NAAC Criterion-I

Key Indicator – 1.1.3

Syllabus copies of the courses highlighting the focus on employability/ entrepreneurship/ skill development along with their course outcomes

1.1.3 Evidences

Central University of Himachal Pradesh, Dharamshala, Kangra

SRINIVASA RAMANUJAN DEPARTMENT OF MATHEMATICS

INDEX

हिमाचल प्रदेश केंद्रीय विश्वविद्यालय
Central University of Himachal Pradesh
(Established under Central Universities Act 2009)
शाहपुर परिसर, शाहपुर, ज़िला काँगड़ा (हि.प्र.) - 176206
Shahpur Parisar, Shahpur, Distt. Kangra (HP) - 176206
Website: www.cuhimachal.ac.in

Central University of Himachal Pradesh

Srinivasa Ramanujan Department of Mathematics, Shahpur Parisar

Program Specific Outcomes

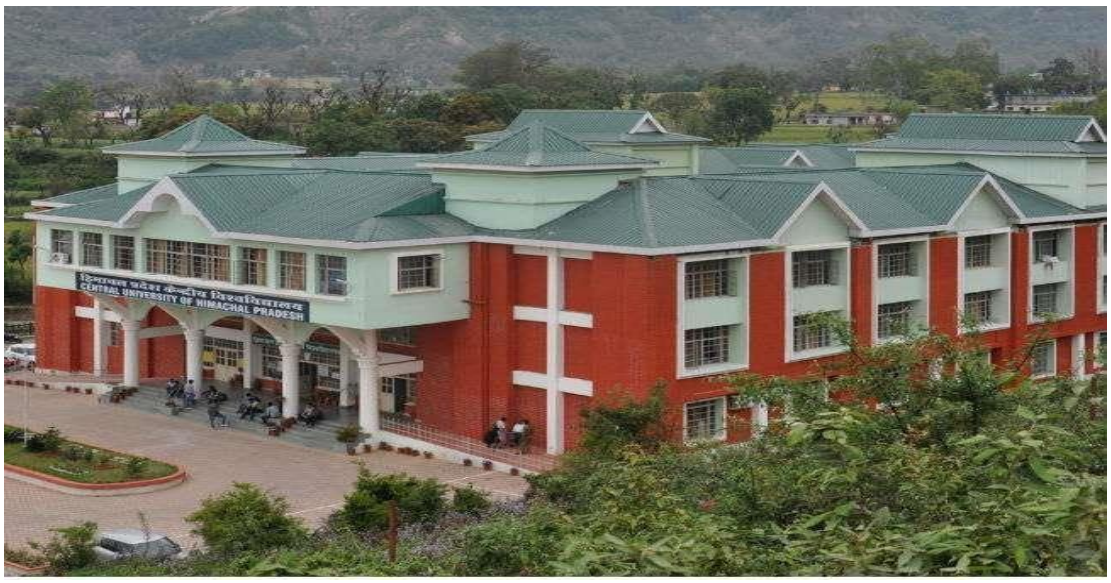
Program Outcomes

Course Outcomes & Course Contents

of

Master of Science in Mathematics (MSc Mathematics)

School of Mathematics, Computers & Information Sciences



Programme Specific Outcomes of Master of Science in Mathematics

PSO[1]: To possess the systematic understanding of the concepts, theories and methods of mathematics at higher education level.

PSO[2]: To deal with the real-world problems and their significance by critical understanding, analyzing and synthesizing the various mathematical concepts.

Programme Outcomes of Master of Science in Mathematics

PO[1]: To comprehend and analyze mathematical theories, methods, and findings in their appropriate contexts.

PO[2]: To learn the generalization of mathematical theories, as well as how to bridge them to broader concepts.

PO[3]: To review the literature related to pure/applied mathematics, and identify the knowledge gaps.

PO[4]: To analyze data critically, prepare scientific reports/papers, and defend the work.

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Shahpur Parisar, Shahpur, Distt. Kangra (HP) - 176206
Website: www.cuhimachal.ac.in

Batch 2021-23

M.Sc. Mathematics
Semester-I
(Monsoon Semester, 2021)

COURSES OFFERED BY SRINIVASA RAMANUJAN DEPARTMENT OF MATHEMATICS

Sr. No.	Course Name	Course Code	Credits
Major Courses (Disciplinary Courses) (10 Credits)			
1	Linear Algebra	MTH 403	04
2	Real Analysis	MTH 406	04
3	One course to be Chosen from the Course basket at University Level which is different and distinct from the programme which s/he is enrolled in.		02
Minor Courses (Disciplinary Courses) (04 Credits)			
4	Mathematical Methods	IAM 404	04
Vocational/Skill Courses (04 Credits)			
5	Operational Research	MTH 502	02
6	Discrete Mathematics	MTH 503	02
Indian Knowledge System Courses (at University Level) (02 Credits)			
8	Indian Knowledge System	IKS	02

Course Contents:

Major Courses (Disciplinary Courses) (10 Credits)

Course Code: MTH-403

Course Name: LINEAR ALGEBRA

Course Credit: 04

Course Instructor: Dr.Pankaj Kumar S/O Late Sh. Maniram

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom

activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The purpose of this course is to acquaint the students with the Numerical analysis which is necessary to develop the basic understanding of numerical algorithms for solving problems in science, engineering and technology.

Course Outcome:

By the end of the course students should be able to understand:

Co^1: The abstract definition of a set theory, and be familiar with the definition of Vector space with examples.

Co^2: All concept of linear transformation.

Co^3: Knowledge about the Eigen vector, Eigen values minimal polynomials.

Co^4: Knowledge about the functional, inner product space and quadratic forms.

Co^5: How apply some underlining and cross-cutting concepts of Vector space and related concepts.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

Mid Term Examination: 40
End Term Examination: 120
Continuous Internal Assessment: 40

Course Contents:

Unit I:

Vector Spaces, Subspaces, Basis and dimension, Linear Transformations, Quotient spaces, Direct sum, The matrix of a linear transformation, Duality **(12 Hours)**

Unit II:

Eigenvalues and eigenvectors, Annihilating polynomials, Invariant subspaces, Triangulation and diagonalization. **(10 Hours)**

Unit III:

Canonical Forms, Jordan Form, Inner Product Spaces, orthonormal basis, Linear functional and adjoints. **(10 Hours)**

Unit IV:

Bilinear Forms, Definition and examples, Symmetric and skew-symmetric bilinear forms. **(08 Hours)**

Prescribed Text Book:

1. K. Hoffman and R. Kunze : Linear Algebra, Second Edition, Pearson,2015.

Suggested Additional Readings:

1. StrangG.: Linear Algebra and its applications, 4th Edition, CENGAGE LEARNING, 2007.
2. KumaresanS.: Linear Algebra, A Geometric approach, Prentice Hall of India,2000.
3. LipschutzS. and LipsonM. L.: Linear Algebra, 3rd Edition, McGraw Hill Education India, Pvt. Ltd., 2001.
4. AntonH. AndRorresC.: Elementary Linear Algebra, 11th Edition, Wiley,2014.

