# DAV UNIVERSITY JALANDHAR

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

## Syllabi Applicable for Admissions in 2018 onwards

# Scheme of Course

| Sr. No. | Course Code | Course Name | Course Type | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1 | PHD 800 | Research Methodology | Core | 4 | 0 | 0 | 4 |
| 2 | MTH 801 | Seminar-I | Core | 0 | 0 | 0 | 2 |
| 3 | MTH xxx | Subject Specific | Departmental Elective | 4 | 0 | 0 | 4 |
| 4 | MTH xxx | Subject Specific | Departmental Elective | 4 | 0 | 0 | 4 |

## Total Credits: 14

**L: Lectures** **T: Tutorial** **P: Practical** **Cr: Credits**

# Departmental Elective (Choose any two courses)

| Sr. No. | Course Code | Course Name | Course Type | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1 | MTH 802 | Advanced Algebra | Departmental Elective | 4 | 0 | 0 | 4 |
| 2 | MTH 803 | Commutative Algebra | Departmental Elective | 4 | 0 | 0 | 4 |
| 3 | MTH 804 | Univalent Function Theory | Departmental Elective | 4 | 0 | 0 | 4 |
| 4 | MTH 805 | Theory of Differential Subordination | Departmental Elective | 4 | 0 | 0 | 4 |
| 5 | MTH 806 | Harmonic Mappings in the Plane | Departmental Elective | 4 | 0 | 0 | 4 |
| 6 | MTH 807 | Continuum Mechanics | Departmental Elective | 4 | 0 | 0 | 4 |
| 7 | MTH 808 | Computational Techniques | Departmental Elective | 3 | 0 | 0 | 3 |
| 8 | MTH 809 | Computational Techniques Lab | Departmental Elective | 0 | 0 | 2 | 1 |
| 9 | MTH 810 | ODE and System of ODE | Departmental Elective | 4 | 0 | 0 | 4 |
| 10 | MTH 811 | Homological Algebra | Departmental Elective | 4 | 0 | 0 | 4 |

**Course Title: Research Methodology**
**Course Code: PHD 800**

| L | T | P | Credits |
|---|---|---|---|
| 4 | 0 | 0 | 4 |

**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**

Introduction to Research: Meaning of Research, Objectives of Research, Types of Research, Research Approaches, Research Process. Defining the Research Problem: What is a Research Problem? Selecting the Problem, Necessity of Defining the Problem, Review of Literature. Research Design: Meaning of Research Design, Need for Research Design, Features of a Good Design, and Important Concepts Relating to Research Design, Different Research Designs like various experimentation-Quasi, Latin Square, Factorial Design, their uses& methods.

**UNIT-II** **14 Hours**

Methods of Data Collection: Collection of Primary Data, Observation Method, Interview Method, Collection of Data through Questionnaires, Collection of Data through Schedules, Some Other Methods of Data Collection, Collection of Secondary Data, Selection of Appropriate Method for Data Collection. Measurement and Scaling: Non-comparative Scaling Techniques, Continuous Rating Scale, Itemized Rating Scale, Non-comparative Itemized Rating Scale Decisions, Multi-item Scales, Scale Evaluation, Choosing a Scaling Technique. Questionnaire & Form Design: Questionnaire & Observation Forms, Questionnaire Design Process.

**UNIT-III** **13 Hours**

Sampling design and Procedures: Sample or Census, The Sampling Design Process, A Classification of Sampling Techniques, Choosing Nonprobability Versus Probability Sampling, Uses of Nonprobability versus Probability Sampling. Data Preparation: Editing, Coding, Transcribing. Hypothesis Testing- T-test, Z-test, ANOVA-test, Chi-Square etc.

**UNIT-IV** **12 Hours**

Organization of Research Report: Types, Structure, Bibliography, References & Appendices. Style Manuals: APA style, MLA style, The Chicago Manual of style etc. Evaluation of Research Report, When and where to publish?, Ethical issues related to publishing, Plagiarism.

**Reference Books:**


1. Kumar, R. *Research Methodology: A step-by-step guide for Beginners*. London: SAGE, 2005.
2. Kothari, C. R. *Research methodology: Methods & Techniques (Rev. Ed.)* New Age International, New Delhi, 2006.
3. Malhotra, N. K. *Marketing research: An applied orientation, 6th ed.* SaddleRiver, N.J.: Pearson. Additional, 2010.

**Course Title: Seminar-I**
**Course Code: MTH 801**

| L | T | P | Credits |
|---|---|---|---|
| 0 | 0 | 0 | 2 |

**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.

**Course Title: Advanced Algebra**
**Course Code: MTH 802**

| L | T | P | Credits |
|---|---|---|---|
| 4 | 0 | 0 | 4 |

**Objective:** This is 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**

Introduction to Galois Theory: Automorphism groups and fixed fields, Fundamental theorem of Galois Theory, Proof of fundamental theorem of Algebra using Galois Theory.

