DEPARTMENT OF MATHEMATICS

NATIONAL INSTITUTE OF TECHNOLOGY SRINAGAR

J & K-190006

M.Sc. Mathematics

Curriculum and Syllabi
(w.e.f. Autumn-2022)

CURRICULUM FOR POST-GRADUATE PROGRAM LEADING TO MASTER OF SCIENCE (M.Sc.) DEGREE IN MATHEMATICS

(I). Program Details:

Name of the degree	Name of Specialization	Intake (Full Time)	Year of Starting (Proposed)	Duration	Eligibility for Admission
M.Sc.	Mathematics	25+*5 = 30	2022	2 years	A candidate must be Graduate (10+2+3 pattern) in Science with Mathematics as Major Subject/Honors and must have secured at least 60% mark or CGPA 6.5/10 or equivalent for OC/OBC/EWS/SF and for SC/ST/PWD candidates, minimum marks are 50% or CGPA 5.5/10 at UG level from a recognized University/Institution with valid JAM score/Institute Entrance Examination Score.

**Five (05) seats will be reserved for candidates of J&K (UT).*

Programme Structures

M.Sc. Mathematics (Two Year Full Time Programme)

FIRST YEAR													
I Semester							II Semester						
S. No.	Course Code	Course Name	L	T	P	C	S. No.	Course Code	Course Name	L	T	P	C
1.	MM- 101	REAL ANALYSIS	3	1		4	1.	MM - 201	TOPOLOGY	3	1		4
2.	MM - 102	ALGEBRA	3	1		4	2.	MM - 202	NUMBER THEORY	3	1		4
3.	MM-103	COMPLEX ANALYSIS	3	1		4	3.	MM - 203	PROBABILITY AND STATISTICS	3	1		4
4.	MM-104	DIFFERENTIAL EQUATIONS	3	1		4	4.	MM - 204	DISCRETE MATHEMATICS	3	1		4
5.	MM105	C PROGRAMMING IN C++	3		2	4	5.	MM -205	PYTHON LANGUAGE	3		2	4
		Total Credits				20			Total Credits				20

SECOND YEAR														
III Semester							IV Semester							
S. No.	Course Code	Course Name	L	T	P	C	S. No.	Course Code	Course Name	L	T	P	C
1.	MM - 301	MEASURE THEORY AND INTEGRATION	3	1		4	1.	MM - 401	Project Work/Dissertation				8
2.	MM - 302	OPERATION RESEARCH	3	1		4	2.		ELECTIVE -I	3	1		4
3.	MM - 303	DIFFERENTIAL GEOMETRY	3	1		4	3.		ELECTIVE -II	3	1		4
4.	MM - 304	FUNCTIONAL ANALYSIS	3	1		4			Seminar				4
5.	MM -305	COMPUTAIONAL FLUID DYNAMICS	3	1		4							
	Total Credits					20		Total Credits					20

Note: Elective–I and Elective-II is to be selected from the following available course

S. No.	Course Code	Course Name	L	T	P	C
1.	MM - 401	Wavelet Analysis	3	1		4
2.	MM - 402	Polynomial Theory	3	1		4
3.	MM - 403	Summability Theory	3	1		4
4.	MM - 404	Optimization Theory	3	1		4
5.	MM -405	Advanced Graph Theory	3	1		4
6.	MM -406	Riemannian Geometry	3	1		4
7.	MM -407	Algebraic Combinatorics	3	1		4
8.	MM -408	Variational Calculus	3	1		4
9.	MM -409	Numerical Methods for Partial Differential Equations	3	1		4
10.	MM-410	Advanced Complex Analysis	3	1		4

SUMMARY					
Semesters	Sem-I	Sem-II	Sem-III	Sem-IV	Overall
Credits	20	20	20	20	80

It is proposed that there will be 800 credits spread over the entire course. Thus, the total minimum credits required for completing the M.Sc. in Mathematics is 80.

Department of Mathematics
National Institute of Technology Srinagar

Real Analysis MM-101	M.Sc. Mathematics First Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Unit –I (10 Lectures)

A review of basic set theory, finite, countable and un-countable sets, real number system as complete order field, Archimedean property, Bounded and un-bounded sets, Supremum and Infimum, Dedekind's form of completeness propertyInequalities: Arithmetic Mean- Geometric mean inequality, Cauchy-Schwarz inequality, Chebyshev's inequality, Holder's and Minkowski inequalities, Convex and concave functions, Jensen's inequality, Bernoulli's inequality, some applications involving inequalities

Unit-II (10 Lectures)

Definition and existence of the Riemann-Stieltjes integral, upper and lower sums and integrals. Refinementofpartitions.NecessaryandsufficientconditionsforR-Sintegrability.Someproperties of the Riemann-Stieltjes integrals. The integral as a limit of a sum. R-Sintegrability of continuous and monotonic functions, reduction of the R-S integral to a Riemann integral. First and second Mean Value Theorems. Change of variables.

Unit-III (10 Lectures)

Improper Integrals: integration of un-bounded functions with finite limit of integration. Comparison of tests for convergence of improper integrals. Cauchy's test for convergence. Absolute convergence. Infinite range of integration of bounded functions. Convergence of integrals of unbounded functions with infinite limits of integration. Integrated as a product of functions. Abel's and Dirchlet's tests of convergence.

Unit-IV (10 Lectures)

Uniform convergence of sequences and series of functions: Pointwise convergence,uniform convergence on an interval,Cauchy's criterion for uniform convergence, M_n-test for uniform convergence of sequences, Weirestrass'sM-Test, Abel's and Dirchlet's tests for uniform convergence of series.Uniform convergence and continuity, uniform convergence and integration and uniform convergence and differentiation, Weirestrass Approximation Theorem

Text Books

1. Walter Rudin, Principles of Mathematical Analysis, 3rd Edition. Mc-GrawHill, 1976.
2. S.C. Malik, Mathematical Analysis, Wiley Eastern Limited Urvashi, Press, 1983, Meerut
3. B.J. Venkatachala, Inequalities- An Approach Through Problems, Hindustan Book Ageny (India),2009.