Course Articulation Matrix MTH-403- Linear Algebra

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	1	2	2	2		1	1	2
CO2	2	2	1	2		1	1	2
CO3	1	2	2	2		2	2	2
CO4	2	1	2	3		2	1	1
CO5	1	2	2	2		2	1	2

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: MTH 406

Course Name: Real Analysis

Course Instructor: Dr Meenakshi

Credits: 04

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The purpose of this course is:

- To obtain the thorough understanding of the origins of Number System
- To gain the knowledge of sequence and series of real numbers and convergence
- Studying the notions of continuous functions of real number system and their properties

Course Outcomes: After successful completion of the course, a student will be able to:

CO[1]Define and recognize the basic properties of the field of numbers
CO[2]Define and recognize the continuity and differentiability of the functions and their properties
CO[3]Improve and outline the logical thinking of Number system
CO[4] Understand Applications of Integration and Differentiation

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 40

2. End Term Examination: 120

3. Continuous Internal Assessment: 40

Course Contents:

Unit-I: Real and complex number systems, Basic Topology: Rational Numbers, Dedekind' Theorem, Cantor' Theory of Irrational Numbers, Ordered sets, Fields, The Real field and Complex field, Euclidean spaces, Countable and Uncountable sets, Metric spaces, Compact sets. **(10 Hours)**

Unit-II: Sequence, Series and Continuity: Sequence, subsequence, Convergent sequence, upper and lower limits, Series of non-negative terms, the root and ratio test, Power series and Summation by parts, Absolute

convergence, Continuity and compactness, monotonic functions.

(10 Hours)

Unit-III: Differentiation: Differentiation of a Real valued functions, Mean value theorem, Differentiation of Vector valued functions, L. Hospital Rule, Taylor's Theorem and Derivatives of Higher order.

(10 Hours)

Unit-IV: Sequence, Series of Functions and Functions of several Variables: Uniform Convergence, Equi-continuous Families of Functions, The Stone-Weierstrass Theorem, Differentiations of a Function of Several Real Variables and the Contraction Principle. **(10 Hours)**

Prescribed Text Books:

- Rudin, Walter, "Principles of Mathematical Analysis", 3rd Edition, McGraw Hill.
- Robert G. Bartle, Donald R. Sherbert, "Introduction to Real Analysis" , 3rd Edition, Wiley.

Suggested Additional Readings:

1. G.F. Simmons, "Topology and Modern Analysis", 1st Edition, McGraw Hill.
2. Russell A. Gordon, "Real Analysis: A First Course", Addision-Wesley Higher Mathematics Series.

Course Articulation Matrix of MTH 406- Real Analysis

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	2	2	1		3	3
CO^2	3	2	2	1		3	2
CO^3	3	2	2	1		3	2
CO^4	3	2	2	1		3	3

1. Partially Related
2. Moderately Relate
3. Highly Related

Minor Courses (Disciplinary Courses) (04 Credits)

Course Code: IAM 404

Course Name: Mathematical Methods

Credits: 04

Course Instructor: Dr S. K. Srivastava

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The purpose of this course is to acquaint the students with the integral equations and calculus of variations.

Course Outcomes: After successful completion of the course, a student will be able to understand:

CO1 The methods of solving Fredholm integral equations.

CO2 The methods of solving Volterra integral equations.

CO3 The notion of variations, Euler Lagrange's equations.

CO4 Applications of calculus of variations.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examinations.

Evaluation Criteria:

1. MidTermExamination:40
2. EndTermExamination:120
3. ContinuousInternalAssessment:40

Course Contents:

Unit I: Review the basic concepts for solving ODE: First order and second order Linear differential equations, Series solution for ODE where x=0 is ordinary point, Leibnitz rule for differentiation of integrals, Cauchy formula for reducing multiple integrals to single integral and Laplace transforms. Integral equations: classification of integral equations; conversion from IVP to Volterra integral equations and conversely; conversion from BVP to Fredholm integral equations and conversely, Integral equations with separable kernels. **(10Hours)**

Unit II: Method of successive approximations, eigenvalues and eigenfunctions, Resolvent kernels, Symmetric kernels, Hilbert Schmidt theorem and solution of symmetric integral equations.
(10 Hours)

Unit III: Calculus of Variations: Concept of variation, Linear functional, Euler-Lagrange equation, Necessary and sufficient conditions for extrema, Euler-Lagrange differential equation for n-dependent variables, Functional dependent on higher order derivatives, Functional dependent on functions of several variables. **(10 Hours)**

Unit IV: Applications of calculus of variations to various problems: Shortest distance, minimum surface of revolution, Brachistochrone problem,geodesic, Isoperimetric problem, Calculus of variations for problems in parametric form, variational problems with moving boundaries. (**10 Hours)**

Prescribed Text Books:

M.D. Raisinghania (2016), Integral equations and boundary value problems, S. Chand Publishing.
I.M. Gelfand and S.V. Fomin (2012): Calculus of Variations, Prentice Hall Inc.

Suggested Additional Readings:

F.G. Tricomi,(1985): Integral Equations, Cambridge University Press.
A. S. Gupta (1996): Calculus of Variations with Applications, Prentice–Hall of India.
RobertWeinstock(1975):CalculusofVariationswithapplicationstoPhysicsandEngineering,DoverPublications Inc.

CourseArticulation MatrixofIAM404-MathematicalMethods

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	2	1	1		3	2
CO^2	3	2	1	1		3	2
CO^3	3	2	1	1		3	2
CO^4	3	2	1	1		2	3

1. Partially Related
2. Moderately Relate
3. Highly Related

Vocational/Skill Courses (04 Credits)

Course Code: MTH 502

Course Name: Operational Research

Course Instructor: Dr. Khushbu Srivastava &Anuj Kumar

Credits: 02

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The purpose of this course is to acquaint the students with theoperational Research which is mainly concerned with the techniques of applying scientific knowledge, besides the development of science and provides an understanding which gives the expert/manager new insights and capabilities to determine better solutions in his decision–making problems, with great speed, competence and confidence.

Course Outcomes: After successful completion of the course, a student will be able to understand:

CO^{1}The formulation and solution to real mathematical models of LPP.
CO^{2}The Graphical and Simplex methods for the solution of LPP.
CO^{3}Degeneracy and dual Simplex methods.
CO^{4}Queueing systems and solution of Queueing Models.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 20
2. End Term Examination: 60
3. Continuous Internal Assessment: 20

Course Contents:

Unit I: Operations research & its scope, Necessity of operations research in industry .Introductions to Linear programming problems, General linear programming problems, Mathematical Formulation of L.P.P .and examples, Feasible, Basic feasible and optimal solutions, Extreme points, Graphical Methods to solve L.P.P., Simplex Method. **(10 Hour)**

Unit II: Big M Method, Two phase Method, Degeneracy, Unrestricted variables, unbounded solutions, Duality in LPP, fundamental properties of Dual problems, dual simplex method and Revised Simplex method. **(10 Hours)**

Unit III: Queueing systems, Queueing problem, Transient and steady states, Probability Distributions in Queueing systems .Poisson process pure birth process(, Properties of poissons arrivals, Exponential process, Markovian property, Pure death process, Service time distribution, Erlang service time distribution, Solution of Queueing Models. **(10 Hours)**

Prescribed Text Books:

1. Kanti Swarup, P.K .Gupta and Manmohan (2000), Operations Research, Sultan Chand & Sons, 12th Edition.

Suggested Additional Readings:

1. S. D .Sharma (2004), Operations Research, KedarNath Ram Nath & Co .14th Edition.

Course Articulation Matrix of MTH 502- Operational Research

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	2	1	1		2	3
CO^2	3	2	1	1		2	3
CO^3	3	2	1	1		2	3
CO^4	3	2	1	1		2	3

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: MTH 503

Course Name: Discrete Mathematics

Credits: 02

Course Instructor: Dr. Pankaj Kumar S/o Sh. Krishan Singh

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: To introduce students to language and methods of the area of Discrete Mathematics. The special focus of the module is on basic mathematical concepts in discrete mathematics and on applications of discrete mathematics in algorithms and data structures. To show students how discrete mathematics can be helpful in modern computer science so that they may able to relate these to practical examples.

