**Shaheed Bhagat Singh State University, Ferozepur**

**Study Scheme of M.Sc. (Mathematics)**

**Scheme of the Program:**

**First Semester Contact Hours: 25 Hrs.**

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| **Course Code** | **Course Title** | **Load Allocation** | **Marks Distribution** | **Credits** |
| **L** | **T** | **P** | **Internal** | **External** | **Total** |
| **MSMM101C** | **Abstract Algebra** | 4 | 1 | 0 | 40 | 60 | 100 | 4 |
| **MSMM102C** | **Real Analysis** | 4 | 1 | 0 | 40 | 60 | 100 | 4 |
| **MSMM103C** | **Complex Analysis** | 4 | 1 | 0 | 40 | 60 | 100 | 4 |
| **MSMM104C** | **Ordinary Differential Equations** | 4 | 1 | 0 | 40 | 60 | 100 | 4 |
| **MSMM105C** | **Linear Algebra** | 4 | 1 | 0 | 40 | 60 | 100 | 4 |
| **Total** | 20 | 05 | 00 | 200 | 300 | 500 | 20 |

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| Semester | First |
| Course code | MSMM 101C |
| Category | Mathematical Science |
| Course title | Abstract Algebra |
| Scheme and Credits | L | T | P | Internal Marks | External Marks | Credits |
| 4 | 1 | 0 | 40 | 60 | 4 |

**Course Objectives:** This course is designed to give students a foundation for all future mathematics courses. The fundamentals of algebraic problem-solving are explained. Students will explore: foundations of Algebraic structures, Groups, Rings, Ideals, Fields, Homomorphisms etc. The course also fulfills the objective to make students aware of the applicability of abstract mathematics in real world problems.

**Course Outcomes**: At the end of the course, the students will be able to

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| CO1 | Apply the knowledge of Algebra to attain a good mathematical maturity and enables to build mathematical thinking and skill.  |
| CO2 | Utilize the class equation and Sylow theorems to solve different related problems. |
| CO3 | Identify and analyze different types of algebraic structures such as Solvable groups, Simple groups, Alternate groups to understand and use the fundamental results in Algebra. |
| CO4 | Design, analyze and implement the concepts of homomorphism and isomorphism between groups and rings for solving different types of problems, for example, Isomorphism theorems, quotient groups, conjugacy etc. |
| CO5 | Create, select and apply appropriate algebraic structures such as finitely generated abelian groups, Ideals, Fields to explore the existing results. |
| CO6 | Identify the challenging problems in modern mathematics and find their appropriate solutions. |

**Detailed Contents**

Chapter 1: Groups, Subgroups and Cosets, Cyclic groups, Permutation groups, Normal subgroups and quotient groups, homomorphisms, Isomorphism theorems, Automorphisms, Symmetric groups, Conjugacy.

Chapter 2: Normal series, Derived Series, Composition Series, Solvable Groups, Simple groups and their examples, Alternating group An, Simplicity of An.

Chapter 3: Direct Products, Finite Abelian Groups, Fundamental Theorem on Finitely generated Abelian Groups, Invariants of a finite abelian groups, Sylow's Theorems and their applications, Groups of order p², pq.

Chapter 4: Ring, Subring, Ideals, Homomorphism and Algebra of Ideals, Maximal and prime ideals, Ideals in quotient rings, Nilpotent and nil ideals.

**RECOMMENDED BOOKS:**

1. Bhattacharya, P.B., Jain, S.K. and Nagpaul, S.R., Basic Abstract Algebra, 2nd Edition. U.K.: Cambridge University Press, 2004.

2. Dummit, David.S.,and Foote, Richard M., Abstract Algebra, 3rd Edition. New Delhi: Wiley, 2011.

3. Herstein, I.N., Topics in Algebra, 2nd Edition. New Delhi: Wiley, 2006.

4. Singh, Surjeet, and Zameeruddin, Q., Modern Algebra, 7th Edition. New Delhi: Vikas Publishing House, 1993.

5. Artin, M., Algebra, 2nd Edition. Pearson Publications, 2010.

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| Semester | First |
| Course code | MSMM 102C |
| Category | Mathematical Science |
| Course title | Real Analysis |
| Scheme and Credits | L | T | P | Internal Marks | External Marks | Credits |
| 4 | 1 | 0 | 40 | 60 | 4 |

**Course Objectives:** This course is designed to provide a deeper and rigorous understanding of fundamental concepts viz. metric spaces, continuous functions, sequences and series of numbers as well as functions, and the Riemann-Stieltjes integral etc. The main focus of this course will be on theoretical foundation of the above said concepts and it will cultivate the rigorous mathematical logics and skills in the students.

