Course Scheme & Syllabus
For
Ph.D. Mathematics
(Program ID-238)

Syllabi Applicable for Admissions in 2018 onwards
# Scheme of Course

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Course Code</th>
<th>Course Name</th>
<th>Course Type</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>Credits</th>
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<tbody>
<tr>
<td>1</td>
<td>PHD 800</td>
<td>Research Methodology</td>
<td>Core</td>
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<tr>
<td>2</td>
<td>MTH 801</td>
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<td>3</td>
<td>MTH xxx</td>
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<td>MTH xxx</td>
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<td>Departmental Elective</td>
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**Total Credits: 14**

L: Lectures  
T: Tutorial  
P: Practical  
Cr: Credits
## Departmental Elective (Choose any two courses)

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<thead>
<tr>
<th>Sr. No.</th>
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<tr>
<td>1</td>
<td>MTH 802</td>
<td>Advanced Algebra</td>
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<td>Univalent Function Theory</td>
<td>Departmental Elective</td>
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<td>Theory of Differential Subordination</td>
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<td>Harmonic Mappings in the Plane</td>
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<td>MTH 811</td>
<td>Homological Algebra</td>
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</table>
Course Title: Research Methodology
Course Code: PHD 800

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**Objective:** The major objective of this course is the understanding and application of emerging trends and new skills associated with research. The course will also introduce students to the safeguards against various errors in conducting any research.

**UNIT-I**
13 Hours

**UNIT-II**
14 Hours

**UNIT-III**
13 Hours

**UNIT-IV**
12 Hours

**Reference Books:**

Course Title: Seminar-I
Course Code: MTH 801

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Instructions and Guidelines for Seminar

1. Since PhD students must demonstrate the ability to interact with their peer group coherently, this course is designed to prepare students for research presentations.
2. This seminar will be related to the field of research.
3. During the course, researchers are expected to meet their guides regularly to seek guidance.
4. The final responsibility for giving effective presentations lies with researchers, not guides.
5. The evaluation will be based on contents and presentation skills of students.
6. Researchers must have a sound understanding of the research tools.
7. Students will have to meet the deadlines given by their respective guides and the department.
8. Each researcher will have to prepare a PPT on the topic approved by his/her guide.
9. Each researcher will be given 30-40 minutes for presentation
10. Slides must present researchers’ work comprehensively.
Objective: This is an advanced course in Algebra for students who wish to pursue research work in Algebra. Galois Theory, canonical forms and structure of semisimple modules will be discussed in detail.

UNIT-I 13 Hours


UNIT-II 13 Hours

Applications of Galois Theory to classical problems: Roots of unity and cyclotomic polynomials, cyclic extensions, Polynomials solvable by radicals, Symmetric functions, Ruler and compass constructions.

UNIT-III 12 Hours


UNIT-IV 12 Hours

Simple and semi simple modules and rings, Structure of semi simple rings: Wedderburn-Artin theorem.

Reference Books:


Objective: This course will give the student a solid grounding in commutative algebra which is used in both algebraic geometry and number theory.

UNIT-I 12 Hours

Rings and ideals - Rings and ring homomorphism, Ideals, quotient rings, zero-divisors, nilpotent elements, units, The prime spectrum of a ring, the nil radical and Jacobson radical, operation on ideals, extension and contraction.

UNIT-II 13 Hours

Modules - Modules and modules homomorphism, sub-modules and quotient modules, direct sums, free modules, finitely generated modules, Nakayama Lemma, simple modules, exact sequences of modules, Tensor product of modules.

UNIT-II 12 Hours

Rings and Modules of fractions, Local properties, extended and contracted ideals in ring of fractions, primary decomposition, 1st uniqueness theorem, 2nd uniqueness theorem.

UNIT-IV 13 Hours

Modules with chain conditions - Artinian and Noetherian modules, modules of finite length, Artinian rings, Noetherian rings, Hilbert basis theorem.

