Department of Mathematics
NIT Kurukshetra

Mathematics Curriculum

(*July-2017 Onwards*)

B.Tech. 1st year,

B.Tech. 2nd year

and

Pre-Ph.D. Programmes

Contents

<u>Examination Scheme</u>: B.Tech. Ist Semester(Common to all Branches)

CourseNo.	Subject	TeachingSchedule				
		L	T	P/D	Total	CreditPoints
MAIR11 w.e f. July 2017 MAIC11 w.e f. July 2022	Differential Calculus and Differential Equations	3	1	-	4	4

<u>Examination Scheme</u>: B. Tech. 2nd Semester (CommontoallBranches)

CourseNo.	Subject	TeachingSchedule				
		L	T	P/D	Total	CreditPoints
MAIR12 w.e f. July 2017 MAIC12 w.e f. July 2022	Integral Calculus and Difference Equations	3	1	-	4	4

Examination Scheme: B. Tech. 3rd Semester

CourseNo.	Subject	TeachingSchedule				
		L	T	P/D	Total	CreditPoints
MAIR21	Applied Numerical and Statistical Methods (CE, ME)	3	1	-	4	4
MAIR24	Discrete Mathematics (CS, IT)	3	1	-	4	4

<u>Examination Scheme</u>: B. Tech. 4th Semester

CourseNo.	Subject	TeachingSchedule				
		L	**T**	**P/D**	**Total**	**CreditPoints**
MAIR21	Applied Numerical and Statistical Method (PIE)	3	1	-	4	4
MAIR22	Applied Linear Algebra (EE)	3	1	-	4	4
MAIR23	Complex Analysis and Partial Differential Equations (ECE)	3	1	-	4	4

Course Offered in Pre Ph.D. Programme:

Course No.	Subject	CreditPoints
Institutional Requirement		
MAIR-701T	Research Methodology	4
Open Elective (Any Three)		
MAT-703T	Applied Numerical Analysis	3.5
MAT-704T	Advance Numerical Techniques	3.5
MAT-706T	Algebra	3.5
MAT-708T	Lie Theory and Special Functions	3.5
MAT-710T	Mathematical Analysis	3.5
MAT-712T	Ferro Hydrodynamics	3.5
MAT-714T	Boundary Layer Theory	3.5
MAT-716T	Mechanics of Deformable Bodies	3.5
MAT-718T	Statistical Techniques	3.5
MAT-720T	Stochastic Processes and Their Applications	3.5
MAT-722T	Reliability theory and Survival Analysis	3.5

Course Code: MAIC 11

Course Title: Differential Calculus and Differential Equations

Number of Credits: 4

Pre-requisites: The basic knowledge of matrix theory, Limit, Continuity, Differentiability for functions of one variable, Basic knowledge of ordinary differential equations of first order and first degree.

Course Type: IC

Course Objectives:

- To understand matrix algebra and its applicability in different engineering fields.
- To incorporate the knowledge of calculus and its subsequent engineering applications.
- To be able to form and solve the ordinary differential equation with engineering applications.
- To have the idea of Laplace transforms with engineering applications.

Unit 1: Matrix Theory **9L hours**

Matrices, Related matrices, Rank of a matrix, Linear dependence and independence of vectors, Consistency of linear systems of equations, Solution of linear system of equations, Eigen value problem, Eigen values and Eigen vectors with their properties, Cayley-Hamilton theorem and its applications, Similarity of matrices, Diagonalization of a real symmetric matrix, Quadratic form and their reduction to canonical form.

Unit 2: Multivariable Calculus **9L hours**

Limits, continuity and differentiability of multivariable functions, Partial differentiation and its geometrical interpretation, Total differential, Composite function, Taylor's and Maclaurin's expansion for the functions of two variables, Maxima and minima, Lagrange's method of undetermined multipliers, Jacobian, Difference between total derivative and Jacobian.

Unit 3: Ordinary Differential Equations

9L hours

Linear higher order ordinary differential equations with constant coefficients, Solutions of homogenous and non-homogenous equations, Method of variation of parameters, Method of undetermined coefficients, Equations reducible to linear equations with constant coefficients (Euler-Cauchy and Legendre's linear differential equations).

Unit 4: Applications of Differential Equations **9L hours**

First order differential equations: Newton's law of cooling, Radioactive decay, L-R and C-R circuits. Second order differential equations: Mechanical Vibrations- Free undamped and damped vibrations, Forced Oscillations, Resonance phenomenon. Electrical Vibrations- Series LCR circuit, Analogy with mass spring system, LCR circuit with voltage source, Complex impedance and Resonance phenomena.

Unit 5: Laplace Transforms **9L hours**

Laplace transforms- Definition, Laplace transforms of standard functions and their properties, Inverse Laplace transforms and its properties, Convolution theorem, Initial and final values theorems, Laplace transforms of periodic functions, Heaviside unit step function, Dirac-delta function, Solution of ordinary differential equations.

Text Books

1. Erwin Kreyszig, *Advanced Engineering Mathematics*, 9th Edition, Wiley India Pvt. Ltd., (2011).
2. Paras Ram, Engineering Mathematics through Applications, 2nd Edition, CBS Publishers, (2015).