**Course Outcomes:** At the end of the course, the students will be able to

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| CO1 | Apply the knowledge of concepts of real analysis in order to study theoretical development of different mathematical techniques and their applications. |
| CO2 | Understand the nature of abstract mathematics and explore the concepts in further details. |
| CO3 | Identify challenging problems in real variable theory and find their appropriate solutions. |
| CO4 | Deal with axiomatic structure of metric spaces and generalize the concepts of sequences and series, and continuous functions in metric spaces. |
| CO5 | Use theory of Riemann-Stieltjes integral in solving definite integrals arising in different fields of science and engineering. |
| CO6 | Extend their knowledge of real variable theory for further exploration of the subject for going into research. |

**Detailed Contents**

Chapter 1: Finite, Countable and Uncountable sets, Metric spaces, Compactness, Connectedness, Compact sets, Perfect sets, Connected sets, Heine-Borel Theorem.

Chapter 2: Limits of functions, Infinite limits and Limits at infinity, Continuous functions and their relation with connectedness and compactness, Discontinuity, Uniform Continuity, Monotonic functions.

Chapter 3: The Riemann-Stieltjes integral: Definition and existence of the Riemann-Stieltjes integral, Properties of the integral, Integration and differentiation, Integration of vector-valued functions, Rectifiable curves.

Chapter 4: Sequences and series of functions: Convergent sequences, Sub sequences, Cauchy sequences, Power series, Uniform convergence, Absolute convergence, Algebra of series, Rearrangements of elements in a series.

**RECOMMENDED BOOKS:**

1. Rudin, W., Principles of Mathematical Analysis, 3rd Edition. NewDelhi: McGraw-Hill Inc., 2013.

2. Royden, H.L. and Fitzpatrick, P.M., Real Analysis, 4th Edition. New Delhi: Pearson, 2010.

3. Carothers, N. L., Real Analysis, Cambridge University Press, 2000.

4. Apostol, T.M., Mathematical Analysis-A modern approach to Advanced Calculus. New Delhi: Narosa Publishing House, 1957.

5. Abbott, S., Understanding Analysis, 2nd Edition. Springer, 2016.

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| Semester | First |
| Course code | MSMM 103C |
| Category | Mathematical Science |
| Course title | Complex Analysis |
| Scheme and Credits | L | T | P | Internal Marks | External Marks | Credits |
| 4 | 1 | 0 | 40 | 60 | 4 |

**Course Objectives:** The objective of this course is to introduce and develop a clear understanding of the fundamental concepts of Complex Analysis such as analytic functions, Cauchy-Riemann relations and harmonic functions and to make students equipped with the understanding of the fundamental concepts of complex variable theory. In particular, to enable students to acquire skill of contour integration to evaluate complicated real integrals via residue calculus.

**Course Outcomes:** At the end of the course, the students will be able to

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| CO1 | Know the fundamental concepts of complex analysis. |
| CO2 | Evaluate complex integrals and apply Cauchy integral theorem and formula. |
| CO3 | Evaluate limits and checking the continuity of complex function & apply the concept of analyticity and the Cauchy-Riemann equations. |
| C04 | Solve the problems using complex analysis techniques applied to different situations in engineering and other mathematical contexts. |
| CO5 | Establish the capacity for mathematical reasoning through analysing, proving and Explaining concepts from complex analysis. |
| CO6 | Extend their knowledge to pursue research in this field. |

**Detailed Contents**

Chapter1: Function of complex variable, continuity and differentiability, Analytic functions, Cauchy Riemann equation (Cartesian and polar form). Harmonic functions, Harmonic conjugate, Construction of analytic functions. Exponential function, Trigonometric and inverse trigonometric functions, Logarithmic function, Complex powers, Branches of multi-valued functions with reference to arg(z), log(z), zc. Stereographic projection and the spherical representation of the extended complex plane.

Chapter 2: Complex line integral, Cauchy-Goursat theorem, independence of path; Cauchy's integral formulas and their consequences, Cauchy inequality, Liouville's theorem, Fundamental theorem of algebra, Morera's theorem Maximum modulus principle, Schwarz lemma, Poisson's integral formula.

Chapter 3: Power series: circle of convergence, radius of convergence. Taylor's series and Taylor's theorem, Laurent'z series and Laurent theorem, Zeros and singularities of complex functions, classification of singularities: removable singularity, poles, essential singularities, Residue at a pole and at infinity, Cauchy's Residue theorem and its applications in evaluation of real integrals: integration around unit circle, integration over semi-circular contours (with and without real poles), integration around rectangular contours, Argument principle, Rouche's theorem.

Chapter 4: Conformal transformations, Bilinear transformations, Critical points, Fixed points, Problems on cross-ratio and bilinear transformation.

**RECOMMENDED BOOKS:**

1. Ahlfors, L.V., Complex Analysis, 2nd Edition. McGraw-Hill International Student Edition, 1990.

2. Kumar, R.R., Complex Analysis, Pearson Education, 2015.

3. Churchill, R. and Brown, J.W., Complex Variables and Applications, 6th Edition, New-York: McGraw-Hill, 1996.

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| Semester | First |
| Course code | MSMM 104C |
| Category | Mathematical Science |
| Course title | Ordinary Differential Equations |
| Scheme and Credits | L | T | P | Internal Marks | External Marks | Credits |
| 4 | 1 | 0 | 40 | 60 | 4 |

**Course Objectives:** The Objective of this course is to introduce ordinary differential equations and fundamental theorems for existence and uniqueness. This course further explains the analytic techniques in computing the solutions of various ordinary differential equations appearing in various fields of science and technology.