Reference Books:

Course Title: Univalent Function Theory  
Course Code: MTH 804  

**Objective:** The objective of this course is to teach advanced concepts and topics in theory of Univalent Functions.

**UNIT-I**  
13 Hours


**UNIT-II**  
14 Hours

**Univalent Functions:** Elementary Properties and results, Examples of univalent functions, The Area theorem, Growth and Distortion theorems, Coefficient estimates for univalent functions. The maximum modulus of univalent functions.

**UNIT-III**  
14 Hours

**Subclasses of Univalent Functions:** Classes of Convex, Starlike and Close-to-convex functions and their properties in the unit disk, Spirallike functions, Typically Real functions, Growth of Integral Means, Odd Univalent functions, Asymptotic Bieberbach Conjecture.

**UNIT-IV**  
14 Hours

Bounded functions, radius of Univalence, Convexity and Starlikeness, Combinations, Convolution and Subordination of Univalent functions.

**Reference Books:**

Course Title: Theory of Differential Subordination  
Course Code: MTH 805

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**Objective:** This course will give the student a solid grounding in differential subordination and differential superordination for future research.

**UNIT-I**  
14 Hours


**UNIT-II**  
13 Hours

Jack-Miller-Mocanu Lemma, Admissible functions and fundamental theorems, open door lemma and integral existence theorem, Classical Results of Geometric Function Theory Revisited.

**UNIT-III**  
14 Hours

First order linear differential subordination, Briot-Bouquet differential subordinations, Briot-Bouquet applications in Univalent function theory, Generalized Briot-Bouquet differential subordinations, Analytic Integral operators between classes of functions, Subordination-preserving Integral operators.

**UNIT-IV**  
14 Hours

Second order linear differential subordinations, Integral operators preserving functions with positive real part, Integral operators preserving bounded functions, Averaging Integral operators, Hypergeometric functions, Schwarzian derivative, Applications to starlikeness and convexity.

**Reference Books:**

Course Title: Harmonic Mappings in the Plane
Course Code: MTH 806

Objective: This course is design to understand basics and applications of the emerging research topic Planar Harmonic Mappings.

UNIT-I 13 Hours
Complex valued harmonic mappings and their properties, decomposition of harmonic mappings into analytic and co-analytic parts, Jacobian and dilatation of harmonic mappings. The Argument principle, The Dirichlet problem, Lewy's Theorem.

UNIT-II 12 Hours

UNIT-III 12 Hours
Linear combination and convolutions: Univalence of linear combination and convolution of harmonic mappings. Convolutions of harmonic right half plane mapping and related results.

UNIT-IV 13 Hours
Basics of differential geometry and minimal surfaces, Isotheremal parameters, Weierstrass representation of minimal surfaces, connection of planar harmonic mappings and minimal surfaces.

Reference Books:


Objective: The objective of this course is to introduce the concept of strains tensors, stress tensors and basic concepts of elastic body deformation and to make students familiar about the constitutive relations and field equations. Dynamics of elastic bodies and basic problems related to elastic wave propagation are also introduced.

UNIT-I 12 Hours

Tensors: Summation convention, coordinate transformation, tensors of several orders, algebra of tensors, symmetric and skew-symmetric tensors, Kronecker’s delta, Gradient, Divergence, Curl tensor notations, contra-variant and covariant tensors.

UNIT-II 11 Hours

Stress and Strain: Deformation in elastic bodies, affine transformation, strain-displacement relation, principal direction, stress and strain tensors, components of stress and strain, generalised Hooke’s Law- relation between stress and strain, elastic constants and their physical significance.

UNIT-III 13 Hours

Dilatation and Distortion waves: Two dimensional propagation of elastic waves in isotropic solid, waves of dilatation and waves of distortion, equation of motion in classical theory of elasticity, Helmholtz decomposition theorem.

UNIT-IV 12 Hours

Surface Waves: Introduction to surface waves, Rayleigh and Love waves, Frequency equations of Rayleigh waves and Love waves, Radial vibrations of elastic sphere, Reflection and transmission of P/SV and SH waves from liquid/solid, solid/solid interface.

Reference Books:

Course Title: Computational Techniques

Objective: The objective of this course is to introduce the software MATLAB for high-performance numerical computation and visualization. For the purpose of learning programming skill, some Numerical methods which are extremely useful in scientific research are included. For practicing the programs of the numerical methods, the course of practical has also been included in this paper.