Course Outcomes: After completing the course satisfactorily, a student will:

CO1: Be skillful in expressing mathematical properties formally by using the formal language of propositional logic.

CO2: Get experience to comprehend formal logical arguments.

CO3: Acquire ability to specify and manipulate basic mathematical objects such as sets, relations and functions.

CO4: Learn to use various techniques of mathematical induction which will help them prove simple mathematical properties of a variety of discrete structures.

CO5: Be able to apply some basic counting techniques to solve permutation and combination problems.

CO6: Get familiar with to construct mathematical problems along with their Mathematical proofs.

CO7: Know how to apply the knowledge they have gained to solve real life problems.

Attendance Requirements: Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination:20%
2. End Term Examination:60%
3. Continuous Internal Assessment: 20%. i.e. 20 marks out of100

Course Contents:

Unit I

Logic, Propositional Equivalences, Partial Ordered Sets, Lattices and Algebraic Systems, Principle of Duality, Basic Properties of Algebraic Systems defined by Lattices, Distributive and Complemented Lattices, Boolean Lattices and Boolean Algebras, Boolean Functions and Boolean Expressions, Propositional Calculus, Pigeonhole principle: Simple form, Pigeonhole principle: Strong form, A theorem of Ramsey.

Unit II:

Two basic counting principles, Permutations of sets, Combinations of Sets, Generating permutations, Inversions in permutations, Generating combinations, Pascal's formula, The binomial theorem, Identities, Unimodality of binomial coefficients, The multinomial theorem, Newton's binomial theorem. The inclusion-exclusion principle, Combinations with repetition, Derangements. Some number sequences, linear homogeneous recurrence relations, Non-homogeneous recurrence relations.

Prescribed Text Books:

1. CL. Liu and DP. Mohapatra, (2012) Elements of Discrete Mathematics.4th Edition, Tata McGraw Hill Education.
2. Richard A. Brualdi, Introductory Combinatorics, 3rdEdition.

Suggested Additional Readings:

1. J. Matousek and J. Nesetril (2005). Invitation to Discrete Mathematics. Oxford University Press.
2. G. Edgar and PM. Michael (2003). Discrete Mathematics with Graph Theory. Prentice Hall.
3. Kenneth H. Rosen, Discrete Mathematics and Its Application, Tata McGraw-Hill, Fourth Edition.

Course Articulation Matrix of MTH 503- DISCRETE MATHEMATICS

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO1	3	3	1	1		2	2
CO2	2	2	1	1		1	1
CO3	2	2	1	1		2	2
CO4	2	3	1	1		2	2
CO5	1	2	1	1		2	2
CO6	2	2	1	1		3	2
CO7	1	1	1	1		1	3

1. Partially Related
2. Moderately Relate
3. Highly Related

Indian Knowledge System (IKS) Course (02 Credits)

Syllabus is framed centrally as per CUHP Guidelines, and is adopted in totality.

M.Sc. Mathematics
Semester-II
(Spring Semester 2022)

Sr. No.	Course Name	Course Code	Credits
Major Courses (10 Credits)			
1	Abstract Algebra	MTH 404	04
2	Complex Analysis	IAM 401	04
3	Numerical Analysis	IAM 403	02
Major Courses (02 Credits)			
4	To be Chosen from the Course basket at University Level which is different and distinct from the programme which s/he is enrolled in.		02
Minor Courses (04 Credits)			
5	Topology	MTH 501	02
6	Differential Geometry	IAM 407	02
Vocational/Skill Courses (02 Credits)			
7	Basics of Propositional Logic	MTH 529	02
IKS (02 Credits)			
8	Introduction to Rigorous and Precise Thinking	MTH 528	02

Course Contents

Major Courses (12 Credits)

Course Code: MTH-404

Course Name: Abstract Algebra

Course Credits: 04

Course Instructor: Dr. Pankaj Kumar S/o Late Sh. Maniram

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

This course aims to provide a first approach to the subject of abstract algebra, which is one of the basic pillars of modern mathematics. The focus of the course will be the study of certain structures called groups, rings, fields.

Course Outcome:

By the end of the course students should be able to understand:

Co^1: The abstract definition of a group, and be familiar with the basic types of examples, including numbers, symmetry groups and groups of permutations and matrices.

Co^2: Description of algebraic techniques and basic elements of abstract algebra.

Co^3: The state axioms of groups, rings and fields.

Co^4: How apply some underlining and cross-cutting concepts of groups, rings and fields.

Co^5: The concept of cosets of a subgroup of a group and normal subgroups, symmetric groups, cyclic groups and their properties.

Co^6: The concept of quotient groups, homomorphism and isomorphism.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 40
2. End Term Examination: 120

3. Continuous Internal Assessment: 40

Course Contents:

Unit I

Laws of Composition, Groups and Subgroups, Examples of Groups and Subgroups, Groups generated by a Set, Cyclic Groups, Order of an element of a Group, Cosets, Lagrange's theorem, Index of a Subgroup, Cycle decomposition of a Permutation. Homomorphisms, Isomorphisms, Automorphisms, Normal Subgroups, Quotient Groups, The Isomorphism theorems, the Correspondence Theorem, Direct Product of Groups. **(12 hours)**

Unit II

Group Actions, Examples of Group Actions, Orbit and Stabilizer of Group Action, Orbit and Stabilizer Formula, Cayley's theorem, Conjugacy Classes, Center of a Group, Centralizer of a Subset, the Class Equation, Application of the Class Equation, the Center of a p-Group and related results, Simple Groups. **(08 hours)**

Unit III

Stabilizer and Normalizer of a Subgroup, the First Sylow theorem, the Second Sylow theorem, the Third Sylow theorem. Applications of Sylow Theorems, Definition of a Ring, Examples of Rings, Subrings, Homomorphisms of Rings, Kernel of a Homomorphism, Ideals, Ideal Generated by a Set, Principal Ideals. **(08 hours)**

Unit IV

Quotient Ring, Prime Ideals, Maximal Ideals, the Isomorphism theorems for Rings, the Universal Mapping Property of Quotient Rings, The Correspondence theorem, Dircet Product Rings, Integral Domains, Group of Units of a Ring, Associates, Irreducible Elements of Ring, Prime Elements of a Ring, Unique Factorization Domains, An Example of a Non-Unique Factorization Domain.

