarize the industrial problems to students with various methods of solving Linear Programming Problems, Transportation Problems, Assignment Problems and their applications.

Expected Outcomes: This topic is industrial job oriented and it is an important tool in Space Dynamics and mathematical modeling dealing with missile technology. This is also prerequisite for taking other core courses in Nonlinear Programming Problems, Inventory Control Problem and Queuing Theory etc.

Unit-I

Introduction to LPP, Mathematical formulation, Standard form and canonical form, Graphical solution, Simplex Method including Big-M and two phase method, Degeneracy and Revised simplex method.

Unit-II

Dual simplex method with justifications, Duality in Linear Programming, Duality Theorems, Fundamental Theorem of Duality, Transportation and Assignment algorithms.

Unit-III

Introduction to Sensitivity Analysis, variation in cost and requirement vectors, coefficient matrix and applications, Parametric Programming Problems.

Unit-IV

Game Theory, Two persons zero sum game, Maxmin Minimax principle, Mixed strategy, Graphical solutions, Dominance Property, Arithmetic Method and general solution.

Books for Reference:

1. N. S. Kambo (1991) : Mathematical Programming Tech., Affiliated East-West press.
2. G. Hadley (1987): Linear Programming
3. H. A. Taha (l992) :.Operations Research, 5th Ed. (McMillan)
4. P. Rama Murty, Operations Research, New Age International, 2nd Edition (2007).
5. F. S. Hillier, G. J. Lieberman, Introduction to Operations Research, McGraw-Hill International, 9th Edition.
6. K. Swarup, Operations Research, Sultan Chand & Sons, 12th Edition.

FUNCTIONAL ANALYSIS
Course No: MAT-532

Objective: This is the basic course for all Advance Analysis courses. Students are introduced to different function spaces like Banach Spaces, Hilbert Spaces etc. Students will also be exposed to Bounded Linear Operators on Banach Spaces and its spectral Analysis and unbounded operators. Real Analysis and Measure Theory Integration are the pre requisite courses for this.

Expected Outcome: On successful completion of the course, students can opt for courses like Operator Theory, Harmonic Analysis, Spectral Theory, Scattering Theory, Representation Theory etc.

Unit – I

Review of Metric spaces, Lp spaces, Inequalities in Lp -spaces, Completeness of Lp. Normed linear spaces, inner product spaces examples, properties of Normed linear spaces and inner product spaces, Continuity of linear maps.

Unit –II

Hilbert spaces, Examples, orthonormal sets, Gram-Schimdt orthonormalizations, orthonormal polynomials, Bessel‟s inequality, Riesz-Fischer Theorem, Orthonormal basis, Fourier Expansion, Parseval‟s formula, Projection theorem, Riesz Representation Theorem.

Unit – III

Banach Spaces, Hahn Banach Theorem, Baire‟s category theorem, Open mapping Theorem, Closed graph theorem, Uniform boundedness Principle, duals and transpose duals of $Lp[a, b]$ and C[a,b], Reflexivity.

Unit – IV

Bounded Linear Operators on Banach Spaces, Banach algebra, definition, Examples, Spectrum of a bounded operator, Resolvent Set, Compact operators on Banach spaces, spectrum of a Compact operator, Elementary ideas on integral equations, Unbounded Operators and fixed point theorems.

Books for Reference:

1. Kreyszig-Functional Analysis -John Wiley, 1978.
2. Limaye -Functional Analysis, 3rd Ed, 2014.
3. Goffman and Pedrick A first Course in Functional Analysis- Prentice Hall (1 June 1965)
4. Bachmen and Narici, Functional Analysis, Dover Publications Inc.; 2nd edition edition (28 March 2003).

PARTIAL DIFFERENTIAL EQUATIONS
Course No: MAT-533

Objective: The objective of this course is to understand basic methods for solving Partial Differential Equations first order and second order. In the process students will be exposed to Charpit's Method, Jacobi Method and solve wave equation, heat equation, Laplace Equation. They will also learn classification of Partial Differential Equation and handle boundary value problems.

Expected Outcomes: After completing this course, a student will be able to take more courses on wave equation, heat equation, diffusion equation, gas dynamics, non linear evolution equations and integrable models etc. All these courses are importance in engineering and industrial application and in defence problems.

Unit – I

Meaning of Partial differential equation, Classification of first order Partial differential equations, Semi-linear and quasi-linear equations, Pfaffian differential equations, Lagrange's method, Compatible systems, Charpit's method, Jacobi's method,

Unit-II

Integral surfaces passing through a given curve, Cauchy problem, method of characteristics for quasi-linear and non linear partial differential equation, Monge cone, characteristic strip. First order non-liner equations in two independent variables , Complete integral.