UNIT-I
13 Hours
Errors, Error propagation, Order of approximation.

UNIT-II
12 Hours
Operators: Forward, Backward and Shift (Definitions and some relations among them).
Interpolation: Divided differences, Newton’s formulae for interpolation, Lagrange and Hermite interpolation, Cubic Spline interpolation.

UNIT-III
13 Hours
Starting and quitting MATLAB, basic operations of MATLAB, input/output data, the colon operator, types of files, creating and executing a script file, mathematical functions, random number generators. Constants, expressions, variables, numbers, operators, functions, working with arrays and matrices, matrix manipulations, creating vectors, arithmetic operations, relational operations, logical operations, Eigen values and Eigen vectors.

UNIT-IV
12 Hours
Looping statements: if, else, and else-if, for, while, switch and case, break, return, developing algorithms using nested loops.
Graphics, basic 2D plots, style options, labels, title, legend and other text objects, axis control, zoom in, zoom out, 3D plots, view, rotate view, mesh and surface plots.

Reference Books:
Course Title: Computational Techniques Lab  
Paper Code: MTH 809

Objective: Writing Programs in MATLAB for the problems based on the methods studied in theory paper and to run the Program on PC.

List of Practicals

1. Matrix multiplication
2. Secant method and error analysis
3. Newton-Raphson method and error analysis
4. Newton-Raphson’s method for system of non-linear equations and error analysis
5. Newton’s forward/backward interpolation
6. Lagrange interpolation
7. Hermite interpolation
8. Modified Euler’s method
9. Runge-Kutta method of order four
10. Predictor-Corrector methods

Reference Books:

Objective: The objective of this course is to equip the students with fundamental knowledge and problem solving skills in Power series methods of solution of ODE, Existence and Uniqueness theory of Initial Value Problems and Solution of system of differential equations.

UNIT-I 14 Hours

UNIT-II 16 Hours

UNIT-III 15 Hours
Orthogonal set of functions, Orthonormal set of functions, Gram-Schmidt process of orthonormalization, Sturm Liouville’s boundary value problems, Orthogonality of Eigenfunctions and reality of Eigenvalues. Adjoint forms, Lagrange identity, Green function to solve boundary value problems.

UNIT-IV 15 Hours
Power series solution of differential equation about an ordinary point, Solution about regular singular points: The method of Frobenius, Applications, Legendre’s, Hermite’s and Bessel’s equation. Ordinary differential equations in more than two variables: Simultaneous Differential equations of the first order and the first degree in three variables, Methods of their solution and applications.

Reference Books:

Course Title: Homological Algebra
Course Code: MTH 811

Objective: The objective of this course is to introduce the basic concepts of modern Category Theory and Homological Algebra.

UNIT-I

12 Hours

Homology functors: Diagrams over a ring, Translations of diagrams, Translation category, split exact sequence, images and kernel as functors, Homology functors, The connecting homomorphism, Complexes, boundary homomorphism, differentiation homomorphism, homology modules, right and left complexes, exact homology sequence and Homotopic translations.

UNIT-II

12 Hours

Projective and injective modules: Projective modules, injective modules, An existence theorem for injective modules, Complexes over a module, right and left complexes over a module, augmentation translation and augmentation homomorphism, acyclic right and acyclic left complexes over a module, Projective and injective resolutions of a module, Properties of resolutions of a module.

UNIT-III

13 Hours

Derived Functors: Projective and injective resolutions of an exact sequence, Properties of resolutions of sequences, Functors of complexes, Associated translations, Functors of two complexes, Right-derived functors, the defining systems and the connecting homomorphisms, the functor $R^\delta T$, Left-derived functors, the functor $L_\delta T$.

UNIT-IV

13 Hours

Torsion and Extension Functors: Connected sequences of functors, connected right and left sequences of covariant and contravariant functors, homomorphism and isomorphism as a natural equivalence between connected sequences of functors. Torsion functors $T\tau r$, Basic properties of Torsion functors, Extension functors and Basic properties of extension functors.

Reference Books: