### Second Year

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#### Elective group – 1
- 5001: Integral Transforms
- 5002: Advanced Integral Transform

#### Elective group – 2
- 5003: Special Functions - I
- 5004: Special Functions - II
Curves with Torsion:

Tangent, Principal Normal. Curvature, Binormal Torsion Serret-Frenet formulae, Helices, Spherical indicatrix of tangent, etc., Involutes, Evolutes, Bertrand curves,

Envelops Developable Surfaces:

Surfaces, Tangent Plane Normal, Envelope Characteristics, Edge of regression, Developable Surfaces, Osculating developable, Envelope Characteristic points,

Curvilinear Coordinates

Curvilinear coordinates, First order magnitudes, Directions on a surface, The normal, Second order magnitudes, Derivatives of $n$, Curvature of normal section. Meunier's theorem.

Linear operator

Functions, linear operators, null space and range, rank and nullity theorem, operator inverses, application to matrix theory, computation of null space and range of a matrix, matrix of an operator, change of basis and similar matrices.

Preliminaries:

Definitions and examples,

Orthogonal sets:
Fourier coefficients and partial, Identity, gram-Schmidt process, QR factorization,

**Approximation and Orthogonal projection:**
Equivalence of the problems, Computations using orthogonal and nonorthogonal sets, normal equations, projection operators, M-k

**Orthogonal complements:**
Decomposition of the vector space, applications to an approximations and matrix theory,

**The Gram Matrix and Orthogonal Change of Basis:** matrix representation of an inner products, orthogonal change of bases, rank of gram matrix.

**References:**

**Linear Algebra**


**Differential Geometry**

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Syllabus to be offered at M. A. Mathematics External Second Year w.e.f. June 2014-15

Paper :502
Numerical Analysis

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Transcendental and polynomial Equations :
Introduction
Bisection Method
Iteration Method base on first degree equation
Iteration methods based on second degree equation
Rate of convergence
Iteration methods
Method for complex roots
Polynomial equations, model problems

System of Linear algebraic equations and Eigen value problems
Introduction
Direct methods
Iteration methods
Eigenvalues and Eigenvectors
Model problems

Interpolation and Approximation
Introduction
Lagrange and Newton Interpolations
Finite Difference operators
Interpolating Polynomials using finite differences
Model problems

Differentiation and Integration
Introduction
Numerical Differentiation
Partial Differentiation
Numerical Integration
Methods based on Interpolation
Method based on undetermined coefficients
Composite Integration methods
Romberg Integration
Double Integration

- **Ordinary Differential Equations**:  
  Initial value problems  
  Numerical methods  
  Single-step methods  
  Multi-step methods  
  Predictor-corrector methods

- **Ordinary differential Equations**:  
  Boundary value problem  
  Initial value problem method  
  Finite Difference methods  
  Finite Element methods

**References:**

2. Froberg C. E. : Introduction to Numerical Analysis, Addison-Wesley, 1970
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Syllabus to be offered at M. A. Part-I w.e.f. June 2015-16

Paper : 503
Abstract Algebra

Group Theory:
Conjugate of an element, class equation, and Cauchy theorem, First part of Sylow's theorem, Third part of Sylow's theorem, Application of Sylow's theorem, and direct product of a group.

Ring Theory:
A particular Euclidean ring, Fermat's theorem, polynomial rings, primitive polynomials, Guass lemma, the Eisenstein criterion, polynomial rings over commutative rings, unique factorization domain.

Field Theory:
Extension fields, Finite extension field, Algebraic extension, Algebraic number, Roots of polynomials, splitting fields, Uniqueness of Splitting fields, construction with Straightedge and compass, More about roots, Simple extension, Fixed fields, Elementary symmetric functions, normal extension, Galois group, The fundamental theorem of Galois theory.

Normal Series and Conjugacy and G.Sets:
Normal series, solvable groups, Nilpotent groups.
Ideals and homeomorphisms:

Ideal of a ring, principal ideal ring, finitely generated ideal, Quotient ring, Ring homomorphism, Fundamental theorem of Homomorphism, Correspondence theorem, Anti-homomorphism, Anti-isomorphism, The opposite ring of a ring, sum and direct sum of ideals, Maximal and prime ideals, Product of two ideals, Nilpotent and nil ideals.

Modules:


References:

1. Herstein I.N., Topics in Algebra, Wiley eastern Ltd.
Inner product spaces and Hilbert spaces
Total Orthonormal Sets and Sequences, Representation of functional on Hilbert spaces, Hilbert-Adjoint operator, Self-adjoint, Unitary and Normal Operators

Fundamental theorems for Normed and Banach spaces
Zorn's Lemma, Hahn - Banach theorem, Hahn - Banach theorem for complex vector spaces and normed spaces, applications to Bounded linear functional on C [a , b], Adjoint operator, Reflexive spaces, Category theorem and uniform boundedness theorem, Strong and weak convergence, Convergence of sequences of operators and functional, Weak convergence, Open mapping theorem, Closed linear operators, Closed Graph theorem.

Compact Linear operators on Normed spaces and Their Spectrum:
Compact Linear Operators on Normed Spaces, Further Properties of Compact Linear Operators, Spectral Properties of Compact Linear Operators on Normed Spaces, Further Spectral Properties of Compact Linear Operators, Operator Equations Involving Compact Linear Operators, Further Theorems of Fredholm Type, Fredholm Alternative,

Spectral Theory of Bounded Self-Adjoint Linear Operators:
Family, Spectral Family of a Bounded Self-Adjoint Linear Operator, Spectral Representation of Bounded Self-Adjoint Linear Operators, Extension of the Spectral Theorem to Continuous Functions, Properties of the Spectral Family of a Bounded Self-Adjoint Linear Operators,

**Unbounded Linear Operators in Hilbert Space:**

**References:**


Laplace Transforms:

- Introduction and definition of Laplace transforms with examples,
- Existence condition and basic properties of Laplace transforms,
- The convolution theorem and properties of convolution,
- Differentiation and integration of Laplace transforms,
- The inverse Laplace transforms and examples,
- Tauberian theorem and Watson’s lemma,
- Laplace transforms of fractional integrals and fractional derivatives.

Finite Laplace Transforms:

- Introduction,
- Definition of finite Laplace transforms with examples,
- Basic operational properties of finite Laplace transforms,

Applications of Laplace Transforms

- Application of Laplace transforms to ordinary and partial differential equations;
- Initial and boundary value problems and Integral equations;
- Evaluation of definite integral
- Solution of difference as well as differential equations.
• Application of finite Laplace transforms and Tauberian theorem.

**Fourier Transforms:**

- Introduction,
- Basic concepts and definitions,
- The Fourier Integral formulae,
- Definition and examples of Fourier transforms,
- Basic properties of Fourier transforms,
- Applications of Fourier transforms to ordinary differential equations; integral equations and partial differential equations,
- Fourier cosine and sine transforms with examples,
- Properties of Fourier cosine and sine transforms,

**Finite Fourier Cosine and Sine Transforms:**

- Introduction and definition of finite cosine and sine transforms with examples,
- Basic properties of finite Fourier cosine and sine transforms

**Applications of Fourier Transforms:**

- Application of Fourier cosine and sine transforms to partial differential equations
- Evaluation of definite integrals.
- Application of finite Fourier cosine and sine transforms.

**References:**

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Paper : 5002
Advanced Integral Transform

Hankel Transforms:
- Introduction and definition of Hankel transforms with examples,
- Operational properties of the Hankel transforms

Finite Hankel Transforms:
- Introduction and definition of the finite Hankel transforms with examples,
- Basic operational properties

Application Hankel transforms:
- Application of Hankel transforms to partial differential equations
- Applications of finite Hankel transforms.

Hilbert and Stieltjes Transforms (HST):
- Introduction and definition of HST with examples,
Basic operational properties of HST,
Hilbert transform in the complex plane and its applications,
Inverse theorem for Stieltjes transform and its application,
Asymptotic expansion of the one sided Hilbert transform,
The generalized Stieltjes transform,
Basic properties of the generalized Stieltjes transforms with applications.

**Mellin Transforms:**

- Introduction and definition of Mellin transforms with examples,
- Basic operational properties
- Applications of the Mellin transforms,
- Mellin transforms of the Weyl fractional integrals
- Weyl fractional derivatives
- Application of Mellin transforms to summation of series.

**Z-Transforms:**

- Introduction,
- Dynamic linear systems
- and Impulse response,
- Definition of the Z-transforms and examples,
- Basic operational properties,
- The inverse Z-transform and examples,
- Application of Z-transforms to finite difference equations.

**References:**

Infinite Products:

Definition of an Infinite product, A necessary condition for convergence, The associated series of logarithms, Absolute convergence, Uniform convergence.

THE GAMA AND BETA FUNCTIONS:

The Euler or Mascheroni constant $\gamma$, The Gama function, A series for $\Gamma(z) / \Gamma(z')$, Evaluation of $\Gamma(1)$ and $\Gamma(1')$, The Euler product for $\Gamma(z)$, The difference equation $\Gamma(z+1) = z\Gamma(z)$, The order symbols $o$ and $0$, Evaluation of certain infinite products, Euler integral for $\Gamma(z)$, The Beta function, The value of $\Gamma(z) / \Gamma(1-z)$, The factorial function, Legendre’s duplication formula, Gauss’ multiplication theorem, A summation formula due to Euler, The behavior of $\log \Gamma(z)$ for large $|z|$.
**THE HYPERGEOMETRIC FUNCTION:**

The function $F(a, b; c; z)$, A simple integral form, $F(a, b; c; 1)$ as a function of the parameters, Evaluation of $F(a, b; c; 1)$, the contiguous function relations, The hypergeometric differential equation, Logarithmic solutions of the hypergeometric equation, $F(a, b; c; z)$ as a function of its parameters, Simple transformations, Relation between functions of $Z$ and $1-Z$, A quadratic transformation, other quadratic transformations, a theorem due to Kummer, Additional properties.

**ORTHOGONAL POLYNOMIALS:**

Simple set of polynomials, Orthogonality, an equivalent condition for Orthogonality, zeros of orthogonal polynomials, Expansion of polynomials, The three term recurrence relations, The Christoffel-Darboux formula, Normalization; Bessel’s inequality.

**LEGENDRE POLYNOMIALS:**

A generating function, differential recurrence relations, The pure recurrence relations, Legendre’s differential equation, The Rodrigues formula, Bateman’s generating function, Additional generating functions, Hypergeometric forms of $P_n(X)$, Brafman’s generating functions, Special properties of $P_n(X)$, More generating functions, Laplace’s first integral form, Some bounds on $P_n(X)$, Orthogonality, An expansion theorem, Expansion of $X^n$, Expansion of analytic functions.

**HERMITE POLYNOMIALS:**

Definition of $H_n(x)$, Recurrence relations, The Rodrigues formula, Other generating functions, Integrals, The Hermite polynomial as a $_2F_0$, Orthogonality, Expansion of polynomials, More generating functions.

**Reference:**

2. I. N. Sneddon, Special functions of Mathematical Physics and Chemistry, Oliver Boyd.
Syllabus to be offered at M. A. Mathematics External Second Year w.e.f. June 2014-15

**Paper : 5004**

**Special Functions - II**

**GENERALIZED HYPERGEOMETRIC FUNCTIONS:**

The function \( pFq \), The exponential and binomial functions, A differential equation, Other solutions of the differential equation, The contiguous function relations, A simple integral, The \( pFq \) with unit argument, Saalschutz’ theorem, Whipple’s theorem, Dixen’s theorem, Contour integrals of Barns’ type, The Berns’ integrals and the function \( pFq \), A useful integral.

**BESSEL FUNCTIONS:**

Remarks, Definition of \( J_0(z) \), Bessel’s differential equation, Differential recurrence relations, A pure recurrence relations, A generating function, Bessel’s integral, Index half of an integer, Modified Bessel functions, Neumann polynomials, Neumann series.
THE CONFLUENT HYPERGEOMETRIC FUNCTION:

Basic properties of the \( _1F_1 \), Kummer’s first formula, Kummer’s second formula.

GENERATING FUNCTIONS:

The generating function concept, Generating functions of the form \( G(2xt - t^2) \), sets generated by \( e^t \psi(xt) \), the generating functions \( A(t) \exp(-xt/(1-t)) \), another class of generating functions, Boas and Buck generating functions, An extension.

LAGUERRE POLYNOMIALS:

The polynomial \( L_n(X) \), Generating functions, Recurrence relations, The Rodrigues formula, The differential equation, Orthogonality, Expansion of polynomials, Special properties, Other generating functions, The simple Laguerre polynomials.

JACOBI POLYNOMIALS:

The Jacobi polynomials, Bateman’s generating functions, The Rodrigues formula, Orthogonality, Differential recurrence relations, The pure recurrence relations, Mixed relations, Appell’s functions of two variables, An elementary generating functions, Brafman’s generating functions, Expansion in series of polynomials.

ELLIPTIC FUNCTIONS:

Doubly periodic functions, Elliptic functions, Elementary properties, Order of an elliptic function, The Weierstrass function \( P(Z) \), Other elliptic functions, A differential equation for \( P(Z) \), Connection with elliptic integrals.

Reference:

2. I. N. Sneddon, Special functions of Mathematical Physics and Chemistry, Oliver Boyd.