Unit – III

Linear Second order partial Differential Equations : Origin of second order PDEs, Classification of Second order Partial Differential Equations., One dimensional Wave equation, Vibration of an infinite string, origin of the equation, D'Alembert's solution, Vibrations of a semi finite string, Vibrations of a string of finite length, existence and uniqueness of solution, Riemann method,

Unit - IV

Laplace equation , Boundary value problems, Maximum and minimum principles, Uniqueness and continuity theorems, Dirichilet problem for a circle, Dirichlet problem for a circular annulus, Neumann problem for a circle, Theory of Green's function for Laplace equation, Heat equation, Heat conduction problem for an infinite rod, Heat conduction in a finite rod, existence and uniqueness of the solution, Kelvin's inversion theorem, Equipotential surfaces.

Books for Reference:

1. Ian Sneddon, Elements of Partial Differential Equations, International Students Edition.
2. Phoolan Prasad and Renuka Ravindran, Partial Differential Equations, New Age International, 1985.
3. F. John - Partial Differential Equations, Springer-Verlag, New York, 1978.
4. Tyn-Myint-U - Partial Differential Equations North Holland Publication, New York, 1987.
5. T. Amarnath- An elementary course in partial differential equation, Narosa, 1997.
6. J. N. Sharma, K. Singh, Partial Differential Equations for Engineers and Scienists, Narosa, 2nd Edition.

PROGRAMMING LABORATORY - III
Course No: MAT-534

The Candidate should be able to do the following programmes by using C++ Language

1. Matrix Algebra:
   a. Matrix addition using function or pointer
   b. Matrix multiplication using function or pointer
   c. Matrix Inverse
2. Solution of System of linear equation by following method

a. Gauss Elimination Method
b. Gauss Seidal iteration Method
c. Gauss Jordan Elimination Method

3. Rank of a matrix
4. Determinant of a Matrix
5. Solution of System of linear equation by Crammers Rule
6. Eigen value and Eigen vector of a matrix
7. Differential Equations: Solution of Initial value problem using following methods :
   a. Euler"s Method
   b. Backward Euler Method

c. Eulere-Richardson‟s Method
d. Second order Ranga-Kutta Method
e. Milne‟s predictor corrector Method
f. Gauss predictor corrector Method

8. Solution of boundary value problem.
9. Following curve should be trace using ”graphic.h” in C
   (i) Circle (ii) Elipse (iii) Hyperbola (iv) Sine Curve (v) Cosine curve (vi) Cissoid (vii) Cardioid (r = a(1+cos(t)) (viii) Limacon (r= a+bcos(t)) (xi) Laminscate ($a(x^2 + y^2) = (x^2 + y^2)^2$)
10. Linear Programming Problem:
    a. Solution of LPP by Simplex Method
    b. Solution of LPP by Revise Simplex Method
11. Transportation Problem
12. Assignment Problem:The students may use Mathematica, matlab to run some of the above program

Semester – IV

DIFFERENTIAL GEOMETRY

Course No: M-541

Objective: After a course in Analytic Geometry and Differential geometry of curves at undergraduate level, Differential Geometry is a core component of a post graduate syllabus which introduces the methods of differential manifolds, tensor analysis, vector fields, Lie Group, Lie Algebra etc. The objective is to prepare the students for further coursework and research in geometry in future.

Expected Outcome: After completing this course, a student can opt for a course on Lie Group, Lie Algebra, Symplectic Geometry, Poisson Geometry, Global Analysis, Several Complex Variable, Hyperbolic Geometry, Projective and Algebraic Geometry and all these courses are main component for Mathematical Physics, Relativity, Cosmology and Standard Models.

Unit-I

Review of calculus in Rn ,Inverse and implicit function theorem, Rank theorem. Review of local theory of curves and surfaces, Serret Frenet formula, First fundamental forms, second fundamental form, Normal curvature, Geodesic curvature, Gauss formula, , Weiengarten map, principal curvatures, Gaussian curvature, mean curvature , motivation of global theory, Gauss Bonnet formulae.

Unit-II

Introduction to Manifolds, Differential manifolds, Examples, Submanifolds, Tangent vector and tangent space at a point of the manifold, cotangent spaces, vector fields, Lie bracket, Lie algebra, Definition and example of Lie groups, Integration on manifolds, Stoke’s theorem.

Unit-III

Multi linear Algebra: Dual space, tensor of type(r.s), Operations with tensors, contractions, quotient law of tensors, metric tensor, associated tensors, symmetric and antisymmetric tensors, Exterior forms, Wedge product , Exterior Algebra, Exterior derivative, Exact forms, Closed forms.