**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**

Modules over PID: The basic theory, Invariant factors, Elementary divisors, Fundamental theorem of finitely generated Abelian groups, The Rational canonical form, and The Jordan canonical form.

**UNIT-IV** **12 Hours**

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

**Reference Books:**


1. Bhattacharya, P.B., Jain S.K. and Nagpal, S.R. *Basic Abstract Algebra*, 2$^{nd}$Edition. U.K.: Cambridge University Press, 2002.

2. Dummit, David S. and Foote, Richard M. *Abstract Algebra*, 2$^{nd}$ Edition, Wiley India, 2008.

3. Lam, T.Y., *A First Course in Non-commutative Rings*,2$^{nd}$ Edition, Springer-Verlag New York, 2001.

**Course Title: Commutative Algebra**
**Course Code: MTH 803**

| L | T | P | Credits |
|---|---|---|---|
| 4 | 0 | 0 | 4 |

**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, 1$^{st}$uniqueness theorem, 2$^{nd}$uniqueness theorem.

**UNIT-IV** **13 Hours**

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

**Reference Books:**


1. Atiyah, M. F. and I.G. Macdonald. *Introduction to Commutative Algebra*. London: Addison-Wesley, 1969.
2. Musili, C. *Introduction to Rings and Modules.* New Delhi: Narosa Publishing House, 1994.
3. Reid, Miles. *Under-graduate Commutative Algebra*, Cambridge, UK: Cambridge University Press, 1996.
4. Gopalakrishnan, N. S. *Commutative Algebra*. New Delhi: Oxonian Press, 1984.
5. Dummit, David S., and Richard M. Foote. *Abstract Algebra*. Hoboken, NJ: John Wiley & Sons, Inc., 2004.
6. Matsumura, H. *Commutative Ring Theory*. Cambridge, UK: Cambridge University Press, 1989.

**Course Title: Univalent Function Theory**
**Course Code: MTH 804**

| L | T | P | Credits |
|---|---|---|---|
| 4 | 0 | 0 | 4 |

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

**UNIT-I** **13 Hours**

Normal families, Extremal problems, The Riemann Mapping Theorem, Analytic continuation, Harmonic and Sub-harmonic functions, Green's functions, Positive Harmonic functions.

**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:**


1. Duren, P. *Univalent Functions.* New York: Springer, 1983.
2. Goodman, A. W. *Univalent Functions-Volume I & II.* Mariner, Florida, 1983.
3. Pommerenke, C. *Univalent Functions*. Van den Hoek and Ruprecht, Göttingen, 1975.
4. Graham, I. and Kohr, G. *Geometric Function Theory in One and Higher Dimensions*. New York: Marcel Dekker, 2003.

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

| L | T | P | Credits |
|---|---|---|---|
| 4 | 0 | 0 | 4 |

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

**UNIT-I** **14 Hours**

Subordination, Hypergeometric functions, Convex and Starlike functions, Close-to-convex functions, Spirallike functions, Integral Operators: Alexander operator, Libera operator, Bernardi operator.The general theory of differential superordinations, Admissible functions and fundamental results.

**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:**


1. Miller, S. S. and Mocanu, P. T. *Differential Subordinations: Theory and Applications*. New York: Marcel Dekker Inc., 2000.
2. Bulboaca, T. *Differential Subordinations and Superordination: Recent Results*.Cluj Napoca, 2005.

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

| L | T | P | Credits |
|---|---|---|---|
| 4 | 0 | 0 | 4 |

**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**

Construction of harmonic mappings (shear construction). Boundary behavior of harmonic mappings. Subclasses of Univalent Harmonic Mappings: Class $S_H$ and its properties, Subclasses of $S_H$ : Coefficients bounds of Convex, Starlike and Close-to-convex univalent harmonic mappings.

**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:**


1. Brilleslyper, M. A. and Michael J. Dorff et. al. *Explorations in complex analysis*, Mathematical Association of America. 2015.
2. Duren, P. *Harmonic mappings in the plane,* Cambridge university press. U.K. 2004.
3. Graham, I. and Kohr, G. *Geometric Function Theory in One and Higher Dimensions*. New York: Marcel Dekker, 2003.

**Course Title: Continuum Mechanics**
**Course Code: MTH 807**

| L | T | P | Credits |
|---|---|---|---|
| 4 | 0 | 0 | 4 |

**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:**


1. Narayan, S. *A text book of Cartesian Tensors (with an introduction to general tensors), 3rd Edition*. New Delhi: S. Chand publications, 1968.
2. Young, E.C. *Vectors and tensor analysis, 2nd Edition*. USA: CRC Press, 1993.
3. Sokolnikoff, I.S. *Mathematical theory of elasticity, 2nd Edition*. New York: McGraw-Hill, 1982.
4. Kolsky, H. *Stress waves in Solids, 2nd Edition*. USA: Dover Publications, Reprint 2002.
5. Ghosh, P.K. *Mathematics of waves and vibrations*. New Delhi: The Macmillan Company of India Ltd., 1975.
6. Ewing, W.M., W.S. Jardetzky, and F. Press. *Elastic waves in layered media*, New-York: McGraw-Hill Book Co., 1957.