**Course Outcomes:** At the end of the course, the students will be able to

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| --- | --- |
| CO1 | Understand ordinary differential equations of various types, their solutions, and fundamental concepts about their existence. |
| CO2 | Understand the concept and applications of eigen value problems. |
| CO3 | Understand differential equations of Strum Liouville type. |
| C04 | Apply various power series methods to obtain series solutions of differential equations. |
| CO5 | Discuss various kinds of special functions in detail, their properties and relations. |
| CO6 | Solve problems of ordinary differential equations arising in various fields. |

**Detailed Contents**

Chapter 1: Review of linear differential equations with constant & variable coefficients, Fundamental existence and uniqueness theorem for system and higher order equations (Picard's and Piano theorems), an operator method for linear system with constant coefficients, Homogeneous and Non-homogeneous Equations

Chapter 2: System of linear differential equations, Autonomous and non Autonomous system, Phase plane method, Stability.

Chapter 3: Boundary Value Problem, Ordinary differential equations of the Sturm-Liouville problems, Expansion theorem, Extrema properties of the eigenvalues of linear differential operators, Formulation of the eigen value problem of a differential operator as a problem of integral equation, Linear homogeneous boundary value problems.

Chapter 4: Power series solution of differential equations: about an ordinary point, solution about regular singular points, the method of Frobenius, Bessel equation and Bessel functions, Recurrence relations and orthogonal properties., Series expansion of Bessel Coefficients, Legendre's differential equations, Legendre Polynomials, Rodrigue's formula, Recurrence relations andorthogonal properties.

**RECOMMENDED BOOKS:**

1. Ross, S.L., Differential Equations, 3rd Edition. John Wiley & Sons, 2004

2. Boyce, W.E. and Diprima, R.C., Elementary Differential Equations and Boundary Value problems, 4th Edition. John Wiley and Sons, 1986.

3. Sneddon, I.N., Special Functions of Mathematical Physics and Chemistry. Edinburg: Oliver

& Boyd, 1956.

4. Bell, W.W., Special Functions for Scientists and Engineers. Dover, 1986.

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| Semester | First |
| Course code | MSMM 105C |
| Category | Mathematical Science |
| Course title | Linear Algebra |
| Scheme and Credits | L | T | P | Internal Marks | External Marks | Credits |
| 4 | 1 | 0 | 40 | 60 | 4 |

**Course Objectives:** Objective: To introduce the basic concepts of vector spaces and linear transformations.

**Course Outcomes:** At the end of the course, the students will be able to

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| CO1 | To Understand the concept of Vector spaces in detail |
| CO2 | To Understand the concept of Linear Transformation |
| CO3 | To Understand the concept of Canonical forms |
| CO4 | To Understand the concept of Inner Product Space |

**Detailed Contents**

Chapter 1: Vector space, subspace, sum of subspaces, linear combination, linear dependence and independence, basis and dimension, examples of infinite dimensional spaces, ordered bases and coordinates (10 Hrs)

Chapter 2: Basic definitions, rank-nullity theorem, matrix representation, algebra of linear transformations, change of basis, linear functional, Dual Spaces (8 Hrs)

Chapter 3: Eigen-values of linear operators, Eigen-space, minimal polynomial, diagonalisation, invariant subspaces, Jordan canonical representation, Norm of a matrix, computation of a matrix exponential (12 Hrs)

 Chapter 4: Definition of inner product between two vectors, orthogonal and orthonormal vectors, normed space, GramSchmidt process for orthogonalisation, projection operator, quadratic forms, positive definite forms, Symmetric, Hermitian, orthogonal, unitary and Normal transformations/matrices (12Hrs)

**RECOMMENDED BOOKS:**

1. Herstein I. N. Topics in Algebra, 2nd Edition, Willey eastern Limited

2. Hoffman, Kenneth and Kunze R: Linear Algebra, Prentice Hill of India Private Limited.,

3. Peter, J. Olever and Shakiban, C., "Applied Linear Algebra", 1st Edition, Prentice Hall

4. Leon, S.J., "Linear Algebra with Applications", 8th Edition, Pearson

5. Strang, G., “Linear Algebra and its Applications”, 3rd edition, Thomson Learning Asia Pvt Ltd

6. Sudan L., “Applied Linear Algebra”, Prentice Hall

7. A. R. Rao and P. Bhimashankaran, Linear Algebra, Hidustan Book Agency

8. Surjit Singh, Linear Algebra, Vikas publishing House

9. Additional Reading: Sahi and Bist, Linear Algebra, Narosa Publishing House.