(12 hours)

Prescribed Text Books:

1. Isaac I.M., *Algebra: A Graduate Course, AMS (Graduate Studies in Mathematics),* Indian Edition.
2. Artin M., *Algebra,* Second Edition, PHI
3. Bhattacharya P. B., Jain S.K., Nagpaul S. R., *Basic Abstract Algebra,* Second Edition, Cambridge University Press.

Additional Text

1. Dummit D. S. and Richard M. Foote, *Abstract Algebra*, Third Edition, Wiley India
2. Jacobson N., *Basic Algebra,* Vol. 1, Hindustan Publishing Corporation, Delhi

Course Articulation Matrix MTH-404- Abstract Algebra

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	1	1	3	2		1	1	2
CO2	2	3	1	1		1	1	2
CO3	1	2	2	3		2	2	2
CO4	2	1	2	3		2	1	1
CO5	1	2	3	1		2	1	2
CO6	1	1	1	1		1	1	1

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: IAM401

Course Name: Complex Analysis

Credits: 04

Course Instructor: Dr S. K. Srivastava

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives: The objectives of this course are to:

- Provide an introduction to the indispensable ideas for the development of the functions of a complex variable and
- equip students with clear understanding of the elementary concepts of the theory of complex analysis and skills to enable them to work with the concepts effectively.

Course Outcomes: After successful completion of the course the student will be able:

$CO^{1:}$ To understand Stereographic projection, analytic functions and singularities.

$CO^{2:}$ To understand Branch point, conformal transformations and homotopic curves.

$CO^{3:}$ To learn basics of complex integrations and Fundamental theorem of algebra.

$CO^{4:}$ To understand Maximum-Modulus theorem and Rouche's theorem etc.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

Mid Term Examination: 40
End Term Examination: 120
Continuous Internal Assessment: 40

Course Contents:

UNIT-I: Complex Numbers, Geometric description, Stereographic projection, Analytic functions, the Cauchy-Riemann equations, multivalued functions, Branch point. **(10Hours)**

UNIT-II: Complex integration, Cauchy-Goursat theorem, Cauchy integral formula, Derivatives of analytic function. **(10Hours)**

UNIT-III: The Liouville theorem, The Morera theorem, Maximum-Modulus theorem, conformal transformations. **(10Hours)**

UNIT-IV: Taylor's series, Laurent's series, Singularities of complex functions, the Cauchy Residue theorem, Evaluation of integrals. **(10Hours)**

Prescribed text book:

J. B. Conway, Functions of one complex variable, International Student-Edition, Narosa Publishing House, 2000.

Reference books:

- K. Kodaira, Complex Analysis, Cambridge University Press,2007.
- J. W. Brown and R. V. Churchill, Complex Variables and Applications, McGraw Hill,8thEdition,2008.

CourseArticulationMatrixofIAM401-ComplexAnalysis

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	ProgrammeOutcomes 4		Programme SpecificOutcomes 1	ProgrammeSpecificOutcomes 2
CO1	3	2	1	1		3	2
CO2	3	2	1	1		3	2
CO3	3	2	1	1		3	2
CO4	3	2	1	1		3	2

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: IAM 403

Course Name: Numerical Analysis

Credits: 02

Course Instructor: Prof. Rakesh Kumar

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The main objective of this course is to familiarize the students with basic numerical schemes and their applications.

Course Outcomes: After completing the course satisfactorily, the student will be able to:

CO1: Interpolate and approximate functions.

CO2: Perform numerical differential and integration.

CO3: Perform error analysis.

CO4: Apply basic numerical algorithms.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

Mid Term Examination:20%
End Term Examination:60%
Continuous Internal Assessment: 20%. i.e. 20 marks out of 100

Course Contents:

Unit I: Lagrange and Newton interpolations, interpolations using finite differences, Hermite interpolation, piecewise and spline interpolation, Polynomial approximation: least square approximation, orthogonal polynomials, uniform approximation, rational approximation. **(07 HRS)**

Practicum

- Solving the Exercises of the selected Chapters
- Implementation on the selected real world problems
- Performing simulations for the pattern of solutions

Unit II: Numerical Differentiation and Integration: methods based on interpolation, methods based on undetermined coefficients, composite integration methods, Romberg integration. **(07 HRS)**

Practicum

- Solving the Exercises of the selected Chapters
- Implementation on the selected real world problems
- Performing simulations for the pattern of solutions

Unit III: Initial and Boundary value problems: Taylor's series method, Runge-Kutta methods, shooting method. **(06 HRS)**

Practicum

- Solving the Exercises of the selected Chapters
- Implementation on the selected real world problems
- Performing simulations for the pattern of solutions

General Practicum:

i. Class Room Presentation
ii. Model/Chart/PowerPoint based presentations
iii. Assignment/ Write Up/Creative work
iv. Books/Journals Readings
v. Tutorials/PBL

Prescribed Text Book:

1. M.K. Jain, S. R. K. Iyengar and R. K. Jain: Numerical Methods, 6th Edition, New Age International (P) Limited, Publishers, New Delhi.

Suggested Additional Readings:

1. S. S. Sastri; Introductory Methods of Numerical Analysis, PHI Learning Pvt. Ltd., 2005.
2. S.C. Chapra: Applied Numerical Methods with MATLAB, McGraw Hill, 2012.

Course Articulation Matrix of IAM 403- Numerical Analysis

Course Outcomes	Programme Specific Outcomes 1	ProgrammeSpecific Outcomes 2	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4
CO1	3	2	2	3	2	1
CO2	3	2	2	3	2	1
CO3	3	3	3	2	2	2
CO4	2	3	3	2	1	1

1. Partially Related
2. Moderately Relate
3. Highly Related

Minor Courses (04 Credits)

Course Code: MTH 501

Course Name: Topology

Credits: 02

Course Instructor: Dr. Meenakshi

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

The objectives of this course are to:

- To understand the meaning of topology with help of examples
- To make more precise the relationship between geometric translation/ construction and continuous map.

Course Outcomes:

After successful completion of the course the student will be able:

CO^{1} An ability to construct and develop different topologies
CO^{2}An ability to explore applications of topologies
CO^{3}To learn basics of real number system by involving Topology

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 20
2. End Term Examination: 60
3. Continuous Internal Assessment: 20

Course Contents:

UNIT-I: Topological Spaces, Bases for Topology, The Subspace Topology, Sub-basis for Topology, The Order Topology, The Product Topology, Closed Sets, Definition of Topology in terms of Closed Set, Limit Points, the Neighborhood System of a point, Subspace Topology, characterization of Closed Sets in a Subspace, Closure and Interior of a Set, characterization of Closure of a Set in a Subspace.

(10 Hours)

UNIT-II: Definition of a Continuous Function in a Topological Space, various characterizations of Continuous Function in a Topological Space, Quotient Spaces, Homeomorphisms, Definition of a Topological Property, the Product Topology, the Metric Topology, the Connected Spaces, Path Connectedness, Components and Local Connectedness. **(10 Hours)**

Prescribed text book:

J. R. Munkres, Topology, Second Edition, Prentice Hall, 1994.

Reference books:

1. J. L. Kelley, General Topology: Graduate Texts in Mathematics, Springer, 1955
2. M. A. Armstrong, Basic Topology : Undergraduate Texts in Mathematics, Springer, 1955.

Course Articulation Matrix of MTH 501- Topology

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	2	2	2		3	2
CO^2	3	2	2	1		3	1
CO^3	3	3	3	3		3	2

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: IAM 407

Course Name: Differential Geometry

Credit: 02

Course Instructor: Dr. Pankaj Kumar S/o Sh. Krishan Singh

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The prime objective of this course is to provide the basic concepts and knowledge of differential geometry by focusing at the various physical aspects through the different solution schemes/ techniques.

Course Outcomes: After completing the course satisfactorily, a student will be able:

CO1 : To know about the distinct kind of curves and their geometry.

CO2 : To know about the distinct techniques/ schemes which are essential in the wide study of curves and surfaces.

CO3 : To know about the famous naming theorems like Egregium theorem, Gauss-Bonnet theorem etc. which are necessary about the basic study of curves/ surfaces.

Learning Outcomes: The deliverables Learning Outcomes of this paper with students are following:

- Can explain about distinct curves and curvature along with their basic terminology which is soul part of the study of differential geometry.
- Will know about the different solution techniques/schemes related to the wide knowledge of curves and surfaces.
- Can explain about the second fundamental form, Gaussian curvatures, Pseudosphere, Geodesics and use of different basic theorems in various physical aspects.

Attendance Requirements: Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 20%
2. End Term Examination: 60%

3. Continuous Internal Assessment: 20% (i.e. 20 marks out of100).

Course Contents:

UNIT I: The Second Fundamental Form, Curvature of curves on surface, Normal and Principal Curvatures, Gaussian and Mean curvatures. **(10 Hrs)**

Practicum

- Solving the Exercises of the selected Chapters.
- Implementation on the selected real world problems.

UNIT-II: The Pseudosphere, Gauss map, Geodesics: Basic Properties, TheoremaEgregium and Gauss-Bonnet Theorem. **(10 Hrs)**

Practicum

- Solving the Exercises of the selected Chapters.
- Implementation on the selected real world problems.

General Practicum:

i. Class Room Presentation
ii. Model/Chart/PowerPoint based presentations
iii. Assignment/ Write Up/Creative work
iv. Books/Journals Readings
v. Tutorials/PBL

Essential Readings:

- Andrew Pressley, Elementary Differential Geometry, Springer, 2010.

Suggested Additional Readings:

- M.P. doCarmo, Differential Geometry of Curves and Surfaces, Prentice Hall, 1976.
- B. O'Neill, Elementary Differential Geometry, Academic Press, New York, 1966.

Course Articulation Matrix of IAM 407- DIFFERENTIAL GEOMETRY

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO1	2	3	1	1		2	2
CO2	3	2	1	1		3	3
CO3	2	2	1	1		1	2

1. Partially Related
2. Moderately Relate
3. Highly Related

Vocational/Skill Courses (02 Credits)

Course Code: MTH 529

Course Name: Basics of Propositional Logic

Credits: 02

Course Instructor: Dr. Meenakshi

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

The objective of this course is to develop a rational thinking in statements/decision making/ arguments.

Course Outcomes:

After successful completion of the course the student will be able:

CO[1] State the converse, inverse, contrapositive and negation of a conditional statements including quantified statements
CO[2]Construct the truth tables, and interpret the results
CO[3]To write different types of proofs

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 20
2. End Term Examination: 60
3. Continuous Internal Assessment: 20

Course Contents:

UNIT-I: Set and Proposition, Finite and Infinite set, Mathematical Induction, Principle of Inclusion and Exclusion, Multisets, Propositions, Logical Connectives, Conditional and Biconditional, Well-Formed formulas, Tautologies. **(10 Hours)**

UNIT-II: Logical Equivalence, Theory of Inference for Statement Calculus, Validity using Truth Tables, Rules of Inference, Consistency of Premises, Predicate Calculus, The Statement Function, Variables and Quantifier, Predicate Formula, Free and Bound variable, The Universe of Discourse, Inference Theory of Predicate Calculus, Valid formula and Equivalences, Theory of Inference for Predicate Calculus, Formulas

involving more than one Qualifier, Euclidean Algorithms. **(10 Hours)**

Prescribed text book:
C. L. Liu, "Elements of Discrete Mathematics", McGraw Hill publication.

Reference books:
Kenneth H. Rosen, Discrete Mathematics and its Applications, McGraw Hill

Course Articulation Matrix of MTH 529- Basics of Propositional Logic

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	3	2	1	3	2
CO^2	3	3	2	1	3	2
CO^3	3	3	2	1	3	3

1. Partially Related
2. Moderately Relate
3. Highly Related

IKS (02 Credits)

Course Code: MTH 528

Course Name: Introduction to Rigorous and Precise Thinking

Credits: 02

Course Instructor: Dr. Meenakshi

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

The objectives of this course are:

- To understand what is mathematics and its purpose
- To think for the development of Mathematics
- To know about why we need to learn about Mathematics
- To precise about Mathematical statements
- To perform different types of proofs

Course Outcomes:

After successful completion of the course the student will be able:

CO^1 Explain different definitions of Mathematics

CO^2 Explain the basic ideas for the development of Mathematics

CO^3 Explain logical combinators

CO^4 To possess the knowledge to approach for proofs of Mathematical statements

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 20
2. End Term Examination: 60
3. Continuous Internal Assessment: 20

Course Contents:

UNIT-I: What is mathematics?, More than Arithmetic, Mathematical Notation, Modern college- level mathematics, Getting precise about language, the logical combinators, Implication, Quantifiers. **(10 Hours)**

UNIT-II: Proof, Proof by contradiction, Proving Conditional, Proving Quantified statements, Induction Proofs, Proving results about numbers, Real Numbers, Completeness and Sequences

(10 Hours)

Prescribed text book:

Keith Devlin, Introduction to Mathematical Thinking, Publisher: Keith Devlin, 331 Poe St, Unit 4, Palo Alto, CA 94301, USA

Course Articulation Matrix of MTH 528- Introduction to Rigorous and Precise Thinking

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	3	2	1	3	3
CO^2	3	3	2	1	3	2
CO^3	3	3	2	1	3	2
CO^4	3	3	2	2	3	3

1. Partially Related
2. Moderately Relate
3. Highly Related

M.Sc. Mathematics
Semester-III
(Monsoon Semester, 2022)

Sr. No.	Course Name	Course Code	Credits
Major Courses(Disciplinary Courses) (04 Credits)			
1	Mechanics	MTH 504	02
2	Functional Analysis	IAM 501	02
Minor Courses(Disciplinary Courses) (04 Credits)			
3	Research Methodology	MTH 551	04
Vocational/Skill Courses (04 Credits)			
4	Ordinary and Partial Differential Equations	IAM 402A	04
Review of Literature, Research Proposal(08 Credits)			
5	Research Proposal	MTH 556	04
Optional Courses (Review of Literature)			
6	Lebesgue Measure and Integration	MTH 405A	04
7	Dynamical Aspects of Fluid Flows	MTH 557	04
8	Fundamentals of Cryptography	MTH 558	04
9	Galois Theory	MTH 626A	04

Course Contents

Major Courses (Disciplinary Courses) (04 Credits)

Course Code: MTH 504

Course Name: Mechanics

Course Instructors: Dr. Pankaj Kumar S/O Sh. Krishan Singh

Credits: 02

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: To develop familiarity with the physical concepts and facility with the mathematical methods of classical mechanics, and to develop skills in formulating and solving physics problems.