Unit-IV

Affine connection of manifolds, parallel transport, Intrinsic derivative, covariant derivative, curvature tensor, Riemannian metric, Riemannian manifold, Fundamental theorem of Riemannian Geometry, Levi Civita Connection, Riemann Curvature tensor and properties, Bianchi identities, Scalar curvature, applications to relativity.

Books for Reference:

1. Wilmore- Differential and Riemannian geometry, Oxford University Press, 1996.
2. A. Pressley, Elementary differential geometry, Springer international edition, 2014
3. U.C De & A.A Shaikh, Differential Geometry of Manifolds, Narosa, 2009.
4. Warner-Foundations of differential geometry and Lie groups Springer, 1983.
5. Boothby - An introduction to differential and Riemannian geometry, Academic Press; 2 edition (8 September 2002)
6. Thorpe-Introduction to Differential geometry, Springer verlag, 1979

MATHEMATICAL METHODS
Course No: MAT-542

Objective: The objective of this course is to prepare a student in basics of Integral transforms, Integral equations and calculus of variations. These tools have engineering applications. Fourier transform and Laplace transform help in studying differential equations and other engineering problems. Calculus of variations and Euler equations are essential in understanding many physical problems and optimization problems.

Expected outcomes: A student trained in this course can opt for courses like digital signal processing, variational analysis, Wavelets. This exposes the application of mathematics to various real life problems.

Unit-I

Laplace transforms: Definitions, Properties, Laplace transforms of some elementary functions, Convolution Theorem, Inverse Laplace transformation, Applications. Fourier transforms, Definitions, Properties, Fourier Transforms of some elementary functions, Convolution, Fourier transforms as a limit of Fourier Series, Applications to PDE.

Unit-II

Volterra Integral Equations: Basic concepts, Relationship between Linear differential equations and Volterra integral equations, Resolvent Kernel of Volterra In- tegral equations, Solution of Integral equations by Resolvent Kernel, The Method of successive approximations, Convolution type equations, Solutions of integral differential equations with the aid of Laplace transformations.

Unit-III

Fredholm Integral equations: Fredholm equations of the second kind Fundamental, Iterated Kernel, Constructing the resolvent Kernel with the aid of iterated Kernels, Integral equations with degenerate Kernels, Characteristic numbers and eigen functions, solution of homogeneous integral equations with degenerate Kernel- non homogeneous symmetric equations Fredholm alternative.

Unit-IV

CALCULUS OF VARIATIONS: Extremal of Functionals : The variation of a functional and its properties , Euler‟s equations, Field of extremals, Sufficient conditions for the Extremum of a Functional conditional Extremum Moving boundary problem, Discontinuous problems, one sided variations, Ritz method.

Books for Reference:

1. Sneddon I., The use of Integral Transformations (Tata McGraw Hill), 1972.
2. Murray R Spiegel, Schaum‟s Series, Laplace Transforms, 1965.
3. Gelfand and Fomin, Calculus of Variations, Dover Pub, 2003.
4. Krasnov, Problems and Exercises in Calculus of Variations(Mir Publ), 1970
5. Ram P Kanwa, Linear Integral Equations (Academic Press), 2013.
6. A. J. Jerri, Introduction to Integral Equations with Applications, John-Wiley & SONS, INC., 1999.

SYLLABUS OF ELECTIVES
ANALYTIC NUMBER THEORY

Objectives: A course in Number theory is a must solicited course every mathematics students for its beauty and clarity. The objective of the present course is to expose students to basics of Analytic Number Theory, Arithmetic Function, Distribution of Prime Number, Riemann Zeta function and work of Ramanujam.
Expected Outcomes: At the end of the course students are expected to get interested to solve challanging problems in Number Theory. They will be able to collect and utilize Numerical Information to shape conjuctures in Number Theory. This also prepares to opt for courses in Cryptography, Algebraic Number Theory and Ramanujams Works.

Unit-I

Fundamental Theorem of arithmetic, Arithmetical functions and Dirichlet Multiplication

Unit-II

Average of arithmetical function, Elementary theorem in distribution of primes numbers

Unit-III

Congruences, quadratic residues and Reciprocity law.

Unit-IV

Ramanujan Sum. Reimann zeta function

Books for Reference: -

1. Tom. M. Apostal An Introduction to Analytic Number Theory, Springer, 1976. Chandra Shekharan K. Introduction to Analytic Number Theory.
2. G.H. Hardy and E.W. Wright. Theory of Numbers, Oxford University Press; 6 edition , 2008.
3. I. Niven and H.S. Zukerman An Introduction to Theory of Numbers.
4. Richard Guy -Unsolved Problems in Number Theory. Springer Verlag, John Wiley and Sons; 5th Revised edition edition , 1991.