Reference Books

1. G. B. Thomas and R.L. Finney, *Calculus and analytical geometry*, 9 th Edition, Pearson Education, 5th Indian Reprint, (2002).
2. Peter V. 0' Neil, *Advanced Engineering Mathematics*, 5th Edition, Thomson, Book/Cole, (2003).
3. A. K. Nandakumaran, P. S. Datti, and Raju K. George, *Ordinary Differential Equations: Principles and Applications* Cambridge University Press, (2017).

Course Outcomes

By the end of the course the students will be able to

CO1: Understand and analyze the theoretical and practical aspects of matrix applications.

CO2: Identify extreme values of functions and interpret the engineering problems.

CO3: Model simple physical problems as differential equations, analyze and interpret the solutions.

CO4: Use Laplace transforms to solve ordinary differential equations.

Course Code: MAIC 12

Course Title: Integral Calculus and Difference Equations

Number of Credits: 4

Pre-requisites: The basic knowledge of differentiation, Integration, Summation, Scalars, Vectors and trigonometrical functions.

Course Type: IC

Course Objectives

- To provide the students with sufficient knowledge of Integral Calculus and its applications.
- To have the knowledge of vector calculus and its physical interpretation with applications.
- To have the knowledge of fundamental concept of Fourier series and its applications.
- To have the idea of difference equation and Z-transforms with engineering applications.

Unit 1: Power Series Solutions and Special Functions **9L hours**

The Strum-Liouville Problem, Orthogonality of eigen functions, Ordinary and singular points of an equation, Series solution about an ordinary point using Power series solutions, Series solution about a regular singular point using Frobenius method, Solution of Legendre's and Bessel's differential equations, Legendre's and Bessel's functions.

Unit 2: Multiple Integrals **9L hours**

Evaluation of double integrals (Cartesian and polar coordinates), Change of order of integration, Change of variables between cartesian and polar coordinates, Applications of Double Integrals, Triple integrals, Change of variables between Cartesian, cylindrical and spherical polar co-ordinates, Applications of triple integrals, Beta and Gamma functions, Dirichlet integrals.

Unit 3: Vector Calculus **9L hours**

Scalar and vector valued functions, Gradient of a scalar point function and its geometrical interpretation, Directional derivative, Divergence and curl of a vector point function and their physical interpretations, Statement of vector identities, Scalar and velocity potentials, Line, surface and volume integrals, Statement of Green's, Stoke's and Gauss divergence theorems, Verification and evaluation of vector integrals using these theorems.

Unit 4: Difference Equations and Z-transforms **9L hours**

Difference Equation-Definition of Difference equation, First and second order difference equations with constant coefficients, Fibonacci sequence, Solution of difference equations (complementary functions and particular integrals).

Z-transform- Definition of Z-transform, Relation between Z- transform and Laplace transforms, Z-transforms of standard functions, Inverse Z-transforms, Inverse Z-transforms by partial fraction method, Inverse Z-transforms by convolution method, Solution of simple difference equations using Z-transforms.

Unit 5: Fourier Series **9L hours**

Fourier series, Euler's formula, Dirichlet's conditions, Fourier series expansion of functions having point of discontinuity, Change of interval, Expansion of even and odd functions, Half range series, Typical wave-forms, Parseval's formula, Practical Harmonic Analysis.

Text Books

1. Erwin Kreyszig, *Advanced Engineering Mathematics*, 8th Edition, John Wiley & Sons, Wiley
student Edison, (2011).

2. Paras Ram, *Engineering Mathematics through Applications*,·2nd Edition, CBS Publishers, (2015).

Reference Books

1. Michale D. Greenberg, *Advanced Engineering Mathematics*, 2nd Edition, Pearson Education, First Indian reprint (2002).
2. Peter V. O' Neil, *Advanced Engineering Mathematics*, 5th Edition, Thomson, Book/Cole (2003).

Course Outcomes

At the end of this course, the students will be able to

CO1: Understand and analyze the practical aspects of series solution and special functions.

CO2: Interpret the line, surface and volume integrals.

CO3: Use Z-transforms to solve difference equations analytically.

CO4: Apply the analytical technique to express periodic functions as a Fourier series.

Syllabus: B. Tech. 2^{nd}Year (July 2017 onwards)

Course Code: MAIR 21

Course Title: Applied Numerical and Statistical Methods (for CE, ME & PI)

Number of Credits: 4

Pre- requisites: MAIR 11

Course Type: EPR

Course Learning Objectives

This course attempts to cover certain basic, important computer oriented numerical methods and statistical concepts for analyzing problems that arise in engineering and physical sciences.
The students are expected to use MATLAB as the primary computer language to obtain solutions to a few assigned problems.

Course Outcomes

By the end of the course, students should be able to appreciate the power of numerical methods and use them to analyze the problems connected with data analysis, and solution of ordinary differential equations that arise in their respective engineering courses. The student shall be able to understand the concepts and results in regression models, testing samples using Normal, t and X^2distributions.

Unit 1 Numerical Solutions of Nonlinear Equations 9L Hours

General iterative method-secant method- Newton- Raphson method- non-linear equations-solution of system of equations-generalized Newton's method (roots of equation-solution of system of equations), -rate of convergence-Gauss-Seidel method for system of linear equations-convergence criterion-positive definiteness of a matrix- spectral radius of a matrix-tridiagonal system of equations-Thomas algorithm.