Reference Books

1. R. Goldberg, Methods of Real Analysis, John Wiley & Sons, 1976
2. T.M. Apostol, Mathematical Analysis, Narosa Publishing House, 2004

Department of Mathematics
National Institute of Technology Srinagar

Algebra MM-102	M.Sc. Mathematics First Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Unit 1: Group Theory (15 Lectures)

Cyclic groups, generators and relations, Cayley's Theorem, group actions, Sylow Theorems. Direct products, Structure Theorem for finite abelian groups. Simple groups and solvable groups, nilpotent groups, simplicity of alternating groups, composition series, Jordan-Holder Theorem. Semi-direct products. Free groups, free abelian groups.

Unit 2: Ring Theory (10 Lectures)

Rings, Examples (including polynomial rings, formal power series rings, matrix rings and group rings), ideals, prime and maximal ideals, rings of fractions, Chinese Remainder Theorem for pair wise co-maximal ideals. Euclidean Domains, Principal Ideal Domains and Unique Factorizations Domains. Polynomial rings over UFD's.

Unit 3: Linear Algebra (15 Lectures)

Diagonallization, rational canonical form, Jordan-canonical form, inner product spaces, Gram-Schmidt ortho-normalization, orthogonal projections, linear functionals and adjoints, Hermitian, self-adjoint, unitary and normal operators,Spectral Theorem for normal operators. Bilinear forms, symmetric and skew-symmetric bilinear forms,

Text Books:

1. Surjeet Singh and Qazi Zameer-ud-din, Modern Algebra, Vikas Publishing House Private Limited, 2012.
2. Joseph Gallian, Contemporary Abstract Algebra, 6 th Edition, Narosa, 2015.
3. I.N. Hernestien, Topics in Algebra, Wiley , 2014.

References:

1. M. Artin, Algebra, Prentice Hall of India, 1994.
2. D. S. Dummit and R. M. Foote, Abstract Algebra, 2nd Edition, John Wiley, 2002

Department of Mathematics
National Institute of Technology Srinagar

Complex Analysis MM-103	M.Sc. Mathematics First Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

UNIT-I: (10 Lectures)

Functions of a complex variable, Limits, Continuity, Differentiability, Cauchy-Riemann Equations and their applications, Analytic function, Harmonic function, The functions like e^z,$sinz$,$cosz$andthecomplexlogarithm.Contourintegral,Cauchy'stheorem,Cauchy- Goursat's theorem, Cauchy's integral formula, Higher order derivatives, Morera's theorem, Cauchy's inequality, Liouville's theorem and its applications, Winding numbers-index of a point with respect to a closedcurve.

UNIT-II: (10 Lectures)

Power Series, Radius of convergence of a power series, Cauchy's-Hadamard formula for findingradiusofconvergence,Taylortheorem,Taylor'sseries,Expansion of analytic functions in a power series, Laurent's series, Singular Points, Isolated singularities, Poles and essential singular points, Behavior of functions at infinity, Casorati – Weierstrass' sTheorem.

UNIT-III: (10 Lectures)

Bilinear transformations- Properties and Classification, Fixed Points, Cross ratios, Inverse points and Critical points. Conformal mapping, Mappings of: Upper half plan on to unit disc, Unit disc onto unit disc, left half plan on to unit disc, Circle onto circle. The transformations: $w = \sqrt{z}$, z^2, $\frac{1}{2}\left(z + \frac{1}{z}\right)$.

UNIT-IV: (10 Lectures)

Residues: Cauchy's residue theorem and its applications, Calculation of residues, Evaluation of definite integrals by the method of residues, Parseval's identity. Infinite products, Convergence and divergence of infinite products.

Text Books:

1. Brown and Churchill, Complex Variables and Applications, Eighth edition, Mc Graw Hill, 2018.
2. S. Ponnusamy, Foundations of Complex Analysis, Second Edition, Narosa publication, 2014.

Reference Books:

1. J.B. Conway, Functions of a complex variable-I, Springer-Verlag New York Heidelberg Berlin, 2008.
2. L. Ahlfors, Complex Analysis, Third edition, McGraw Hill Publication, 2015.

Department of Mathematics
National Institute of Technology Srinagar

Differential Equations MM-104	M.Sc. Mathematics First Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Unit I: Introduction (06 lectures)

Review of fundamentals of ODEs, Lipschitz condition, Gronwall's lemma, Existence and uniqueness theorems, Method of successive approximation, Dependence of solutions on initial conditions.

Unit II: Series Solution (08 lectures)

Review of Linear second order differential equations and Power series solutions, Legendre, Chebyshev, Bessel, Hermite and Laguerre's differential equations, generating functions and recurrence relations.

Unit III: Sturm-Liouville Boundary Value Problems (06 lectures)

Sturm-Liouville Problems, Eigen value problems, Orthogonality of Characteristic Functions, The Expansion of a Function in a Series of Orthonormal Functions.

Unit IV: Non-Linear Differential Equations (10 lectures)

Phase Plane, Paths, Autonomous systems and Critical Points, Type of critical points, Stability of critical points, Critical points and Paths of Linear Systems.

Unit V: Partial Differential Equations (10 lectures)

First-order linear and quasi-linear PDE's, Lagrange's method, Charpit's method, Cauchy problem, Second order PDEs, Classification of PDE, Canonical form, Solution of hyperbolic, Parabolic and elliptic equations, Dirichlet's and Neumann problems.

Textbooks:

1.S.L. Ross, Differential Equations, John Wiley and Sons, 2018.
3. G.F. Simmons, Differential Equations with Applications and Historical Notes, Tata McGraw Hill, 2017.
4. I.N. Sneddon, Elements of Partial Differential Equations , Tata McGraw Hill, 2002.

References Books:

1. E.A. Coddington and N.Levinson, Theory of Ordinary Differential Equations, Tata McGraw Hill, 2011.
2. H.T.H. Piaggio, Differential Equations, CBS Publisher, 2003.

Department of Mathematics
National Institute of Technology Srinagar

Programming in C++ MM-105	M.Sc. Mathematics First Semester		Total Course Credit: 4		
			L	T	P
			3	0	2
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Unit-I: Computers and Programming Languages: (2 lectures)

Elements of a Computer System, Language of a Computer, Evolution of Programming Languages, Processing a C++ Program, Fundamentals of the Object-Oriented Approach.

Unit-II: Basic Elements of C++: (5 lectures)

Basics of a C++ Program, Data Types, Variables, Arithmetic Operators, Casting, Assignment and Input Statements.

Unit-III: Input/Output, Control Structures: (7 lectures)

I/O Streams, Predefined Functions, Output Formatting, Relational Operators, Logical Expressions, If/If…else, Block Statements, while Looping, for Looping, do…while looping.

Unit-IV: User-Defined Functions: (6 lectures)

Value-Returning Functions, return Statements, Void Functions, Parameters, Overloading, Enumeration Types.

Unit-V:Arrays, Records (Structs), Classes and Data Abstraction: (7 lectures)

One-Dimensional Array, Indexing, Array Searching, Parallel Arrays, Multidimensional Arrays, Accessing struct Members, I/O structs, Arrays vs Structs, UML Diagrams, Object Declaration, Data Abstraction and Types, Struct vs Class.

Unit-VI: Pointers, Classes, Virtual Functions, and Abstract Classes: (6 lectures)

Pointer data types, Address of Operator (&), Pointer Variables, Dynamic Arrays, Shallow and Deep Pointers.

Unit-VII: Operator Overloading and Templates, Recursion, Searching and Sorting:

(7 lectures)

Operator Syntax, Overloading an Operator, this Pointer, Binary Operator, Unary Operator. Direct Recursion, Indirect Recursion, List Processing, Bubble Sort, Binary Sort, vector Type (class).

Text Books:

1. Walter Savitch, Problem Solving with C++: Global Edition, 9th edition, Pearson Education, November 2014.

Reference Books:

1. Bjarne Stroustrup, The C++ Programming Language, Pearson Education, 4th Edition, 2013.
2. C++ Programming: From Problem Analysis to Program Design, 6th Edition; D.S. Malik.

Department of Mathematics
National Institute of Technology Srinagar

Topology MM-201	M.Sc. Mathematics Second Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Unit 1: Metric spaces: (08 Lectures)

Definition and Examples, open and closed sets, convergence and completeness, continuous mappings, spaces of continuous functions.

Unit 2. Toplogical spaces: (08 Lectures)

Definition and examples, elementary concepts, open bases and open subbases, weak topologies.

Unit 3. Compactness: (08 Lectures)

Definitions and examples, compact spaces, product of spaces, Tychnoff's theorem and locally compact spaces, compactness for metric spaces, Ascoli's therorm.

Unit4. Seperation: (08 Lectures)

Definition and examples, T1 sapces and Hausdroff spaces, completely regular spaces and normal spaces, Urysohn's lemma and Tietze extension theorem, Urysohn's imbedding theorem, the Stone – Cech compactification.

Unit 5. Connectedness: (08 Lectures)

Definition and examples, connected spaces and properties, the component of space, locally connected spaces, totally disconnected spaces.

Textbooks: Books:

1. Topology and Modern Analysis, G. F. Simmons, McGraw Hill Book Company, 2014.

Reference Books:

1. Topology, James Munkres, Pearson Publications, 2

Department of Mathematics
National Institute of Technology Srinagar

Number Theory MM-202	M.Sc. Mathematics Second Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

UNIT I: (10 Lectures)

Divisibility, the Division Algorithm. Greatest Common Divisor and its properties, Radix-representation, Least Common Multiple. Prime numbers, Euclid's first theorem, factorization in primes, Fundamental Theorem of Arithmetic, Linear Diophantine Equations; NecessaryandSufficientconditionforsolvabilityoflinearDiophantineequations.

UNIT II: (10 Lectures)

Sequences of Primes : Euclid's second theorem, infinitude of the primes of the form 4n+3 and 6n+5, No polynomial $f(x)$with integral coefficients, not a constant, can represent primes for all integral values of x, Fermat numbers and their properties, Mersenne numbers, Arbitrary large gaps in the sequence of primes, Congruence's, Complete Residue Systems and Reduced Residue Systems and their properties, Euler's ϕ -function; $\phi(mn) = \phi(m)\phi(n)\, for\, (m,n) = 1$. Fermat's theorem and Euler's theorem.

UNIT III: (10 Lectures)

Wilson's theorem and its application to the solution of the congruence, Solution of linear congruence's. The necessary and sufficient for the solution of the congruence $a_1x_1 + a_1x_1 + \cdots + a_1x_1 \equiv c(mod\ m)$, Chinese Remainder Theorem, Congruences of higher degree, Polynomial congruence, congruences with prime power moduli. Lagrange's theorem; viz, the polynomial congruence $F(x) = 0\ (mod\ p)$ of degree n has at most n solutions, The criteria for the congruence of degree n having exactly $n$solutions.

UNIT IV: (10 Lectures)

Factor theorem and its generalization, Polynomial congruence in several variables; equivalence of polynomial congruences, number of solutions in polynomial congruences, Chevelley's theorem, Warning's theorem, Quadratic form over the field of characteristic ≠2; Equivalence of Quadratic forms Witt'stheorem, Representation of field elements, Hermite's theorem on the minima of a positive definite quadratic form and its application to the sum of two squares.

Text Books

1. IvanNivenandH.S.Zuckerman,AnIntroductiontotheTheoriesofNumbers,5thedition, Wiley Eastern,2000.
2. Leveque, Topics in Number Theory, Springer, 2008.
3. Boevich and Shaferwich, Number theory, I.R. AcademicPress, 2004.

References

1. D.M. Burton, Elementary Number Theory,2ndedition, Universal BookStall, New Delhi,1994.
2. G.H.Hardy and E.M.Wright, An Introduction to the Theory of Numbers, 4thedition, Oxford, Claredon Press,1960.

Department of Mathematics
National Institute of Technology Srinagar

Probability & Statistics **MM-203**	**M.Sc. Mathematics** **Second Semester**		**Total Course Credit: 4**		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Unit I: (10 Lectures)

Random variables, change of variables, probability distributions of random variables, Moments, moment generating function, characteristics function, standard discrete and continuous distributions, two dimensional random variables, conditional expectation, Chebyshev's inequality, law's of large numbers, convergence in probability

UnitII: (10 Lectures)

Types of sampling, parameters and statistic, tests of significance, procedure for testing of hypothesis, tests of significance large samples, sampling of attributes, sampling of variables, sampling distributions of Chi, F and Z.

Unit III: (10 Lectures)

Unbiased estimates and efficient estimates, estimates and interval estimates, reliability, confidence interval estimates of population parameters, confidence interval for mean, confidence interval for proposition, confidence interval for the variance of a normal distribution, confidence interval for variance ratios, maximum likelihood estimation, methods of minimum variance, method of moments and least squares

Unit IV : (10 Lectures)

Statistical hypothesis, null hypothesis, tests of hypothesis and significance, critical region, level of significance, Type I and Type II errors, power of test, analysis of variance, one way and two way classification.

Textbook Books:

1. A.M. Mood, F.A. Graybill and D.C. Boes, Introduction to the Theory of Statistics. McGraw Hill, New Delhi, 2008.
2. G. James, D. Witten,T. Hastie and R. Tibshirani, An Introduction to Statistical Learning: with Applications in R. Springer, 2013.

Reference Books:

1 R. Shanmugam and R. Chattamvelli, Statistics for scientists and engineers. John Wiley, 2015.
2 R. Hogg, E. Tanis and D. Zimmerman, Probability and Statistical Inference. Pearson Education, India, 2019.

Discrete Mathematics MM-204	**M.Sc. Mathematics Second Semester**		**Total Course Credit: 4**		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Unit I: Introduction to graphs (10 Lectures)
Basic definitions, Isomorphism, Some special graphs, Operations on graphs, Bipartite graphs and Konig's Theorem, Degree sequences; Havel-Hakimi and Erdos-Gallai Theorems, Walks, Paths, Cycles, Eulerian graphs and their characterization, Konigsberg bridge problem, Hamiltonian graphs and Dirac's theorem. Distance in graphs.

Unit II: Trees and signed graphs (10 Lectures)
Trees and their properties, Spanning trees, Cayley's theorem, Fundamental cycles, Generation of trees, Helly property, Signed graphs, Balanced, unbalanced and anti-balanced signed graphs. Characterization of balance in signed graphs, Switching in signed graphs, switching equivalence and switching isomorphism.

Unit III: Connectivity and Planarity (10 Lectures)

Cut vertices, Cut edges, vertex and edge connectivity, connectivity parameters, Whitney's theorem, Blocks, Block graphs, Planar graphs, Euler's formula and its consequences, Kuratowski's theorem, Geometric Dual, Regular polyherda.

Unit IV: Directed Graphs (10 Lectures)
Basic concepts, Connectedness, Eulerian digraphs, Hamiltonian digraphs, Tournaments, Redei's theorem, Camion's theorems, Score sequence, Landau's theorem, Oriented graphs and Avery's theorem.

Text Books:

1. F.Harary, Graph Theory, Narosa Publishing House (2001).
2. S. Pirzada, An Introduction to Graph Theory, Universities Press, Orient Blackswan, Hyderabad, 2012.

Reference Books:
1. J. A. Bondyand U.S.R Murthy, Graph Theory with Applications, Elsevier Science Publishing Co. Inc, 1982.
2. D. B. West, Introduction to Graph Theory, 2nd edition, Pearson Publication, 2002.

Department of Mathematics
National Institute of Technology Srinagar

Python Language MM-205	M.Sc. Mathematics Second Semester		Total Course Credit: 4		
			L	T	P
			3	0	2
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

UNIT I: ALGORITHMIC PROBLEM SOLVING (4 Lectures)

Algorithms, building blocks of algorithms (statements, state, control flow, functions); Notation(pseudo code, flow chart, programming language); specification, composition, decomposition,iteration, recursion.

UNIT II: DATA, EXPRESSION, STATEMENT, CONDITIONAL (8 Lectures)

Data and types: int, float, boolean, string, list; variables, expressions, statements, simultaneousassignment, precedence of operators; comments; in-builtmodules and functions; Conditional: boolean values and operators, conditional (if), alternative (if-else), case analysis (if-elif-else).

UNIT III: ITERATION, FUNCTION, STRINGS (8 Lectures)

Iteration: while, for, break, continue, pass; functions: function definition, function call, flow of execution, parameters and arguments, return values, local and global scope, recursion; Strings: string slices, immutability, string functions and methods, string module.

UNIV IV: LISTS, TUPLES (6 Lectures)

Lists: list operations, list slices, list methods, list loop, mutability, aliasing, cloning lists, list parameters, nested lists, list comprehension; Tuples: tuple assignment, tuple as return value, tuple operations.

UNIV V: DICTIONARIES, FILES (4 Lectures)

Dictionaries: operations and methods, looping and dictionaries, reverse lookup, dictionaries and lists; Files: Text files, reading and writing files, format operator, file names and paths;

Textbooks:

1. Allen B. Downey, Think Python: How to think like a computer, Shroff publication, 2016.
2. John Zelle, Python Programming, An introduction to Computer Science, Franklin, Beedle & Associates Inc, 2003.
3. Yashavant Kanetkar and Aditya Kanetkar, Let's Python, BPB Publication, 2010.

Python Lab

1) SIMPLE PROGRAMS: I/O, Basic Arithmetic On data types,

2) CONDITIONS AND LOOPS: working with Comparison Operators, Single Loop and Nested Loop Programs.

3) LIST PROGRAMS: Working with Lists in Python, Usage of In-built list functions

4) STRING PROGRAMS: Working with Strings in Python, Usage of In-built String Functions.

5) MATH PROGRAMS I : Using python to solve basic Math Problems.(User-Defined Functions to be used)

a) Write a program in python to find quotient and reminder after division
b) FIND GCD of two number
c) FIND Area and Perimeter of A given Polygon (Triangle or Rectangle or Square)
d) WRITE a function to determine the number of solutions of a given quadratic equation.
e) Write a function to Check if a given Number is a prime
f) Using the Function defined in (e), compute all the prime numbers in the range 'a' to'b' taken from user. Store them in a list

6) MATH PROGRAMS II: Using python along with 'NumPy' library to solve math Problems (Such as Matrix Operations)

7) MATH PROBLEMS III: Using python along with 'Matplotlib' to display Graphs and visualize data.

Department of Mathematics
National Institute of Technology Srinagar

Measure Theory & Integration MM-301	M.Sc. Mathematics Third Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Unit I: (10 Lectures)

Measure Theory: Definition of outer measure and its basic properties, outer measure of an interval as its length, countable additivity of an outer measure, Borel measurable sets and Lebesgue measurability of ofBorel sets, Cantor set, non- measurable sets, Outer measure of monotonic sequences of sets.

Unit II: (10 Lectures)

Measurable functions and their characterization. Algebra of measurable functions, Steinhaus's theorem on sets of positive measure, Ostrovisk's theorem on measurable solution of $f(x+y) = f(x) + f(y), x, y \in R$. Convergence a.e., convergence in measure and almost uniform convergence, their relationship on sets of finite measure, Egroff's theorem.A brief Introduction to the Abstract Measure theory.

Unit III: (10 Lectures)

Riemann integral and its deficiency, Lebesgue integral of bounded function, comparison of Riemann and Lebesgue integrals, properties of Lebesgue integral for bounded measurablefunction.

Unit IV: (10 Lectures)

The Lebesgue integral for unbounded functions, integral of non-negative measurable functions, general Lebesgue integral, improperintegral

Text Books:

1. H.L. Royden, Real Analysis, Pearson,2008
2. S.C. Malik and Savita Arora, Mathematical Analysis ,3rdEdition, New Age International(P) Ltd., NewDelhi, 2008
3. G. De Barra, Measure Theory and Integration, Narosa Publishing House, NewDelhi, 2011.

Reference Books:

1. R.R. Goldberg, Methods of Real Analysis, John Wiley & Sons,1976
2. T.M. Apostol, Mathematical Analysis, Narosa Publishing House,2004
3. W. Rudin, Principles of Mathematical Analysis, 3rd Edition, Mc- Graw Hill Publications, 1

Differential Geometry MM-303	M.Sc. Mathematics Third Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Unit I: Curves: (15 Lectures)

Definition and various examples of Curves, Differentiability, Regular point and singularities, Parametrization, Arc length, Parameterization of curves (Generalized and natural parameters), Change of parameter regular curves and singularities Parametrization by arc length, Unit Speed curves, Plane Curves, Osculating circle, Curvature of a plane curve, Computation of curvature of various plane curves, Space curve, tangent vector, normal vector and binormal vector of a space curve, Curvature and torsion of a space curve, the Frenet-Serret theorem, first fundamental theorem of space curves, intrinsic equation of a curve, computation of curvature and torsion of space curves.

Unit II: Surfaces (15 Lectures)

Definition and various examples of a regular surface, Coordinate charts, change of coordinate charts, tangent plane at a regular point, normal to the surface, orientation of the surface, Smooth maps between two regular surfaces, differential of a smooth map, First Fundamental form of a surface, line element, invariance of a line element under change of coordinates, angle between two curves, area of a bounded region, change of area under change of coordinates. Second Fundamental form on a surface, Gauss map and Gaussian curvature, TheormaEgrigium(Gaussian curvature is intrinsic), isometric surfaces have same Gaussian curvatures at corresponding points, Gauss and Weingarten formula, Christoffle symbols, expressing Christoffel symbols in terms of metric coefficients and their derivative , Some coordinate transformations, Codazzi equation and Gauss theorem, Fundamental theorem of a surface. Parallel transport and covariant derivative, Curvature of a curve on the surface, geodesics, geodesic curvature and normal curvature, geodesic curvature is intrinsic, equations of geodesic, geodesic on sphere and pseudo sphere, geodesic as distance minimizing curves. Gauss-Bonnet theorem (statement only), geodesic triangle on sphere, implication of Gauss-Bonnet theorem for geodesic triangle.

Unit III: Differentiable Manifolds (10 Lectures)

Review of Multivariable calculus, Topological Manifold, Coordinate charts, atlases, differentiable atlas, Definition and examples of Differentiable manifold. Smoot maps, Space of smooth maps , Diffeomorphism, Jacobi Identity, Tangent Vector and Tangent Space, Differential of a smooth map, Immersion, Embedding and Submanifolds, Vector fields and forms on manifolds, Stokes's Theorem, Divergence Theorem, Integral Curves, Distributions and Inerrability , Frobenius inerrability theorem, 1-parameter group of transformations, Tensors and forms, The Koszul connection, Covariant, Lee and Exterior derivative, Geodesics and curvature.

Textbooks:

1.A. Presley, Elementary differential geometry. Springer Science & Business Media, 2010.
2. B. O. Neil, Elementary differential geometry. Elsevier, 2006.
3. R. L. Bishop and R. J. Crittenden, Geometry of manifolds. Academic press, 2011.
4. S.S. Chern, W.H. Chen and K.S. Lam, Lectures on Differential Geometry, World Scientific, 2000.

Reference Books:

1. M. P. Do Carmo, Differential geometry of curves and surfaces: revised and updated second edition. Courier Dover Publications, 2016.
2. J.M. Lee, Introduction to Smooth Manifolds, Springer, 2006.
3. M. Spivak, A Comprehensive Introduction to Differential Geometry, Vol. 1, 3rd ed., Publish or Perish, 1999

Department of Mathematics
National Institute of Technology Srinagar

Functional Analysis MM-304	M.Sc. Mathematics Third Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Unit I: (15 Lectures)

Normed linear spaces, Banach spaces; Classical examples: $C([0,1])$, l_p, c, c_0, c_{00}, $L_p[0,1]$; Continuity and boundedness of linear operator; Quotient spaces; Finite dimensional normed spaces; Riesz lemma, (non)compactness of unit ball; Seperability with examples.

Unit II: (10 Lectures)

Hahn Banach extension theorem, Open mapping theorem, Closed graph theorem, Uniform boundedness principle.

Unit III: (15 Lectures)

Inner product spaces, Hilbert spaces, Projection theorem; Orthonormal basis, Bessel inequality, Parseval equality; Dual, Duals of classical spaces-c_0, l_p, $L_p[0,1]$; Riesz representation theorem, Adjoint of an operator; Double dual, Weak and weak* convergence;

Textbooks:

1. J.B. Conway, A Course in Functional Analysis, 2nd, Springer, Berlin, 1990.
3. M. T. Nair, Functional analysis, PHI-Learning, New Delhi, Fourth Print, 2014.

Reference Books:

1. C. Goffman and G. Pedrick, A first course in functional analysis, Prentice-Hall, 1974.
2. P. D. Lax, Functional analysis, Willey Interscience, 2002.
3. B.V Limaye, Functional analysis, New Age International, 1996.

Computational Fluid Dynamics MM-305	M.Sc. Mathematics Third Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Unit I: (02 Lectures)
Introduction: Historical Perspective, Comparisons of experimental, Theoretical and Numerical approaches. Different numerical Approaches

Unit II: (06 Lectures)
Governing Equations: Classification of Partial Differential Equations, Physical Classification, Mathematical Classification, Well-posed problems, Navier-Stokes System of equations.

Unit III: (16 Lectures)
Finite Difference Methods: Derivation of Finite Difference Equations, Simple Methods, General Methods, Multidimensional Formulas, Accuracy of Finite Difference solutions, Solution Methods of Finite Difference Equations: Elliptic Equations, Parabolic Equations, Hyperbolic Equation, Example Problems, Stability, Convergence and Consistency of the Solution methods.

Unit IV: (10 Lectures)
Application of Finite Difference Methods to the Equations of Fluid Mechanics: Numerical Methods for Inviscid Flow Equations, Numerical Methods for Boundary-Layer Type Equations.

Unit V: (06 Lectures)
Introduction to Finite Volume Methods: Basic Formulations, SIMPLE algorithm, TECPLOT Software.

Textbooks:

1. D. A. Anderson, J. C. Tannehill, and R. H. Pletcher, Computational Fluid Mechanics and Heat Transfer, 2nd ed, Taylor & Francis, 1997.
2. J. D. Anderson Jr, Computational Fluid Dynamics, McGraw-Hill International Edition, 1995.

Reference Books:

1. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, Hemisphere, 2000.
2. T. J. Chung, Computational Fluid Dynamics, 2nd ed. Cambridge University Press, 2010.

Department of Mathematics
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Wavelet Analysis MM-401	M.Sc. Mathematics Fourth Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Unit-I:

(12 Lectures)

Fourier series, Fourier transforms, Inversion formula, Parseval Identity and Plancherel Theorem, Continuous-time convolution and the delta function, Heisenberg uncertainty principle , Poisson's summable formula, Shannon sampling theorem, Discrete Fourier transform, Fast Fourier transform

Unit-II:

(12 Lectures)

Time - frequency localization, definition and examples of wavelets, Dyadic wavelets, Wavelet series, Orthonormal wavelet bases, continuous and discrete wavelet transform, frames.

Unit-III:

(16 Lectures)

Multiresolution analysis, orthonormal systems and Riesz systems, scaling equations and structure constants, from scaling function to MRA and orthonormal wavelet. Biorthogonal wavelets.

Textbooks:

1. D. F. Walnut: An Introduction to Wavelet Analysis Birkhauser, Boston, 2002
2. E. Hernandez and G. Weiss ,A First Course on Wavelet Analysis, , CRC Press
3. P. Wojtaszczyk, A Mathematical Introduction to Wavelets , London Math. Society student texts, Cambridge university Press, 1997.

Reference Books:

1. M. Frazier, An Introduction to Wavelets Through Linear Algebra, Springer-Verlag New York Inc. 2014.
2. G. Bachman, L. Narici and E. Beckenstein, Fourier and Wavelet Analysis, Springer, 2000.

Polynomial Theory MM-402	M.Sc. Mathematics Fourth Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Unit I: (9 Lectures)
Introduction, The fundamental theorem of algebra, (Revisited) Symmetric polynomials, The Continuity theorem, Orthogonal Polynomials, General Properties, The Classical Orthogonal Polynomials, Harmonic and Sub Harmonic functions, Tools from Matrix Analysis

Unit II: (10 Lectures)
Critical points in terms of zeros, Fundamental results and critical points, Convex Hulls and Gauss-Lucas theorem, some applications of Gauss Lucas theorem. Extensions ofGauss-Lucas theorem, Average distance from a line or a point. Real polynomials and Jenson's theorem, Extensions of Jenson'stheorem

Unit III: (11 Lectures)
Derivative estimates on the unit interval, Inequalities of S. Bernstein and A. Markov, Extensionsofhigherorderderivatives,twootherextensions,Dependenceoftheboundsonthe zeros, some special classes, Lpanalogous of Markov'sinequality.

Unit IV: (10 Lectures)
Coefficient Estimates, Polynomials on the unit circles. Coefficients of real trigonometric polynomials, Polynomials on the unit interval.

Text Books:

1. Q. I. Rehman and G. Schmeisser, Analytic theory of Polynomials, Oxford Academic Press, 1978.
2. M. Marden, Geometry of polynomials, Springer, 1970

References:

1. G. Polya and Szego, Problems and theorems in Analysis II, Springer, 1998.

Department of Mathematics
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Summability Theory MM-403	M.Sc. Mathematics Fourth Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Unit-I: (15 Lectures)

Special methods of summation: Nörlund means, Regularity and consistency of Nörlund means, Inclusion, Equivalence, Euler means, Regularity of (E,1) method, , Abelian means, Regularity of (A,λ) method, A-method and its regularity, A Theorem of inclusion for Abelian means, Complex methods, Summability of 1-1+1-... by special Abelian Methods, A theorem of consistency, Methods ineffective for the seris 1-1+1-... , Riesz's Typical means.

Unit-II: (10 Lectures)

Arithmetic means: Hölder's means, Simple theorems concerning HölderSummability, Cesàro means, Simple theorems concerning Cesàrosummability, Cesàro and Abel summability, Cesàro means as Nörlund means, Equivalence Theorem, Riesz's arithmetic means, Uniformly distributed sequence, Tauberian theorems for Cesàrosummability.

Unit-III: (15 Lectures)

The Methods of Euler and Borel: The (E,q) method, Simple properties of the (E,q) method, The formal relation between Euler's and Borel's methods, Borel's Methods, Normal, absolute and regular summability, Abelian Theorems for Borel'ssummability.

Textbooks :

1. A. Zygmund, Trigonometric Series Vol.1&2, Cambridge University Presss, 1959.
2. G.H. Divergent Series, Oxford Clarendon Press, Cambridge university press,1947.

Reference Books:

1.M. Mursaleen, F. Basar, Topics in Modern Summability Theory, CRC Taylor & Francis Group New York 2020.

Department of Mathematics
National Institute of Technology Srinagar

Optimization Techniques MM-404	M.Sc. Mathematics Fourth Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Unit I: Optimization using Calculus (10 Lectures)

Stationary points; Functions of single and two variables; Global Optimum; Convexity and concavity of functions of one and two variables; Optimization of function of one variable and multiple variables; Gradient vectors; Examples; Optimization of function of multiple variables subject to equality constraints; Lagrangian function, Optimization of function of multiple variables subject to equality constraints; Hessian matrix formulation; Eigen values; Kuhn-Tucker Conditions; Examples.

Unit II: Non-linear programming Problems (15 Lectures)

Introduction, One dimensional minimization methods; unrestricted search with examples, Basic optimization methods and their convergence analysis. Random search method, univariate method, pattern search method with examples.Hookes and Jeeves method, Simplex Method: reflection, expansion, contraction, NLP, constraint optimization techniques, cutting plane method with examples.

Unit III: Project Management Techniques (15 Lectures)

Basic steps in PERT/CPM techniques, Network diagram representation, Fulkerson's i-j rule for drawing network diagram, crashing, illustrative examples.

Textbooks:

1. G. Hadlay, Linear Programming, 1st Edition, Narosa, 1962.
2. Hamidi A. Taha, Operations Research -An Introductory, 8^{th} Edition , Macmillan, 2005.
3. S.S. Rao, Engineering Optimization: Theory and Practice, New Age International Pvt Ltd., New Delhi, 2000.

Reference Books:

1.S.I. Gass , Linear Programming, 5^{th} Edition Mc-Graw Hill, 1985 .
2.W. Chuchman, Introduction to Operations Research, John Wiley and Sons, New York, 1957.

Department of Mathematics
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Advanced Graph Theory MM-405	M.Sc. Mathematics Fourth Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Unit I: Coloring of graphs (10 Lectures)

Vertex coloring, Vertex Chromatic number, Mycielski's theorem, Greedy Coloring Algorithm, Kempe- chain argument, Brooks theorem, Edge coloring, Vizing's theorem, Map Coloring, Four color theorem (statement only), 5-color theorem, Tait's theorem.

Unit II: Matchings, Covering and Edge graphs (10 Lectures)

Matchings, Berge theorem, Hall's theorem, Konig's theorem on matchings, Factors in graphs, Tutte's 1- factor theorem, Anti factor sets, Concept of vertex and edge covering, Edge graphs, Krausz characterization, Van-Rooij and Wilf characterization, Beineke's theorem (statement only).

Unit III: Matrices in graphs (10 Lectures)

Incidence matrix, Modified incidence matrix, Rank of the incidence matrix, Adjacency matrix, Powers of adjacency matrix, Degree Matrix, Laplacian Matrix, Matrix Tree Theorem, Non negative matrices and PerronFrobenius theory.

Unit IV: Spectra of graphs (10 Lectures)

Characteristic polynomial of a graph, Coefficient theorem, Eigenvalues of complete graph, complete bipartite graph, Cycle, Path, Spectral characterization of bipartite graphs, Eigenvalues of regular graphs and their line graphs. Energy of graphs; definition and simple examples.

Textbooks:

1. R. B. Bapat, Graphs and Matrices, Hindustan Book Agency, New Delhi, 2010.
2. J. A. Bondy and U.S.R Murthy, Graph Theory with Applications, Elsevier Science Publishing Co. Inc ,1982.
3. Frank Harary, Graph Theory, Narosa Publishing House (2001).
4. S. Pirzada, An Introduction to Graph Theory, Universities Press, Orient Blackswan, Hyderabad (2012).

Reference Books:

1. D. B. West, Introduction to Graph Theory, 2nd edition, Pearson Publication, 2002.
2. D.M. Cvetković, M. Doob, H. Sachs, Spectra of graphs, Academic press, New York, 1980.

Department of Mathematics
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Riemannian Geometry MM-406	M.Sc. Mathematics Fourth Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Unit I: Differential forms and Tensors (15 Lectures)

Differential forms, Exterior product, Grassman algebra of forms, Exterior derivative, Tensor Analysis: Summation convention and indicial notation, Coordinate transformation and Jacobian, Tensors of different ranks, Contravariant, Covariant and mixed tensors, Symmetric and skew symmetric tensors, Addition, Subtraction, Inner and outer products of tensors ,Contraction theorem, Quotient law, The line element and metric tensor , Christoffel symbols.

Unit II: Riemannian Manifolds (15 Lectures)

Riemannian metric, Definition and examples of Riemannian Manifold, Riemannian connection, Fundamental theorem of Riemannian Geometry, Affine Connection, Levi-Civita connection, Geodesics and parallel transport, Exponential map, convex neighbourhoods, Curvature: Riemannian curvature, Bianchi Identities, Sectional Curvature, Ricci Curvature, Scalar curvature, theorem of Cartan on the determination of the metric by means of the curvature.

Unit III: Geometry of Submanifolds (10 Lectures)

Induced metric, definition and examples of Riemannian submanifolds, Induced connection and second fundamental form, Equation of Gauss, Codazzi and Ricci, Totally umbilical submanifolds, Curvature of submanifolds, Gauss map, basic inequalities for Riemannian submanifolds

Textbooks:

1. M. P. do Carmo, Riemannian Geometry, Birkhauser,1992.
2. J.M. Lee, Introduction to Riemannian Manifolds, 2nd ed., Springer, 2018.
3. S.S. Chern, W. H. Chen and K.S. Lam,Lectures on Differential Geometry, World Scientific, 2000.