Course Outcomes: After completing the course satisfactorily, the student will be able to:

CO^1: Understand about the basic concepts related to the Lagrangian and Hamiltonian Mechanics.

CO^2: Understand about the Lagrange and Poisson's brackets and their role in mechanics.

CO^3: Learn about the various useful mathematical techniques/methods used in Lagrangian and Hamiltonian mechanics.

CO^4: Apply the basic concepts of mechanics to the real world problems and their significance.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in examinations.

Evaluation Criteria:

Mid Term Examination: 20

End Term Examination: 60 Continuous Internal Assessment: 20

Course Contents:

Unit I: Generalized coordinates, constraints, work and potential energy, generalized forces, the principle of virtual work, introduction to Lagrange's equation, Lagrange's equation for a particle in a plane, the classification of

dynamical systems, Lagrange's equation for any simple dynamical system. Lagrange's equation for non-holonomic systems with moving constraints, Lagrange's equations for impulsive motion, the Branchistochrone problem.

Unit II: Hamilton's principle, stationary values of a function, constrained stationary values, stationary value of a definite integral, Hamilton's equation, Derivation of Hamilton's equations. Ignorable coordinates, the Routhian function, modified Hamilton's principle, principle of least action, the Hamilton-Jacobi equation. Lagrange and Poission brackets, invariance of Lagrange and Poission brackets under canonical transformations.

Prescribed Text Books:

1. John L. Synge and Byron A. Griffith Principles of Mechanics, McGraw Hill, 3rd Edition.

2. Donald T. Green and Wood, Classical Dynamics, Prentice Hall of India, 1979.

Suggested Additional Readings:

1. K Sankara Rao, Classical Mechanics, Prentice Hall of India, 2005.

2. S.L. Gupta, V. Kumar and H.V. Sharma, Classical Mechanics, Pragati Prakashan, 13th Edition, 2019.

Course Articulation Matrix of MTH 504- Mechanics

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	2	3	2	3	2
CO^2	3	2	3	2	3	2
CO^3	2	3	2	2	3	2
CO^4	2	3	2	2	2	3

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: IAM 501

Course Name: Functional Analysis

Course Instructors: Dr. Meenakshi

Credits: 2

Course Objectives:

- To introduce students to the ideas and some fundamental theorems of functional analysis
- To show students the use of the abstract algebraic/ topological structures in studying spaces of functions
- To give students a working knowledge of basic properties of bounded operators between different spaces.

Course Outcomes: After completion of the course, a student will be able to

CO^1 Understand how functional analysis uses and unifies ideas from vector spaces, the theory of metrics and complex analysis

CO^2 Demonstrate capacity for mathematical reasoning through analyzing, proving and explaining concepts from operators

CO^3 Appreciate the role of Zorn's Lemma

CO^4 Have the knowledge of central concepts from functional analysis, including the Hahn-Banach Theorem.

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Attendance Requirement:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 20
2. End Term Examination: 40

3. Continuous Internal Assessment: 20

Course Contents:

Unit-I: Metric Space , Examples of Metric Spaces, Open set, Closed set, Neighborhood, convergence, Cauchy sequence, completeness, completion of metric spaces, Normed Linear Spaces, Banach Spaces, Properties of Normed Linear Spaces, Properties of Banach Spaces. **[10 Lectures]**

Unit-II: Compactness and Finite Dimensions, Linear Operators, Bounded and Continuous Operators, Linear Functional, Dual Space, Double Dual Space, Inner Product Spaces, Hilbert Spaces, Properties of Inner Product Spaces, Orthogonal Complement, Direct Sum, Orthonormal Sets and sequences. **[10 Lectures]**

Prescribed Text Book:

1. E. Kreyszig, "Introductory Functional Analysis with Applications", Wiley Classic Library.

Suggested Additional Readings:

1. Bollobas, "Linear Analysis", Second Edition, Cambridge University Press.
2. N. Akhierzer and I. Glazman, "Theory of Linear Operators in Hilbert Spaces", Dover Books.

Course Articulation Matrix IAM 501- Functional Analysis

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO1	3	2	2	3	3	1
CO2	2	1	3	3	3	1
CO3	2	2	2	2	2	1
CO4	2	2	3	3	2	1

1. Partially Related
2. Moderately Related
3. Highly Related

Minor Courses (04 Credits)

Course Code: MTH 551
Course Name: Research Methodology
Credits: 04
Course Instructor: Prof. Rakesh Kumar
Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The main aim of this course is to develop the research aptitude in the students by acquainting them with the research design, methods and ethics of research.

Course Outcomes: After the successful completion of this course, the student will be able to

CO^1 analyze hypotheses, theories and scientific statements and methods.
CO^2 design the proper research problem.
CO^3 critically analyze the data/solution obtained from research problems.
CO^4 Write scientific paper in proper format and referencing style.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:
1. Mid Term Examination: 40
2. End Term Examination: 120
3. Continuous Internal Assessment: 40

Course Contents:

Unit I: Research: Definition, Concepts and General introduction; Mathematics and science, Hypotheses, theories and laws; scientific statements: Their justification and acceptance, Objectives & types of Research; Attributes of good Research; Research Methods and Research Methodology; Research Process; Time/Effort Management; and Role of a Supervisor; Finding and Solving Research Problems.
Research tools: Searching google (query modifiers), Math. Sci. Net., Zentralblatt Math, Scopus, ISI, Web of Science, Impact factor, Concept of citation index, h-index, Google Scholar, Research Gate, ORCID, JSTOR, JabRef, Mendley, EndNote (Clarivate Analytics), Online and open access journals, National Digital Library Project (NDL), Virtual library of various countries, Introduction to Latex, MathType, Introduction to MS Office, Open Office.

Unit II: Scientific Writing: writing a paper for conference and Journal, communicating research, Publishing a Paper, obtaining offprints of papers, Reviewing a Paper, Scientific Norms and Conventions; Collaborative Work, research grant proposal writing, copyright issues, ethics and plagiarism.

Unit III: Introduction to Computational Software: Maple, Mathematica, Matlab. Research Design Measurement and Scaling; Formulation of Hypothesis: Meaning, Characteristics and various concepts relating to research design; classification of research design and Importance; Graphical presentations (Bar-chart, Histograms, Pie-chart, Table-chart and Line-chart, surface plots).