Unit 2 Numerical Differentiation and Integration 9L Hours

Interpolation-finite differences-Newton's formulae for interpolation-Langrage interpolation numerical differentiation-maxima minima for tabulated values-numerical integration: Trapezoidal rule, Simpsons 1/3 rd and 3/8th rules.-Romberg's method.

Unit 3 Numerical Solutions of Ordinary Differential Equations 9L Hours

(Review: Taylor series method-Euler and modified Euler's methods) Runge Kutta methods-fourth order R.K. method- systems of equations and higher order equations-multi step methods: Adams-Bashforth method-boundary value problems-finite difference method.

Unit 4 Statistical Methods 12L Hours

Distributions: Binomial and Poisson distributions-normal distribution
Testing of hypothesis: Large sample tests-procedure of testing hypothesis- small sample tests-Student's T-test-chi-square test-independence of attributes and goodness of fit.

Unit 5 Linear Programming Problems 6L Hours

Linear Programming Problem-Formulation-Simplex method-Dual Simplex method.

Reference Books

1. M.K. Jain, S.R. lyengar and R.K. Jain, Numerical methods for scientific and Engineering, New Age International Ltd., 5th Edition (2010). The topics in the chapter 2, 3, 4, 5, 6, 7.

2. Erwin Kreyszig, Advanced Engineering Mathematics, 8th Edition, Johan Wiley & Sons, Wiley student Edison)(2011). Topics in the Chapters 2, 4,7,10

3. Paras Ram, Engineering Mathematics through Applications, 2nd Edition, CBS Publishers, (2015).

4. Ronald E. Walpole, Raymond H. Myers Sharon L. Myers Keying E. Ye, Probability and Statistics for Engineers and Scientists (9th Edition.)

5. Steren C. Chapra and Ra P. Canale, Numerical methods for Engineers with programming and software applications, 3rd Edition, Tata McGraw Hill (2001).

Syllabus: B. Tech. 3rd Semester (July 2017 onwards)

Course Code: MAIR 24

Course Title: Discrete Mathematics (for CS & IT)

Number of Credits: 4

Pre- requisites:

Course Type: EPR

Course Learning Objectives:

Enable the students to write the algorithms for the real life problems and logical development of and analysing the solutions.

Course Outcomes

At the end of this course, the students are expected to better understand algebraic concepts and logic required for programming and developing algorithms & software packages.

Unit I Discrete Probability **9LHours**

Introductory Examples, Basic definitions, Engineering applications of probability, Set theory, Sample space & Events, Probability Multiplications principle, Product of sums principle, Cross product of sample spaces, Theorem of Total Probability, Conditional Probability, Mutual Exclusion and Independent Events, Principle of Inclusion and Exclusion, Bayes' Rule.

Unit II Discrete Random Variable & Distributions **9LHours**

Random variables and their event spaces, probability Mass function, Distribution function, Discrete Uniform Distribution, Bernoulli Trial & Binomial distribution, Poisson distribution, Geometric distribution, Mean and Variance of random variables.

Unit III Relations and Logic **9LHours**

Binary Relation and their properties, Equivalence relations and partitions, partial ordering relations, functions and Pigeonhole principle, Propositions, Logic

Unit IV Algebraic system **9LHours**

Definitions and elementary properties of algebraic structures, semigroups, monoids and submonoids, groups and subgroups, Homomorphism and lsomorphism of monoids and Groups, Definition and Examples of Rings and subrings, Types of Rings, Commutative Ring, Integral Domain, Division Ring, Relation of Isomorphism in the set of rings, Field, its characteristics and subfield**.**

Unit V Graphs and Trees **9LHours**

Introduction, Basic Terminology, Multigraphs and Weighted Graphs, Paths and Circuits, Shortest Paths in Weighted Graphs, Eulerian Paths and Circuits, Hamiltonian Paths and circuits, Planar Graphs, Trees, Rooted Trees, Path Lengths in Rooted trees, Binary Search Trees, Spanning Trees and Cut-sets, Minimum spanning Trees.

Reference Book

1. Joe L,Mott, Kandel and Baker, *Discrete Mathematics for Computer Scientists, PHI, 2008*
2. J. P. Tremblay and R Manohar,*Discrete Mathematical Structures with applications to computer Science, Tata McGraw Hill (2001).*
3. Kolman, Bubby Ross, *Discrete Mathematics Structures, PHI, 2001.*
4. C.L.Liu,*Elements of Discrete Mathematics 1986.*
5. Gary Haggard, J. Schlipf, S. Whitesides, *Discrete Mathematics for Computer Science, Cengage Learning; 2005.*

Syllabus: B. Tech. 4thSemester(July 2017 onwards)

Course Code: MAIR 22

Course Title: Applied Linear Algebra (for EE)

Number of Credits: 4

Pre- requisites:

Course Type: EPR

Course Learning Objectives

Linear algebra is one of the most important subjects in the study of engineering because of its widespread applications in electrical, communications and computer science. The objective of this course is to give a presentation of basic concepts of linear algebra to illustrate its power and utility through applications to computer science and engineering.

Course Outcomes:

By the end of the course the students are expected to learn the concepts of vector space, linear transformations, matrices and inner product space. Further the students are expected to solve problems in cryptography, computer graphics and some physical problems.

Unit 1 Linear Equations and Matrices9L Hours

System of linear equations-Gaussian elimination/Jordan- block matrices- elementary matrices finding inverse of matrices-permutation matrix-LDU factorization-Applications in cryptography and electrical network.