ALGEBRAIC TOPOLOGY

Objective: The objective of this course is to augment to the course in topology using methods in Group theory and Ring theory. This course has a intrinsic application value having applications in network analysis. The homotopy theoretic method in differential equations and concept of homology and co-homology help in modelling in Physics. The students is exposed to Simplective Homology Groups, Co-homology and Homotopy in this course.

Expected Outcome: A students can take followup courses in co-homology theory, homotopy theory, homology theory, category theory. This course has application in Graph Theory and Networking also.

Unit-I

Motivation and Historical background. Geometric complexes and Polyhedra, Orientation of simplex, simplicial Complexes and Simplicial maps. Review of Abelian Grourps, chains, Cycles, Boundary, Homology groups of simplicial complexes, examples of Homology groups, Structure of Homology groups, Relative Homology groups, Euler Poincare theorem.

Unit-II

Homology Groups of Sn , Homology of cone, relative Homology, Simplicial Approximation, Barycentric Subdivision, induced Homomorphism, Exact homolgy sequences, Mayer Vietories sequences, Eilenberg Steenrod Axioms.Singular Homology theory ,Axioms of singular the- ory,Excision in homology theory

Unit-III

Cohomology,Simplicial cohomology groups,Relative cohomology,cohomology theory,Cohomology of free chain complexes,Cup products,CW complexes the cohomology of CW complexes,Join of two complexes, Homology manifolds, Poincare duality, cap products

Unit-IV

Homotopic path, fundamental Groups, Covering Homotopy property for S" Examples of Fun- damental groups, Relation between H1(K) and *1(*K *) , Definition of covering spaces classification of covering spaces, Basic Properties of Covering Spaces.

Books for Reference:

1. Munkres, Elements of Algebraic Topology,Perseus Books; Re- vised ed. edition (11 December 1995)
2. Rotman, Algebraic Topology Springer Verlag, 1988.
3. Croom, Basic Concepts of Algebraic Topology. Springer, 1978
4. Spanier, Algebraic Topology Springer Verlag, Springer; 1966 edition (22 December 1994)
5. Vick, Homology theory Springer; 2nd ed. 1994 edition (25 January 1994).
6. Massy, Algebraic Topology, Springer (January 8, 1990).

ADVANCED COMPLEX ANALYSIS

Objective: This course is aimed to provide some selected topics in complex analysis for functions of a complex variable. This course is designed for students who have completed a basic course in complex analysis in their under graduate or post graduate level. As a pre-requisite to this course students are required to have a reasonable mastery of analytic properties of complex functions. The content of the course mainly covered the notion of harmonic and sub harmonic functions; entire functions; meromorphic functions and elliptic functions.

Expected outcomes: After completing this course, students are expected to be able to

- Know the harmonic analogue of analytic functions. Able to explain the concept, state and prove theorems and properties involving harmonic and sub harmonic functions. For example, able to recognize and apply Poisson Integral, Mean Value theorem, Maximum and minimum modulus theorem for harmonic and sub harmonic functions. This may help a student to continue higher study on potential theory.
- Construct entire functions as well as meromorphic functions when information about the zeros and poles respectively, are given. It provide a platform to continue more study on the growth and order of entire and meromorphic functions. Able to continue higher study on Nevannlina theory.
- Know the properties of double periodic functions mainly elliptic functions. Can able to know the behavior of Weirstrass P-function, Riemamm zeta function, gamma functions, Psi functions, etc. This will motivates the student to work on other directions of complex analysis, analytic number theory and modular functions.
- Completions of this course ultimately open up higher studies in many directions related to complex analysis in general.

Unit-I

Analytic continuation: direct analytic continuation, Natural boundary, function elements, complete analytic function, Harmonic functions, Harmonic functions in the disk, mean value theorem, Poisson integral, maximum/minimum principle for harmonic functions, Hrnack‟s in- equalities, reflection principle for harmonic functions, Dirichlet problems for upper half plane, Normal family, equicontinuity.

Unit-II

Entire function: Product development, Zeros of entire functions, Weierstrass factorization the- orem, exponent of convergence of zero of entire function, Genus, order and type of entire functions, Poincare theorem, Borel theorem, Hadamard theorem, entire functions with finitely many zeros.

Unit-III

Meromorphic functions: Mittag-Leffler representation of a meromorphic function, Gamma function, Digamma functions and their properties, Riemann zeta functions, Analytic continu- ation of zeta function, Poisson- Jensen"s formula, Nevanlinna first fundamental theorem, order and type of meromorphic functions.

Unit-IV

Elliptic functions: doubly periodic functions, General properties of elliptic functions, Weier- strass P-function, ?-function and ?-function, addition theorem for P and ?-function, Elliptic Modular functions.