Unit IV: Data types Nominal, Ordinal and Ratio scale; scaling techniques- meaning, characteristics and concepts relating to testing of Hypothesis (parameter and statistic, standard error, level of significance, type-I and type-II errors, critical region, one tail and two tail tests); procedure of testing hypothesis; Numerical problems based on chi-square test and Ftest (variance ratio test only). Data analysis and interpretation: introduction to multivariate analysis-multiple and partial correlation, multiple regression analysis (with two independent variables), specification of regression models and estimation of parameters, and interpretation of results.

Prescribed Text Books:

1. P. Pruzan, Research Methodology, Springer, 2016.

2. R. Kumar, Research Methodology, Pearson Education, 2009.

3. C.R. Kothari, Research Methodology Methods & Techniques, Second Edition, New Age International publisher, 2004.

Additional Suggested Readings:

1. J.N. Kapoor, Research Methodology for Scientists and Engineers, Mathematical Science Trust Society, 1997.

2. Robert A. Day, How to write and Publish a scientific Paper, University Press, Fourth Edition 1996.

3. F. Mittelbach, M. Goossens, J. Braams, D. Carlisle & C. Rowley, The LaTeX Companion (Tools and Techniques for Computer Typesetting) 2nd Edition, Addison-Wesley Professional, 2004.

4. T. Tantau, The BEAMER class: User Guide for version 3.49, 12th Media Services, 2016.

Course Articulation Matrix of MTH 551- Research Methodology

Course Outcomes	Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4
CO1	3	2	3	3	2	2
CO2	3	2	3	3	2	3
CO3	2	3	3	2	3	3
CO4	2	3	2	2	3	3

1. Partially Related
2. Moderately Related
3. Highly Related

Vocational/Skill Courses (04 Credits)

Course Code: IAM 402A

Course Name: Ordinary and Partial Differential Equations

Course Instructors: Dr S. K. Srivastava and Dr. Pankaj Kumar S/O Sh. Krishan Singh

Credits: 04

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The purpose of this course is to acquaint the students with introductory-ODEs, PDEs and their applications.

Course Outcomes: After successful completion of the course, a student will be able to understand:

CO^{1} Existence and Uniqueness Theorem
CO^{2} Sturm-Liouville Boundary Value Problem
CO^{3} Charpit and Jacobi Methods for solving first order nonlinear PDEs
CO^{4} Classification of second order PDEs

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 40
2. End Term Examination: 120
3. Continuous Internal Assessment: 40

Course Contents:

Unit-I: Existence and uniqueness theorem; dependence of solutions on initial conditions and on the function; existence and uniqueness theorems for systems and higher order equations. **(10 Hours)**

Unit-II: The theory of linear differential equations; homogeneous and non-homogeneous systems, nth order homogeneous and non-homogeneous linear differential equations, Sturm theory, Sturm-Liouville boundary value problems. **(10 Hours)**

Unit-III: Surfaces and curves in three dimensions, simultaneous differential equations, orthogonal trajectories, Pfaffian differential equations, First order PDEs, Cauchy's method of characteristics, compatible system of first order equations, Charpit's and Jacobi's methods.

(10 Hours)

Unit-IV: Classification of second order PDEs, first General solution of higher order PDEs with constant and variable coefficients, Method of separation of variables. **(10 Hours)**

Prescribed Text Books:

1. Ross S.L. (1984). Differential Equations. Third Edition. John Wiley & Sons Inc.
2. Ian N. Sneddon (2006), Elements of Partial Differential Equations, Dover Publications Inc.

Suggested Additional Readings:

1. W.E. Boyce and R.C. Diprima (2013). Elementary Differential Equations and Boundary Value Problems, Ninth Edition, Wiley.
2. W.A. Strauss; Partial differential equations an introduction, John Wiley & Sons, 2008.

Course Articulation Matrix of IAM 402A- Ordinary and Partial Differential Equations

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	2	2	1		3	3
CO^2	3	2	2	1		3	2
CO^3	3	2	2	1		3	2
CO^4	3	2	2	1		3	3

1. Partially Related
2. Moderately Relate
3. Highly Related

Review of Literature, Research Proposal (08 Credits)

Course Code: MTH 556

Course Name: Research Proposal

Course Credit: 04

Course Instructor: All Faculty Members

Course Contents and Evaluation Criteria as finalized in the BoS meeting vide Agenda Item No. SRDM-BOS-9/22-6

Review of Literature (08 Credits) (Optional Courses)

Course Code: MTH 405A

Course Name: Lebesgue Measure and Integration

Course Credit: 04

Course Instructor: Dr S. K. Srivastava

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom

activity / contact hours; 5 hours such as independent individual/ group work; obligatory/ optional work placement; literature survey/ urs of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other work load library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The purpose of this course is to acquaint the students with the concept of measure, a means for comparing the size of sets and generalizing intuitive notions such as length and area, and moves on to describe the elements of the Lebesgue theory of integration. Lebesgue integration is a fundamental tool for advanced study in areas of mathematics such as functional analysis and potential theory, and provides the foundation for the axiomatic treatment of probability theory.

Course Outcome: By the end of the course students will be able to understand:

CO^1: Countability and Cantor's like sets.

CO^2: Measurable sets, Borel sets and their measurability.

CO^3: Convergence in measure and Lebesgue Integrals.

CO^4: Dini's derivatives and functions of bounded variations.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

Mid Term Examination: 40

End Term Examination: 120

Continuous Internal Assessment: 40

Course Contents:

Unit I: Set theory, Topological ideas, sequence and limits, functions and mapping, cardinal number and Countability, properties of open sets and Cantor's like sets. **(10 Hours)**

Unit II: Lebesgue outer measure, measurable sets, properties of measurable sets, Borel sets and their measurability, characterizations of measurable sets, measurable functions and their properties. **(10 Hours)**

Unit III: Borel measurable functions, convergence in measure, Lebesgue Integrals and integral of non-negative measurable functions. **(10 Hours)**

Unit IV: The four derivatives, Continuous and Non- differentiable functions, functions of bounded variation, Lebesgue's differentiation theorem, differentiation, integration and the Lebesgue set.**(10 Hours)**

Prescribed Text Book:

1. P.K. Jain, V.P. Gupta and P. Jain (2012), Lebesgue measure and integration, Anshan Publishers, 2nd Edition.

Suggested Additional Readings:

1. P. R. Halmos, Measure Theory, Graduate Text in Mathematics, Springer-Verlag, 1979.
2. G. De Barra (2003), Measure theory and Integration, Horwood Publishing.

Course Articulation Matrix MTH 405A- Lebesgue Measure and Integration

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO1	2	3	1	1	1	1
CO2	3	3	1	1	1	1
CO3	3	3	2	2	2	2
CO4	3	3	2	2	2	1

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: MTH 557

Course Name: Dynamical Aspects of Fluid Flows

Credits: 04

Course Instructor: Dr. Pankaj Kumar (s/o Sh. Krishan Singh)

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The main purpose of this course is to acquaint the students with the fundamental concepts fluid dynamics and enable them to search the gaps in the literature related to fluid flow patterns.

Course Outcomes: After completing the course satisfactorily, a student will be able:

CO1: To identify the key fluid properties used in the analysis of fluid behavior.

CO2: To apply the Reynolds transport theorem.

CO3: To apply conservation of mass and energy and Newton's second law of motion to the contents of a finite control volume to get important answers.