Reference Books:

1. N. J. Hicks, Notes on Differential Geometry, Von Nostrand, 1965.
2. P. Petersen, Riemannian Geometry, Springer, 2006.
3. J. Jost, Riemannian, Geometry and Geometric Analysis, 6ed. Springer, 2011.

Department of Mathematics
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Algebraic Combinatorics MM-407	M.Sc. Mathematics Fourth Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Unit 1: (15 Lectures)

Sperner property of posets, algebraic characterization of strong Sperner property, unimodality of q-binomial coefficients. Young lattice and counting tableaux, RSK correspondence.

Unit 2: (15 Lectures)

Polytopes and convexity, circulantHadmard matrices, Wedderburn's Theorem and some consequences. Representations of symmetric groups

Unit 3: (15 Lectures)

Combinatorial invariants in algebraic structures, algebraic methods in combinatorics, The Combinatorial Nullstellensatz and some of its applications.

Textbooks:

1. A. Prasad, Representation theory (a combinatorial view point), Cambridge University Press, 2015.

Reference Books:

1. R. P. Stanley, Algebraic Combinatorics: Walks, Trees, Tableaux, and More, Springer, 2013.
2. R. P. Stanley. Enumerative Combinatorics, vol. 2, Cambridge University Press, 1999.

Department of Mathematics
National Institute of Technology Srinagar

Variational Calculus MM-408	M.Sc. Mathematics Fourth Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Unit-I (Calculus of Variations): (10 Lectures)

Variation of a functional, Euler-Lagrange equation, Necessary and sufficient conditions for extrema. Variational methods for boundary value problems in ordinary and partial differential equations.

Unit-II (Linear Integral Equations): (15 Lectures)

Linear integral equation of the first and second kind of Fredholm and Volterra type, Solutions with separable kernels. Characteristic numbers and eigenfunctions, resolvent kernel.

Unit-III (Classical Mechanics): (15 Lectures)

Generalized coordinates, Lagrange's equations, Hamilton's canonical equations, Hamilton's principle and principle of least action, Two-dimensional motion of rigid bodies, Euler's dynamical equations for the motion of a rigid body about an axis, theory of small oscillations.

Textbooks:

1. M. Gelfand and S.V. Fomin, Calculus of Variation, Dover Publication,2002.
2.K. Sankara Rao, Classical Mechanics, PHI India, 2005.

Reference Books:

1. Synge and Griffith,Principle of Mechanics, McGraw Hill Company, 2001
2. R. Weinstocks, Calculus of variations with applications to physics, Dover,1994.
3. Integral equations, F G Tricomi, Dover, 1988.

Numerical methods for Partial Differential Equations MM-409	M.Sc. Mathematics Fourth Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Unit I: (15 Lectures)

Introduction to Finite difference schemes - Finite difference schemes for partial differential equations, explicit schemes, implicit schemes, single step schemes, multi-step schemes.Finite difference schemes for boundary value problems - FTCS,backward Euler and Crank-Nicolson schemes, ADI methods, Lax Wendroff method, upwind scheme.

Unit II: (10 Lectures)

Consistency, stability and convergence Analysis - Stability analysis by von Neumann method, CFL condition, Lax's equivalence theorem.

Unit III: (07 Lectures)

Introduction to Finite element method - Finite element method for partial differential equations, variational methods, method of weighted residuals.

Unit IV: (08 Lectures)

Finite element discretization and error analysis -Finite element discretization for one-dimensional and two-dimensional elliptic equations, apriori and a posteriori error estimates.

Textbooks:

1.G. D. Smith, Numerical Solutions to Partial Differential Equations, Oxford University Press, 3rd Edn., 1986.

2. C. Johnson, Numerical Solution of Partial Differential Equations by the Finite Element Method, Dover Publications, 2009.

Reference Books:

1. J. C. Strikwerda, Finite Difference Schemes and Partial Differential Equations, SIAM, 2004.

2. E. Suli, Finite Element Methods for Partial Differential Equations,University of Oxford, 2000.

3J. N. Reddy, An Introduction to Finite Element Method, 3rd Edn.,McGraw Hill, 2005

Advanced Complex Analysis MM-410	M.Sc. Mathematics Fourth Semester		Total Course Credit: 4		
			L	T	P
			3	1	0
Evaluation Policy	Mid-Term (30 Marks)	Class Assessment (10 Marks)	Final-Term (60 Marks)		

Unit-I : (12 Lectures)

Maximum Modulus Principle, Schwarz Lemma and its generalization,Meromorphicfunction, Argument Principle, Rouche's theorem with application, Inverse function Theorem, Poisson integral formula for a circle and half plane, Poisson Jenson formula, Carleman's theorem, Hadamard three-circle theorem and the theorem of Borel and Caratheodory.

Unit-II: (10 Lectures)

Principle of analytic continuation, uniqueness of direct analytical continuations and uniqueness of analytic continuation along a curve. Power series method of analytic continuation, Functions with natural boundaries and related examples. Schwartz reflection principle, functions with positive real part.

Unit-III: (10 Lectures)

Space of analytic functions, Hurwitz's theorem, Montel's theorem, Riemann Mapping theorem (Statement only), Weierstrass factorization theorem, Gamma function and its properties. Riemann Zeta function, Reimann's functional equation. Harmonic functions on a disc, Harnack's inequality and theorem, Dirichlet's problem.

Unit IV: (10 Lectures)

Canonical products, order of an entire functions, Exponential convergence, Borel theorem, Hadamard's factorization theorem, The Range of analytic functions, Bloch's Theorem, Schottky's Theorem, The Little Picard's Theorem, Landau's Theorem, Great Picard Theorem (statement and applications only), Univalent function. Bieberbach's conjecture (statement only) and the 1/4 – theorem.

Text Books:

1. L. Alfors, Complex Analysis, Third Edition, Springer,1992 .
2. E. C. Titchmarsh, Theory of Functions, Oxford UniversityPress,1985.

References:

1. J.B. Conway, Functions of a complex variable –I, Springer-Verlag New York Heidelberg Berlin, 1982.
2. R. Silverman, Complex Analysis, Doverpublications,1978.