Book for Reference:

1. Mario O. Gonzalez, Complex Analysis selected topics: Pure and applied mathematics. A series of Monographs and Textbooks, Dekker Publication. 1992.
2. J.B.Conway, Functions of one complex variable, Springer International student edition, 1978.
3. Lars V. Ahlfors, Complex Analysis, McGraw-Hill Int. edition, 1979.
4. G. Sansone and J. Gerretsen, Noordhoff, Groningen,Lectures on theory of functions of complex variables, Vol. I, II, 1960
5. Robert E. Greene and S.G.Krantz, Function theory of one complex variables, 3rd Edition, AMS

COMBINATORICS

Objective: Combinatorial tools play a major role in any computational activity in mathematics starting from pure mathematics to computer science. They help in proving many results and identities in almost all branches of mathematics. This course aims at being a basic course introducing basic methods.

Expected Outcomes: A student who has completed this course can opt for new courses like combinatorial topology, combinatorial geometry and analysis in next semester or at higher level of doing mathematics.

Unit-I

Partial order sets, lattices, complements, Boolean algebra, Boolean expressions, counting principle, permutation, combination, multinomial theorem, set partitions, derangements, Stirling numbers.

Unit-II

Pigeon-hole principle, generalized inclusion-exclusion principle, Generating functions: Algebra of formal power series, generating function models, calculating generating functions, exponential generating functions, Recurrence relations, divide and conquer relations, solution of recurrence relations, solutions by generating functions.

Unit-III

Integer partitions, systems of distinct representatives, Polya theory of counting: Necklace problem and Burnside‟s lemma, cyclic index of a permutation group, Polya‟s theorems and their immediate applications.

Unit-IV

Latin squares, Hadamard matrices, Gaussian numbers and q-analogues, Mobius Inversion, combinatorial designs: t-designs, BIBDs, Symmetric designs.

Book for Reference:

1. Lint, J. H. van, and Wilson, R. M.: "A Course in Combinatorics", Cambridge University Press , (2nd Ed.) , 2001.
2. V. K. Balakrishnam, Theory and problems of combinatories, McGraw-Hill, 1994.
3. Sane, S. S.: "Combinatorial Techniques", Hindustan Book Agency , 2013
4. Brualdi, R. A.: "Introductory Combinatorics", Pearson Education Inc. (5th Ed.),2009
5. Krishnamurthy, V.: "Combinatorics: Theory and Applications", Affiliated East-West Press, 1985.
6. Hall, M. Jr.: "Combinatorial Theory", John Wiley & Sons (2nd Ed.), 1986.

Cryptography

Objectives:

- Enable the students to learn fundamental concepts of cryptography and utilize these techniques in computing systems.
- To acquire knowledge on standard algorithms used to provide confidentiality, integrity and authenticity.
- To understand the various key distribution and management schemes

Expected Outcomes: Upon successful completion of this course students will be able to

- Have a strong background of cryptography which has diverse practical applications.
- Encrypt and decrypt messages using block ciphers, sign and verify messages using well known signature generation and verification algorithms.
- Analyse existing authentication and key agreements.
- Develop their skills in the programming of symmetric and/or asymmetric ciphers and their use in the networks.

Unit-I

Some Simple Cryptosystems: The Shift Cipher, Substitution Cipher, Affine Cipher, Vigenere Cipher, Hill Cipher, Permutation Cipher, Stream Cipher. Cryptanalysis of Affine Cipher, Cryptanalysis of Substitution Cipher, Cryptanalysis of Vigenere Cipher, Cryptanalysis of Hill

Cipher.

Unit-II

Linear Cryptanalysis, Differential Cryptanalysis, Basic Encryption and Decryption, Encryption Techniques, Characteristics of Good Encryption Systems, International Data Encryption Algorithm, Shannon‟s Theory: Elementary probability theory, perfect secrecy, Entropy, Properties of Entropy, Product cryptosystems.

Unit-III

Public Key Cryptography, The RSA Cryptosystem, Primality Testing, Square roots modulo m, Factoring Algorithms, Other attacks on RSA, Finite fields, Elliptic Curves.

Unit-IV

Secret Key Cryptography, Diffie-Hellman Key Pre-distribution, Key Distribution Patterns, Diffie-Hellman Key Agreement. Pseudo-random Number Generation, BBS generator, Probabilistic Encryption, Digital Signatures , One-time Signatures, Rabin and ElGamal Signatures Schemes, Digital Signature Standard (DSS).

Recommended Books:

1. Stinson, D. R., CRYPTOGRAPHY: Theory and Practice, CRC Press, 1995.
2. Stallings, W., Cryptography and Network Security, 5 th Edition, Pearson, 2010.
3. Koblitz , N., A Course in Number Theory and Cryptography, Graduate Texts in Mathematics, New-York: Springer-Verlag, 1987.