Unit 2 Vector space9L Hours

The n space R" and vector space-sub space-bases-linear combination-span-linearly dependent-independent-dimensions-finite dimensional-row and column spaces- Rank and nullity-Bases for subspace-invertibility-application in interpolation.

Unit 3 Linear transformations9L Hours

Basic properties of linear transformations-invertible linear transformation-matrices of linear transformations.

Unit 4 Vector Space of Linear Transformations9L Hours
Vector space of linear transformations- change of bases-similarity-application to computer graphics.

Unit 5 Inner product spaces9L Hours

Dot products and inner products-the lengths and angles of vectors- matrix representations of inner products-Gram-Schmidt orthogonalization- projection-orthogonal projections-relations of fundamental subspaces-othogonal matrices and isometrics-applications in least square solutions.

Reference Books:

1. E. Krishnamurthy et. al,*An Introduction to Linear Algebra, East west press, New Delhi(2003).*

2. Gilbert Strang, *Introduction to Linear Algebra, 4th Edition, Wellesley-Cambridge Press (2009).*

3. Jin Ho Kwak and Sungpyo Hong, *Linear Algebra, Second edition, Springer (2004).*

4. Stephen Andrilli and David Hecher, *Elementary Linear Algebra, 3rd Edition, Academic press (2006).*

5. Charles W. Curtis, *Linear Algebra, Springer (2004).*

Syllabus: B. Tech. 4th Semester (July 2017 onwards)

Course Code: MAIR 23

Course Title: Complex Analysis and Partial Differential Equations (for ECE)

Number of Credits: 4

Pre- requisites: MAIR 12

Course Type: EPR

Course Learning Objectives:

The aim of this course is to develop the skills of the students in the areas of complex variables, evaluation of definite integral by using contour integration, boundary value problems and transform techniques. This will be necessary for their effective studies in Engineering subjects like heat conduction, fluid flow and electric current flow etc.

Expected Outcome

At the end of this course, the students are expected to develop the necessary mathematical skills, physical understanding of problems and intuition to independently analyze the mathematical equations which model the problems in their respective fields of study.

Unit 1 Functions of a Complex Variable 9L Hours

Limits and continuity-Cauchy-Riemann equations-analytic and harmonic functions-complex potential-By-linear transformations and conformal mappings: $w= z^2$, $w= e^z$.

Unit 2 Complex Integration 9L Hours

Integration in a complex plane along a contour- Cauchy-Goursat theorem (Statement)-Cauchy's integral formula-Taylor and Laurent series-zeros- singularities-poles-residue-Cauchy's residue theorem-evaluation of integrals by the method of residues-statement of Jordan's lemma-indented contour integral.

Unit 3 Fourier Transforms 9L Hours

Complex form of Fourier series-Fourier integral theorem- Fourier transform pairs-Fourier sine and cosine transform pairs-simple problems-properties of Fourier transform -Convolution theorem for Fourier transforms-Parseval's identity for Fourier transforms.

Unit 4 Partial Differential Equations 9LHours

Formation of PDEs- solutions of PDEs-solution of standard four types of first order PDE-Lagrange's linear equations- linear PDE of higher order with constant coefficients-homogeneous and non homogeneous equations- solution of PDE's by the method of separation of variables.

Unit 5 Applications of Partial Differential Equations 9L Hours

Classification of PDE's reduction to standard form solution of Laplace's equations-variable separable method, Application problems: Potential flow, Heat Equation, Application Problems.Wave equation-vibrations of a stretched string-D'Alembert solution for the initial value problem, Application problems: vibrations of a string and circular membrane.

Reference Books

1. I. W. Brown and R.V. Churchill, Complex Variables and Application, Mc Graw Hill International ed., 7th Edition (2004).

2. Erwin Kreyszing*Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons,(Wiley student Edison) (2001).*

3. B.S. Grewal, *Higher Engineering Mathematics, Khanna Publications, (2009).*

4. Dennis G. Zill, Parick D. Shanahan, *Complex Analysis: A first course with Applications. 3rd Edition (Jones & Bartlett. Student Edition).(2015)*

5. Paras Ram, *Engineering Mathematics Through Applications, 2nd Edition, CBS publishers,(2015).*

Syllabus: Pre Ph.D.(July 2017 onwards)

Course Code: MAIR-701T

Course Title: Research Methodology and Review of Research

Number of Credits: 4

Unit 1:Introduction to Research Methodology and Review of Literature

Objectives:
At the end of this course, the students should be able to understand some basicconcepts of research and its methodologies; the necessity of defining the research problem and techniques involved in it;organize and conduct research in a more appropriate manner; defining their research problems.

Contents:

Types of research, its approaches & significance; Research and scientific methods; Step involved in research process, Criteria of good research & problems for researchers, Definition of the research problems; Identifying and formulating the problem, Necessity of defining the research problem and techniques involved in it, Types of research designs and basic principles.

Outcomes:
At the end of this course students will critically analyze research methodologies identified in existing literatures; propose and develop an appropriate research designs for specific research project; assess the feasibility and practicality of the developed proposal.

Unit 2:Sampling and Statistical Tools in Research Methodology

Objectives: This unit is designed to give knowledge about the methods of data collections and analysis using central tendencies; correlation & regression.

Contents: Methods of data collection: Experimental data, field data, data from other sources; Analyzing data: Error analysis and statistical analysis including mean, mode, median, standard deviation, quartile deviations, skewness and kurtosis, curve fitting, correlation and regression.

Outcomes: By the end, students will understand the methods of data collection, analyze and fit the data.

Unit 3:Basic Numerical Techniques & Research Methodology

Objectives: To understand the given numerical methods and develop the codes for them in modern computer language to solve the algebraic &transcendental equations andlVPs.

Contents: Algebraic&TranscendentalEquations:IterationMethod,RegulaFalsi&SecantMethod, NewtonRaphsonMethod;NumericalTechniquesforInitialValueProblems:Picard'sMethod,TailorsMethod,Euler'sMethodandRunge-KuttaMethod.

Outcomes: Bytheend,studentswillbeabletosolveequationsbyusingthegivennumericalmethods.

Unit 4:Meaning and Content of IPR

Objectives: TheprimeaimofthiscourseistoprovideessentialsofIntellectualPropertyRightstotheResearchScholars.Thestudentswillalso befamiliarabouttheproblemofplagiarismintheirinnovations,publicationsandresearchprojects.

Contents:

Patents - Meaning of Patent, Concept of Novelty, Inventiveness and utility, Inventions not patentable, Process and Product Patents, provisions of TRIPS Agreement-Implications.

Copyright-Meaning & scope of Copyright, Concept of originality, provisions of TRIPS Agreement- Implications.

Trademark- Definition ofTrademark, Certification Marks,ServiceMarks,PropertyMarks,Well-knownMarks, Domain nameprotection, provisions of TRIPS Agreement- Implications.

Industrial Design- Definition of Design, Concept of Novelty/ Originality,ltems not protectedunderDesign,provisionofTRIPSAgreement- Implications.

New forms of intellectual property-Plant varieties, Layout Design, Geographical indications,undisclosed informationetc.,Ethicsand IPR.

Outcomes:

ThestudentswillbeabletodifferentiatebetweenvarioustypeofIPRsandtheywillfeelconfidentinwriting andpublishingtheirresearchpapersandresearchrojects.

Referred / Recommended Books:

1. C.R. Kothari, *Research Methodology: Methods and Techniques.*
2. Melville and Goddard, *Research Methodology and Introductions for Science and Engineering.*
3. Punch,*Developing Effective Research Proposals.*
4. Leonard Bickman, *Applied Research Design*.

5. S.C. Gupta and V.K. Kapoor,*Fundamentals of Mathematical Statistics.*
6. B. S.Grewal, *Numerical Methods in Engineering & Science: with Programs in C and C++*.
7. W. R. Cornish, *Intellectual Property: Patents, Copyright, Trademarks and Allied Rights, Sweet and Max Well London, 2007.*
8. Blakeney,*Trade Related Aspects of Intellectual Property Rights: A Concise Guide to the TRIPS Agreement, Sweet and Max Well London, 1996.*
9. R. Dreyfuss H, *Expanding the Boundaries of Intellectual Property, Oxford University Press, 2001.*
10. Prabuddha Ganguli,*Intellectual Property Rights (TATA McGraw Hill) New Delhi, 2001.*
11. Richard Stim,*Intellectual Property Copyrights, Trademarks, and Patents, Cengage Learning India Private Limited, 2008.*
12. Deborah E. Bouchoux, Intellectual Property Rights, Cengage Learning India Private Limited, 2008.
13. Kumar Ratnesh,*WTO (World Trade Organization), Deep & Deep Publications, 1999.*
14. J. Watal, *Intellectual Property Rights: In the WTO and Developing Countries, Oxford University Press, 2000.*
15. S. K. Datta and Satish Y. Deodhar,*Implications of WTO Agreements for lndian Agriculture, Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.*
16. H. W. Singer, N. Hatti, R. Tandon, *Technology Transfer by multinationals, Ashish Publishing House New Delhi.*

Syllabus: Pre. Ph.D.

Course Code: MAT-703T

Course Title: Applied Numerical Analysis

Number of Credits: 3.5

High Speed Computation: Introduction, computer Arithmetic, errors in numerical Techniques, machine computation and computer software.

Non-Linear Equations: Introduction, General Iterative methods, Complex roots, Error analysis
System of Linear Algebraic Equations and Eigen value Problems: Introduction, Direct Methods - Consistency, Rank of a matrix Gaussian elimination, LU decomposition (Crout's algorithm), Cholesky algorithm, Tridiagonal system of equations and Bounded system of equations.

Eigen values and Eigen vectors: Eigen values and Eigenvectors, bounds on Eigen values, Jacobi's Method for Symmetric Matrices, Given Method for Symmetric Matrices, Householder's Method for Symmetric Matrices, largest Eigen value by power method.

Interpolation and Approximation: Introduction, Newton and Lagrange's Interpolations, Interpolating polynomials - piecewise ·polynomial interpolation, Spline's interpolation formula, Hermite Interpolation.·

Numerical Integration: Newton Cotes quadrature formulae; Gaussian Quadrature.

Ordinary Differential Equations: Boundary Value Problems: Initial Value Problem and boundary value problem, Runge - Kutta's Method, Predictor - Corrector methods, Shooting method for BVP.