**Course Title: Computational Techniques**
**Paper Code: MTH 808**

| L | T | P | Credits |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**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.
Solution of non-linear equations: Review of Bisection, Regula-Falsi and Secant method. Newton-Raphson method and its family, Functional iteration method. Rate of convergence of these methods. Newton's method for complex roots and multiple roots, Simultaneous non-linear equations by Newton-Raphson method.

**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.
Solution of Ordinary Differential Equations: Picard method of Successive approximations, Taylor series method, Euler's method, Modified Euler's method, Runge - Kutta methods, Predictor-Corrector methods.

**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:**


1. Conte, S.D., and Carl De Boor, *Elementary Numerical Analysis, An Algorithmic Approach*. New Delhi: Tata McGraw Hill, 1981.
2. Bradie, B., *A Friendly Introduction to Numerical Analysis*. India: Pearson Education, 2007.
3. Gerald C.F., and P.O. Wheatley, *Applied Numerical Analysis*. India: Pearson Education, 2008.
4. Pratap, R. *Getting Started with MATLAB*, Oxford University Press, New Delhi, 2015.
5. Chapman, S.J., *MATLAB Programming for Engineers, 4th Edition*, Cengage Learning, Boston, USA. 2015.

| L | T | P | Credits |
|---|---|---|---|
| 0 | 0 | 2 | 1 |

**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:**


1. Pratap, R. *Getting Started with MATLAB*, Oxford University Press, New Delhi, 2015.
2. Chapman, S.J., *MATLAB Programming for Engineers, 4th Edition*, Cengage Learning, Boston, USA. 2015.
3. Duffy, D.G. *Advanced engineering mathematics with MATLAB*, CRC Press (Chapman and Hall), Boca Raton, Florida, 2003.
4. Kalechman, M. *Practical MATALB basics for engineers*, CRC Press (Chapman and Hall), Boca Raton, Florida, 2009.
5. Mathews, John H., and D. Fink Kurtis. *Numerical Methods using Matlab 4th Edition.* New Delhi: PHI Learning Private Limited, 2012.

**Course Title: ODE and System of ODE**
**Paper Code: MTH 810**

| L | T | P | Credits |
|---|---|---|---|
| 4 | 0 | 0 | 4 |

**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**

Review of fundamentals of Ordinary differential equations. The method of successive approximation. Initial value problem, Ascoli's Lemma, Gronwall's inequality, Cauchy Peano Existence Theorem, Picard's existence and uniqueness theorem, Lipschitz condition.

**UNIT-II** **16 Hours**

Linear system of equations (homogeneous & non-homogeneous). Superposition principle, Fundamental set of solutions, Fundamental Matrix, Wronskian, Abel Liouville formula, Reduction of order, Adjoint systems and Self Adjoint systems of second order. Linear $2^{nd}$ order equations, preliminaries, Sturm's separation theorem, Sturm's fundamental comparison theorem.

**UNIT-III** **15 Hours**

Orthogonal set of functions, Orthonormal set of functions, Gram-Schmidth 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:**


1. Coddington, E. A. *An Introduction to Ordinary Differential Equations*. Prentice-Hall of India Private Ltd., New Delhi, 2001.
2. Piaggio, H. T. H. *Differential Equations*. New Delhi: CBS Publisher, 2004.
3. George, F Simmons. *Differential equations with applications and historical notes*. New Delhi: Tata McGraw Hill, 1974.
4. Sneddon, I. N. *Elements of Partial Differential Equations*. New Delhi: Tata McGraw Hill 1957.
5. Ross, S. L. *Differential Equation*s. New Delhi: John Wiley and Sons 2004.

**Course Title: Homological Algebra**
**Course Code: MTH 811**

| L | T | P | Credits |
|---|---|---|---|
| 4 | 0 | 0 | 4 |

**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 modules, 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, Associted translations, Functors of two complexes, Right-derived functors, the defining systems and the connecting homomorphisms, the functor $R^0T$, Left-derived functors, the functor $L_0T$.

**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 Torn , Basic properties of Torsion functors, Extension functors and Basic properties of extension functors.

**Reference Books:**


1. Northcott, D. G. *An introduction to Homological Algebra.* Cambridge University Press, UK, 2009.
2. Rotman, J. *An introduction to Homological Algebra.* Springer, New York, 2009.


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