DATA STRUCTURE

Objective: Data Analysis has become the spine of all computational and statistical research having major contributions in social sciences, computer science and day to day life. Data structure is taught as a first course in Data analysis to expose the students to basics.

Expected outcomes: The students completing this course in Data structure can go for advance courses in Data structure, Data base management and can be introduced to machine learning and artificial intelligence courses if he has already taken some programming courses.

Unit-I

What are data structures, Java Refesher, JAVA refresher and generics, Analysis Tools and Techniques, Algorithm Analysis, Mathematical Background, Model, Running Time Calcula- tions

Unit-II

Abstract Data Types (ADTs), vector and list in the STL, Linked lists and Iterators, Stacks and Queues, The Stack ADT, The Queue ADT

Unit-III

Binary Trees, The Search Tree ADTBinary Search Trees, AVL Trees, Splay Trees, B-Trees, Hash Function, Separate Chaining, Hash Tables Without Linked Lists, Rehashing

Unit-IV

Priority Ques, Models, Simple Implementations, Binary Heap, Applications of Priority Queues, d-Heaps, Sorting, Graph

Books for Reference:

1. M. A. Weiss. Data Structures and Algorithm Analysis in C++ (3rd edition), by Addison- Wesley
2. Alfred V. Aho, Jeffrey D. Ullman, John E. Hopcroft. Data Structures and Algorithms. Addison Wesley, 1983.
3. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein. Introduction to Algorithms. McGraw-Hill, 2001.
4. Donald E. Knuth. The Art of Computer Programming, Volumes 1-3. Addison-Wesley Professional, 1998.

DISCRETE DYNAMICAL SYSTEMS

Objective: The evolution of a point in time under a map has caused major studies in Mathematics introducing Discrete Dynamical System. The concept of Fatou Sets, Julia Sets, Cellular automata, Fractals Horseshoes, Hyperbolic dynamics has added many new results and has evolved many new modelling techniques. The objective of the course is to expose the students to this new direction.

Expected Outcome: This first course will train the students in understanding topological dynamics essentially and will help in opting for new course on Fractal Geometry, Bifurcation, Cellular Automata, Julia Set etc. later. This will also help in going for a second course in continuous dynamical system and its application to differential equations.

Unit-I

Phase Portraits, Periodic Points and Stable Sets, Sarkovskii‟s Theorem, Hyperbolic, Attracting and Repelling Periodic Points. Families of Dynamical Systems, Bifurcation, Topological Conjugacy. The Logistic Function, Cantor Sets and Chaos, Period-Doubling Cascade

Unit-II

More examples,Rotations, Horse shoes ,solenoid Limit sets and recurrence, topological transi- tivity,topological mixing, expansiveness

Unit-III

Topological entropoy, examples . Symbolic Dynamics. Sub shifts and codes, subshifts of finite type,topological entropy of an SFT, Newton‟s Method. Numerical Solutions of Differential Equations

Unit-IV

Complex Dynamics, Quadratic Family, Julia Sets, Mandelbrot Set. Topological Entropy, At- tractors and Fractals, Theory of Chaotic Dynamical System.

Books For Reference

1. Richard M. Holmgren: A First Course in Discrete Dynamical Systems,Springer Verlag,1996.
2. Devaney : Introduction to Chaotic Dynamical Systems.

FOURIER ANALYSIS

Objective: This is a basic course in Fourier series. It is designed so as to know the conditions under which Fourier series expansion of a function exists, to study on criteria for convergence and summability of Fourier series. It gives an idea how knowledge of Fourier series helps to define Fourier transform and to study its convergence and summability. Basic of Discrete Fourier series as also introduced. The pre requisite courses for this is real analysis, complex analysis and Functional analysis. This course carries its importance since more than century because of its vast application and analytic beauty.

Expected Outcomes: This course prepare a students to go for courses in Fourier Trnasform, Wavelets, Image Processing and Harmonic Analysis. Using Dirichlet conditions students can evaluate infinite series. Students can directly be exposed to state of the art research problem in this area.

UNIT-I

Fourier Series: Trigonometric series, Fourier Series, Fourier Sine Series and Cosine Series, Other type of whole range series, Half range series, Uniqueness of Fourier series, The Riemann- Lebesgue Lemma, Dirichlet Kernel, Criterion and tests for Pointwise convergence of Fourier Series, Dirichlet"s Pointwise convergence theorem.

UNIT-II

Convergence of Fourier Series:, Uniform convergence, The Gibb"s phenomenon, Termwise inte- gration, Termwise differentiation, Cesaro summability, Toeplitz summability, Abel summabil- ity, Fejer Theory, Smoothing effect of (C,1) Summability, Lebesgue"s Pointwise convergence.

UNIT-III

Fourier transform: Finite Fourier transform, Convolution on T, Fourier transform, Basic properties of Fourier transform, The Fourier map, Convolution on R, Inversion, Criterion and tests for convergence of Fourier integral formula, (C,1) summability for Integrals.

UNIT-IV

The Fejer-Lebesgue Inversion theorem, Integrability of Fourier Transform, Transforms of Deriva- tive and Integrals, Fourier Sine and cosine transforms, Parseval"s identities, The Plancheral theorem, Discrete Fourier transform(DFT), Inversion theorem for the DFT, Parseval"s Identi- ties.

Book for Reference:

1. G. Bachman, L. Narici, E. Beckenstein, Fourier and Wavelet Analysis, Springer,2000.
2. I.N. Sneddon, Fourier Series by Dover Publications, 1969.
3. Lokenath Debnath and Dambaru Bhatta, Integral Transforms and Their Applica- tions, Chapman and Hall/CRC, New York, 2007.
4. Fourier Analysis, T.W. Korner, Cambridge University press, 1988.
5. Elian M Stein and Rami Shakarchi, Fourier Analysis: An Introduction, Princeton Lectures in Analysis, Princeton University Press, Princeton and Oxford, 2003.

GRAPH THEORY

Objectives: Graphs are used to model networking problems in physical and biological sciences etc. As an essential tools in computer and information sciences, the concepts in Graph Theory address problems of social media, linguistics, chemical bonds, computational neuro science, market and financial analysis, communication system, data organisation, flows and links. The objective of this course is to introduce the basic of Graph Theory to students.

Expected Outcomes: A course in Graph Theory is prerequisite to almost all courses and research in computer science. Besides it has applications to other branches in mathematical sciences. A student can opt for Matroid theory, Network Analysis, Algorithm and Data Analysis courses after completing this course.

Unit- I

Definition and Examples, Connectedness, Walk, Path circuits, Euleriar graph, Hamiltonian graph, Some application.

Unit- II

Trees: Elementary proportion of trees, Enumeration of trees, More application. Cut sets:- Fundamental circuits and cut-sets, network flows, 1-isomorphism, 2-isomorphism.

Unit- III

Planarity:- Kuratowski two graphs, detection of planarity, geometric dual, thickness and cross- ing.

Unit- IV

Coloring problems, chromatic number, four color problem. Directed graph: Digraphs and bi- nary relations, Euler digraphs.

Books for Reference:

1. N. Deo Graph Theory and its Application to Engineering and Computer Science, PHI, 1979.
2. F. Harary Graph Theory, Addison Wesley Publishing company, 1969.
3. R. J. Wilson Introduction to Graph Theory, Longman Group Ltd., 1985 .

MECHANICS

Objective: This course is aim to be a second course to the existing undergraduate courses. They will introduce Lagrangian and Hamiltonian mechanics with all necessary Geometric pre requisites like differential Geometry and Symplectic Geometry.

Expected Outcome: This course can be followed by courses in Integrable models, foundation of Mechanics, Celestial Mechanics etc. This prepares an adequate mathematical background for understanding any research papers in Mechanics.

Unit- I

Newtonian Mechanics : Experimental facts, Investigation of Equation of Motion.

Unit- II

Lagrangian Mechanics : Variational Principles, Lagrangian Mechanics on Manifolds,

Unit- III

Oscillations, Rigid Bodies.

Unit- IV

Himiltonian Mechanics : Differential forms, SimplCetic structure on manifolds

Books for Reference

1. Ordinary Differential Equations V. I. Arnold, Springer, 1992.
2. Mathematical Methods in Classical Mechanics" by V.I. Arnold. Springer Verlag, 1978.

MATHEMATICAL MODELING

Objective: Apart from getting exposed to pure forms of mathematical abstractions, the objective of the course is to expose the students to hands on state of the art methods in modeling, real life situations in industry, Biology and nature.

Expected Outcomes: This course is based on modelling using elementary mathematics and differential equations. This can lead to more modelling courses using stochastic process, Discrete dynamical system, Optimization methods, finite elements, wavelets learning techn

UNIT-I

Need, Techniques, Classification and Characteristics of Mathematical Modeling. Mathematical modeling through first order ODE: Linear and nonlinear growth and decay model, Compartment model, Model of geometrical problems, Prey-Predetor model through delay-differential equations.

UNIT-II

Mathematical modeling through system of first order ODE: Modeling on population dynamics, Epidemic model, Compartment models, Modeling on Economics, Model in medicine, Models in arms race and battles.