Referred/ Recommended Books:

1. M.K. Jain, S.R.K. Iyengar Jain, *Numerical: New Age International Publishers.* ·
2. S. C. Chapra and Raymond P. Canal, *Numerical methods for Engineers*, *Tata McGraw - Hill Publications.*
3. Curtis F.Gerald, Patrick O. Wheatley, *Applied numerical analysis, Addison-Wesley Pub. Co.*
4. Paras Ram, *Engineering Mathematics through application, C.B.S. Publications Delhi.*
5. K. Shankar Rao, *Numerical Methods for Scientists & Engineers.*

Syllabus: Pre. Ph.D.

Course Code: MAT-704T

Course Title: Advanced Numerical Techniques

Number of Credits: 3.5

Iterative Methods for Linear Systems: Classic iterative methods (Jacobi, Gauss-Seidel and successive over relaxation (SOR) methods), Krylov subspace methods, GMRES, Conjugate-gradient, biconjugate-gradient (BiCG), BiCGStab methods, preconditioning techniques, parallel implementations.

Finite Difference Method: Explicit and implicit schemes, Crank-Nicolson schemes, consistence, stability and convergence, Lax's equivalence theorem, numerical solutions to elliptic, parabolic and hyperbolic partial differential equations. Dirichlet, Neumann and Mixed problems. Sparseness and the ADI method.

Approximate Method of Solution: Galerkin method, properties of Galerkin approximations, Petrov- Galerkin method, generalized Galerkin method.

Finite Element Method (FEM): FEM for second order problems, one and two dimensional problems, finite elements (element with a triangular mesh and a rectangular mesh and three-dimensional finite elements), fourth-order problems.

Referred Books:

1. Chapra and Canale,*Numerical Methods for Engineers*,*Tata Mc Graw Hill*, *New Delhi.*
2. Desai and Abel,*Introduction to the Finite Element Method, Affiliated East West Press New Delhi.*
3. O. C. Zienkiewiez,*The Finite Element Method, Tata Mc Graw Hill.*
4. H. M. Wodsworth, *Handbook of statistical methods for engineers and scientists by: Mc Fraw Hill Publishing Co. Inc.*
5. Curtis F. Gerald, Patrick O. Wheatley,*Applied numerical analysis, Addison-Wesley Pub. Co.*

Syllabus: Pre. Ph.D.

Course Code: MAT-706T

Course Title: Algebra

Number of Credits: 3.5

Group: Series of groups, Nilpotent groups, Solvable groups, Sylow theorems, free groups.

Rings & Modules: Commutative Rings, Noetherian & Artinian rings and modules.

Integral Domains: Principal ideal domains (PID), Unique Factorization Domain(UFD), Modules over PID.

Algebraic structures: Groups with operators, Modules, Algebras.

Fields: Algebraic & transcendental extensions, Introduction to Galois Theory.

Referred Books:

1. M. Artin,*Algebra.*
2. I.N. Herstein,*Topics in Algebra.*
3. Y. Sahai, V. Bist: *Algebra , Narosa Publishing House.*
4. S. Lang, *Algebra.*
5. J.B. Fraleigh, *A first course in Abstract Algebra, Narosa Publishing House.*

Syllabus: Pre. Ph.D.

Course Code: MAT-708T

Course Title: Lie Theory and Special Functions

Number of Credits: 3.5

Lie groups, local transformation groups, Lie algebra and one paramenter subgroups, representation of Lie algebras, Realization of representation, The Lie algebra $\mathcal{g}$ (a, b), Realization of $\mathcal{g}$ (a, b) in two variables, Realization of $\mathcal{g}$ (a , b) in one variable, Lie theory and hypergeometric functions.

Hypergeometric and basic hypergeometric series, The q-binomial theorem, Heine's transformation formula, Heine's q-analogue of Gauss summation formula, Bibasic hypergeometric series, multibasic hypergeometric series, Generating relations, Multivariable Hypergeometric functions, Lie derivatives, Lie's fundamental theorems, matrix elements, addition theorems.

Referred Books:

1. WillardMiller,*Lietheoryandspecialfunctions,AcademicPress.*
2. G. Gasper,M.Rahan,*Basichypergeometricseries*,*CambridgeUniversityPress.*
3. H.Exton, *q-Hypergeometric Functions & Applications.*
4. E.D.Rainville , *SpecialFunctions,Macmillan.*
5. H.M. Srivastav, H.L. Manocha, *A Treatise on Generating Functions, Ellis Horwood*
6. F.W.Warner, *FoundationofDifferentiableManifolds&LieGroups.*
7. N. J.Hicks, *GeometryofManifolds.*

Syllabus: Pre. Ph.D.

Course Code: MAT-710T

Course Title: Mathematical Analysis

Number of Credits: 3.5

Measure Theory: General introduction, Product measures, Fubini's theorem, Lebesgue measure, Complex measure, Radon-Nikoldym theorem.

Lp-Spaces: Introduction, Holder's inequality and Minkowski inequality, Completeness, Duality.

Differential Manifolds:Tangent spaces,Vectorfields,Implicitfunctiontheoremandinverse functiontheorem.

ComplexAnalysis: Integrationincomplexplane,Sequenceandseries,Taylorseries,Laurentseries,Zerosandpoles,Residues andresiduetheorem,Applications.

Referred Books:

1. W.Rudin , *RealandComplexAnalysis.*
2. H.L.Royden ,*RealAnalysis.*
3. F.W.Warner ,*FoundationsofDifferentiableManifolds&LieGroups.*
4. Dennis G. Zill, PatrickD. Shanahan, *AFirstcourseinComplexanalysiswithApplications*.
5. SergeLang,*ComplexAnalysis ,SpringerVerlag.*

Syllabus: Pre. Ph.D.