CO4: To analyze certain types of flows using the Navier–Stokes equations.

CO5: To develop a set of dimensionless variables for a given flow situation.

Attendance Requirements: Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination:20%
2. End Term Examination:60%
3. Continuous Internal Assessment: 20%. i.e. 20 marks out of 200

Course Contents:

UNIT I: Basic concepts and definitions, continuum hypothesis, basic algebra with vectors and tensors, fluid statics, Bernoulli equation, fluid kinematics; velocity field, acceleration field.

(Chapters 1-4) (12 HRS)

UNIT-II: Reynolds transport theorem, Control volume analysis: continuity equation, momentum equation, First law of thermodynamics-energy equation, Second law of thermodynamics-irreversible flow.

(Chapters 4-5) (08 HRS)

UNIT-III: Differential analysis: fluid element kinematics, conservation of mass and momentum, inviscid flow, plane potential flows, viscous flow, some simple solutions for viscous incompressible fluids.

(Chapter 6) (12 HRS)

UNIT-IV: Dimensional analysis, similitude and modelling: dimensional analysis, Buckingham Pi theorem, correlation of experimental data, modelling and similitude. **(Chapter 7) (08 HRS)**

Text Book:

1. B.R. Munson, D.F. Young, T.H. Okiishi, W.W. Huebsch, (2009). Fundamentals of Fluid Mechanics, Sixth Edition, John Wiley & Sons, Inc.

Reference Books

1. Ronald L. Panton, (2014). Incompressible flow, Third Edition, Wiley.

2. Edward J. Shaughnessy, Jr. Ira M. Katz James P. Schaffer, (2005). Introduction to Fluid Mechanics and Fluid Machines, Oxford University Press.

Course Articulation Matrix of MTH 557- Dynamical Aspects of Fluid Flows

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO1	3	3	2	2	3	2
CO2	3	3	2	3	2	3
CO3	2	3	3	2	2	3
CO4	3	2	2	3	3	2
CO5	3	3	2	2	3	2

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: MTH 558

Course Name: Fundamentals of Cryptography

Course Instructor: Dr Pankaj Kumar S/o Late Sh. Maniram

Credits: 04

Credits Equivalent:

Credits Equivalent: 02 Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity /contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Outcomes

After completing the course satisfactorily, a student will be able:

CO^1 To understand the basics of Cryptography.

CO^2 To be able to secure a message over an insecure channel by various means.

CO^3 To learn about how to maintain the Confidentiality, Integrity and Availability of a data.

CO^4 To understand various protocols for network security to protect against the threats in the networks.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 25%

2. End Term Examination: 50%

3. Counseling, Activities and Tutorials (CAT): 25%

i. Subjective / Objective Assignment: 10 %

ii. Numerical Assignments using programming: 10 %

iii. Presentations and Class Tests: 5 %

Course Contents:

UNIT I:

Group, Rings, Polynomial and modular arithmetic, Introduction to finite field of the form GF(p) and GF(2n), Fermat theorem and Euler's theorem(statement only), Chinese Remainder theorem, Discrete logarithm-Hallman problem, Need of security, Security attacks, Security services. (8 Hours)

Unit II:

Symmetric Key Cryptography: Definition of a cryptosystem, Symmetric cipher model, Classical encryption techniques, Substitution and transposition ciphers, caesar cipher, Playfair cipher. Block cipher Principles, Shannon theory of diffusion and confusion, Data encryption standard (DES). (8 Hours)

UNIT III:

Asymmetric Key Cryptography: Introduction to public key cryptography, RSA algorithm and security of RSA, Key distribution – Key management, Introduction to elliptic curve cryptography. Introduction to chaos-based cryptography, Identity Based Public key Cryptography, Certificateless Public Key Cryptography, Provable Security, Security against Chosen-Ciphertext Attacks, Random Oracle Model. (12 Hours)

UNIT IV:

Advance in Cryptography: Diffie Hellman key exchange, Digital signature, Elgamal signature, Digital signature standards. Digital Signatures: Proxy Signature, Aggregate Signature, Multi-signature, Partially Blind Signature and Blind Signature.

Authentication requirement, Authentication function, MAC, Hash function, Security of hash function and MAC, SHA –Digital signature and authentication protocols, DSS- Entity Authentication: Biometrics, Passwords, Challenge Response protocols- Authentication applications - Kerberos, X.509 (12 Hours)

Prescribed books:

1. William Stallings, "Cryptography and Network Security", Principles and Practise, Fifth Edition, Pearson Education, 2012.

2. H. Xiong, Z. Q. Athanasios V. Vasilakos, "Introduction to Certificateless Cryptography", CRC Press Taylor & Francis Group

Reference Book:

1. Douglas R. Stinson, "Cryptography theory and practice", CRC Press, Third edition, 2005.

Course Articulation Matrix MTH 558- Fundamentals of Cryptography

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO1	2	3	2	2	2	2
CO2	2	3	3	3	1	2
CO3	1	3	2	2	2	2
CO4	2	2	2	3	2	2

1. Partially Related

2. Moderately Related

3. Highly Related

Course Code: MTH 626A

Course Name: Galois Theory

Course Instructor: Dr. Meenakshi

Credits: 04

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives: The purpose of this course are

- To discuss the Field Theory
- To introduce Galois Groups
- To explore the application area of Galois Theory

Course Outcomes: After successful completion of the course, a student will be able to:

CO^1 Understand how to write, correct and clear arguments in abstract Mathematics with proofs.

CO^2 Have the knowledge about Field Extensions

CO^3 Solve polynomials having different degrees

CO^4 Understand the basis of Galois's Criterion for solvability of an equation by radicals.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 40
2. End Term Examination: 120
3. Continuous Internal Assessment: 40

Course Contents:

Unit-I: Polynomial, Irreducible polynomials and Eisenstein criterion, Adjunction of roots, Algebraic extensions, algebraically closed fields, Splitting fields, Normal extensions, Multiple roots. **(10 Hours)**

Unit-II: Prime Fields, Finite fields, Roots of Irreducible Polynomials, Roots of unity and cyclotonic polynomials, Representation of Elements of Finite Fields, Order of Polynomials **(10 Hours)**

Unit-III: Primitive Polynomials, Irreducible Polynomials, Galois Theory and its Applications, Perfect Field, Separable extensions, Simple extensions

(10 Hours)

Unit-IV: Automorphism groups and fixed fields, Fundamental theorem of Galois theory, Fundamental theorem of algebra. **(10 Hours)**

Prescribed Text Book:

P.B. Bhattacharya, S.K. Jain & S.R. Nagpaul, 'Basic Abstract Algebra', Second Edition, Cambridge University Press.

Suggested Additional Readings:

1. I.N. Herstein, "Topics in Algebra", 2nd Edition (1975) (Wiley International Editions).
2. M. Artin, "Algebra", 2nd Edition (1991)(PHI).

Course Articulation Matrix of MTH 626A- Galois Theory

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	3	2	3	3	2
CO^2	3	2	2	3	3	1
CO^3	3	2	2	3	3	2
CO^4	3	2	2	3	3	1

1. Partially Related
2. Moderately Relate
3. Highly Related