UNIT-III

Mathematical modeling through second order ODE: Modeling of Planetory motion, circular motion, Motion of satellite. Modeling on rectilinear motion, freely falling body, oscillation of pendulum. Mathematical modeling on the Catenary.

UNIT-IV

Mathematical modeling through integral equations. Mathematical modeling through PDE: One dimensional wave equation, One dimensional heat equations, Two dimensional heat equations and Laplace equations.

Books for Reference

1. D. N. Burghes- Modeling through Differential Equation, Ellis Horwood and John Wiley.
2. C. Dyson and E. Levery, Principle of Mathematical Modeling, Academic Press New York.
3. Giordano, Weir, Fox, A First Course in Mathematical Modeling 2nd Edition, Brooks/ Cole Publishing Company, 1997.
4. J. N. Kapur, Mathematical Modeling, Wiley Eastern Ltd. 1994.
5. B. Barnes, G. R. Fulford, *Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab,* 2nd Ed., Taylor and Francis group, London and New York, 2009.

OPERATOR THEORY

Objective: The dominance of operator methods in foundation of quantum mechanics and the success of spectral analysis and scattering methods and the evolution of operator algebras has found operator theory as an essential course at post graduate level. The objective of the course is to introduce basic operator theoretic methods as a second course to functional analysis.

Expected Outcomes: This course prepare a student to take a second course in operator algebra, Differential operators, Spectral theory, scattering theory, Fundamental solutions quantum probability etc. This is highly applicational. This course open ways to different research areas in this branch particularly and also in the area of functional analysis broadly, like representation theory , operators on different function spaces etc..

Unit- I

Banach Algebra : Introduction , Complex homomorphism Basic properties of spectra, Com- mutative Banach Algebra : Ideals, Gelfand transform, Involution, Bounded operator.

Unit-II

Bounded Operator : Invertibility of bounded operator, Adjoints, Spectrum of bounded op- erator, Fundamentals of spectral Theory, Self adjoint operators, Normal, Unitary operators, Projection Operator, introduction to complex measure, Resolution of the Identity.

Unit- III

Spectral Theorem, Eigen Values of Normal Operators, Positive Operators, Square root of Positive operators, Partial Isometry, Invariant of Spaces, Compact and Fredholm Operators, Integral Operators.

Unit- IV

Unbounded Operators : Introduction, Closed Operators, Graphs and Symmetric Operators, Cayley transform, Deficiency Indices, Resolution of Identity, Spectral Theorem of normal Op- erators, Semi group of Operators.

Books for Reference

1. Walter Rudin, Functional Analysis, Tata McGraw Hill, 2010.
2. Walter Rudin, Real and Complex Analysis, Tata McGraw Hill, 2010.
3. R.G. Douglas, Banach Algebra Techniques in Operator Theory, Springer,1997.
4. Gohberg and Goldberg Basic Operator Theory, 2001.
5. M. Schecter, Principle of Functional Analysis, American Mathematical society, 2002.
6. Akhietzer and Glazeman Theory of Linear Operator, Vol I, II ,Pitman Publishing House,1981.
7. Donford and Schwarz, Linear Operator, vol. 1. 2. 3., 1988.
8. Weidman J, Linear Operators on Hilbert Spaces, Springer, 1980.

OPTIMISATION TECHNIQUES-II

Objective: Optimization Technique-II is an advanced study in technology world with the knowledge of Optimization Technique-I. In particular, this topic keeps one more step forward in the field of industrial revolution.

Expected Outcomes: This topic enhances the development in global industrial process which is expected to affect the global economics with a new look.

Unit-I

Markov process, transition matrix, transition diagram, construction of transition matrix, n- step transition prob. Equilibrium condition, Markov analysis algorithm, Nerwork Scheduling by PERT/CPM.

Unit-II

Inventory decision, cost associated with inventory, Factors affecting inventories, EOQ, Deter- ministic inventories with no shortage and with shortage, inventory with uncertain demand, System of inventory control, Probabilistic inventory problems.

Unit-III

Queuing system, Operating characteristic, probability distribution, Classification of queuing models, Transient and Steady state, Poisson and Non-Poisson Queuing System, Cost model in queuing, Queuing control, Queuing Theory and Inventory control.

Unit-IV

Formulation of Non Linear programming, Constrained optimization. with equality constraint and inequality constraint, Saddle point and NLLP. Graphical solution, Kuhn- Tucker conditions, Quadratic Programming,Wolfes‟ and Beales‟ method.

Books for Reference:

1. Kambo.,NS : Mathemetical Pro.gramming Tech., Affiliated East- West press,1991.
2. Hadley, G. , Linear Programming, Narosa, 1987.
3. Taha H.A., Operations Research, 5th Ed. , McMillan,1992.