Course Code: MAT-712T

Course Title: Ferrohydrodynamics

Number of Credits: 3.5

Introduction, magnetic fluids, concepts of fluid mechanics, equation of continuity, substantial derivative, generalized Bernoulli equation magnetic fluids, stability requirements, stability in magnetic field gradient, stability against settling in a gravitational field, stability against magnetic agglomeration, preparation of ferro fluid by chemical precipitation, magnetic precipitation with steric stabilization, cobalt particles in an organic carrier, other magnetic fluids, paramagnetic salt solution, metallic based ferrofluid,ferrofluidmodifications, physical properties, equilibrium magnetization.

Electromagnetism and fields: magnetostatic field equation, magnetic field boundary condition, Maxwells equations, integral equations, differential equations, equations of motion for magnetic fluid and thermodynamics of magnetic fluids.

Ferrohydrodynamic instabilities: Normal field instability, interfacial force balance, kinematics, flow field analysis, perturbed magnetic field, boundary conditions on field vectors, porous medium flow, fingering instability, thermocovective stability.

Referred Books:

1. R.E. Rosenweig, Ferrohydrodynamics,*CambridgeUniversityPress,London.*
2. S.Odenbach , *Magneto viscous Effects in Ferrofluids, Springer-Verlag, Berlin.*
3. E. Blums, A. Cebers andM. M. Maiorov, *Magnetic Fluids , Walter de Gruyter, Berlin and New York*

Syllabus: Pre. Ph.D.

Course Code: MAT-7l4T

Course Title: BoundaryLayerTheory

Number of Credits: 3.5

Some Features of Viscous Flows: Real and Ideal Fluids, viscosity, Reynolds number, laminarandturbulentflows, asymptotic behavior at large Reynolds numbers.

Fundamentals of Boundary Layer Theory: Boundary layer concept, laminar boundary layer on a flat plate at zero incidence, turbulent boundary layer on flat plate at zero incidence, fully developed turbulent flow in a pipe, boundary layer on an airfoil, separation of the boundary layer.

General properties and exact solutions of the boundary layer equations for plane flows: Compatibility conditions at the wall, similar solutions of the boundary layer equations, derivation of the ordinary differential equation, boundary layers with outer flow, boundary layers without outer flow, wedge flows, flow in a convergent channel, mixing layer, moving plane, free jet, wall-jet, series expansion of the solutions, Blasius series, Gortler series.

Asymptotic behavior of solutionsdownstream: Wake behind bodies, boundary layer at a moving wall, integral relations of the boundary layer, momentum integral equation, energy integral equation, moment of momentum integral equations.

Approximate methods for solving the boundary layer equations for steadyplanar flows: Integral methods, Stratford's separation criterion: Comparison of the approximate solutions with exact solutions; Retarded Stagnation point flow, Divergent channel (Diffuser), Circular cylinder flow, symmetric flow past a Joukowsky airfoil.

Referred/ Recommended Books:

1. H.SchlichtingandK.Gersten,*BoundaryLayerTheory, Springer.*
2. CebeciTuncer,*Modelingandcomputationofboundary layerflow,Springer.*
3. L . Harry Evans,*Laminarboundarylayertheory, Addison-WesleyPub.Co.*
4. MD Raisinghania, *Fluid Dynamics with complete hydrodynamics and boundary layer theory, S. Chand.*

Syllabus: Pre. Ph.D.

Course Code: MAT-7l6T

Course Title: Mechanics of Deformable Bodies

Number of Credits: 3.5

Theory of Elasticity: Introduction:Definitionofstress andstrain at apoint, componentsofstressandstrainatapointinCartesianandpolarco-ordinates,constitutiverelations, equilibriumequations,compatibilityequations.andboundarycond itionsin2-Dand3-Dcases

Transformation of stress and strain at a point, Principal stress and principal strains, invariants of stress and strain, hydrostatic and deviatoric stress, spherical and deviatoric strains, maximum shear stress, maximum shear strain.

Plain stress and plain strain: Airy's stress function approach to 2-D problems of elasticity, simple problems of bending of beams. Solution of axi-symmetric problems, stress concentration due to the presence of a circular hole in planes.

Analysis of Stress: Stress Tensor, Equations of Equilibrium, Transformation of coordinates, Stress Quadric of Cauchy, Principal stress and Invariants, Maximum normal and shear stresses, Mohr's circle Diagram.

Elementary problems of elasticity in three dimensions, stretching of a prismatical bar by its own weight, twist of circular shafts; torsion of non-circular .sections, membrane analogy, Propagation of waves in solid media, Applications of finite difference equations in elasticity.

Referred/ Recommended Books:

1. TimoshenkoandGoodier, *Theoryof elasticity, McGrawHillBookCompany.*
2. T.H.Lin, *TheoryofInelasticstructures:JohnWileyandsons.*
3. Y.C.Fung, *FoundationsofSolidMechanics, Prentice-Hall.*
4. S.Vallappan, *ContinuumMechanicsfundamentalsOxfordandIBH.*
5. I. S.Sokolnikoff, *Mathematical Theory of Elasticity,Tata McGraw-Hill Publishing Company Ltd.*

Syllabus: Pre. Ph.D.

Course Code: MAT-7l8T

Course Title: Statistical Techniques

Number of Credits: 3.5

Point Estimation: Unbiasedness and consistency, Maximum likelihood estimation, Method of moment estimation, Goodness properties of estimators, Cramer-Rao inequality and efficiency of estimation.

Data Reduction and Best Estimation: Sufficiency, Minimal Sufficiency, Completeness, Ancillary Statistic, Basu's Theorem, UMVUE, Rao-Blackwell Theorem.

Tests of Hypotheses: Simple and Composite, Null and Alternative hypotheses, Tests, Errors of Type I and Type II, Power, Neyman Pearson lemma, its generalizations and uses, Likelihood Ratio Test (LRT) and Sequential LR Test (SPRT), The Chi-Square test of goodness of fit.

Interval Estimation: Confidence sets and Tests of hypotheses, Confidence intervals for one normal mean, Confidence intervals for one normal variance, Confidence intervals for a success probability, Confidence intervals for the difference of two normal rneans, Confidence intervals for the ratio of two normal variances, Large sample confidence intervals for difference of two probabilities of success.

Referred/ Recommended Books:

1. DudewiczandMishra, *ModernMathematicalStatistics.*
2. Rohatgi and Saleh, *AnIntroductiontoProbabilityaridStatistics, John Wileyand Sons.*
3. B.K.Kale, *ParametricInference, NarosaPublication.*
4. GeorgeCasellaandRoger L. Berger, *StatisticalInference, ColePublishingcompany.*
5. C.R. Rao.LinearStatisticalInferenceanditsApplications, WileyEsteemLtd.
6. B. EfronandR.J.Tibshirani, *AnIntroductiontotheBootstrap, ChapmanandHall*

Syllabus: Pre. Ph.D.

Course Code: MAT-720T

Course Title: Stochastic Processes and Their Applications

Number of Credits: 3.5

Classificationof Stochastic processes, stationary processes, martingales, Markov chains, Markov processes with discrete state space, Markov processes with continuous state space: Brownian motion, Wiener process, Ornstein -Uhlenbeck process.

Renewal process, Renewal equation, Wald's equation, Delayed and equilibrium processes, Residual and excess life timesprocess, cumulative renewal process, Renewal theorems: Blackwell's theorem, Smith's theorem, equilibrium renewal process.

Branching processes, properties of generating functions of Branching processes, Probability of Extinction, Gatton-Watson process, yaglom's theorem, Generalisations of the Galton-Watson process.

Diffusion process, Diffusion equations for the Wiener process, first passage time, Boundary conditions for homogeneous diffusion process, Jump process, Ruin probability, Levy process.

Referred/ Recommended Books:

1. *Concept of Stochastic process*
2. *Stationary processes by Martingales, Markov chains*
3. *Renewal process, Renewal equation*
4. *Branching processes, properties of generating functions*
5. *Element of Queueing Theory*
6. Thomas L. Saaty,*M / M / 1 Model, Pure Birth process, Birth and Death processes Non-Birth and Death Queuing processes, McGraw Hill*
7. *Diffusion process, Diffusion equations for the Wiener process*
8. *Boundary conditions for homogeneous diffusion process*
9. *Ruin Theory*

Syllabus: Pre. Ph.D.

Course Code: MAT-722T

Course Title: Reliability Theory and Survival Analysis

Number of Credits: 3.5

Basic concepts in Reliability: Hazard-rate, Mean Residual Life and Mean time to failure and their interrelationship, Exponential distribution, memory less property, Maximum likelihood estimation and uniformly minimum variance unbiased estimation for the parameter andreliability function.

Gamma and Weibull distributions, Estimation of parameters and reliability function with complete and censored samples. Tests of hypotheses and confidence intervals for the reliability function ofexponential, gamma and Weibull distributions.

Bayes estimation for the parameters and reliability function (under different losses) ofexponential, gamma and Weibull distributions, Bayesian credible intervals for the parameters and reliability function for exponential, gamma and Weibull distributions.

Introduction to Survival Analysis, survival distributions and their applications viz. exponential, gamma, weibull, Death density function for a distribution having Bath-Tub shape hazard function.

Test of goodness of fit for survival distributions, parametric methods for comparing two survival distributions viz. L.R test, Cox's F-test, Non-parametric methods forestimating survival function and variance of the estimator using Kaplan -Meier method.

Referred/ Recommended Books:

1. A.J. GrossandV.A.Clark,*Survival Distribution; Reliability Applications in Biomedical Sciences,JohnWiley&Sons.*
2. J.D. Kalbfleisch and R.L. Prentice, *The Statistical Analysis of Failure Time Data John Wiley and Sons, New York.*
3. Klembaum, G. David, Klein,Mitchel, *Survival Analysis (A Self-Learning Text) Statistics for Biology and Health, Springer, USA.*
4. Elisa T. Lee, StatisticalMethods forSurvivalDataAnalysis,John Wiley & Sons.
5. N.R. Mann, R.E. Schafer and N.D. Singpurwala, *Methods for Statistical Analysis ofReliability and Life Data, John Wiley, New York.*

6. HoangPham,*ReliabilityEngineering, SpringerInternationalEdition.*
7. S. Zacks,*IntroductiontoReliabilityAnalysis,Springer-Verlag,USA.*