MSC (2 YEARS) PROGRAM IN MATHEMATICS
In accordance with HEC's Policy

Session 2020 and onwards

HOD, Department of Mathematical Science, ULM

Director Academics, ULM

MSC-Scheme of Studies in Mathematics

Semester-wise break up

First Year

Semester-I

S. N	Course Code	Course Title	Cr. Hrs
1	MATH-351	Advanced Calculus	3(3 + 0)
2	MATH-322	Ordinary Differential Equation	3(3 + 0)
3	MATH-336	Linear Algebra	3(3 + 0)
4	MATH-333	General Topology	3(3 + 0)
5	MATH-361	Mathematical Computing Tools	3(3 + 0)
		Total	**15(15 + 0)**

Semester-II

S. N	Course Code	Course Title	Cr. Hrs
1	MATH-331	Real Analysis	3(3 + 0)
2	MATH-324	Complex Analysis	3(3 + 0)
3	MATH-424	Vector and Tensor Analysis	3(3 + 0)
4	MATH-332	Group Theory	3(3 + 0)
5	MATH-326	Mathematical methods	3(3 + 0)
		Total	**15(15 + 0)**

Second Year

Semester-III

S. N	Course Code	Course Title	Cr. Hrs
1	MATH-431	Functional Analysis-I	3(3 + 0)
2	MATH-421	Numerical Analysis-I	3(3 + 0)
3	MATH-422	Integral Equations	3(3 + 0)
4	MATH-335	Rings and fields	3(3 + 0)
5	MATH-425	Fluid Mechanics -I	3(3 + 0)
		Total	**15(15 + 0)**

Semester-IV

S. N	Course Code	Course Title	Cr. Hrs
1	MATH-442	Mathematical Statistics	3(3 + 0)
2	MATH-432	Functional Analysis-II	3(3 + 0)
3	MATH-428	Partial Differential Equation	3(3+0)
4	MATH-423	Numerical Analysis-II	3(3 + 0)
5	MATH-433	Measure Theory	3(3 + 0)

6	MATH-500	Viva Voce	3(3 + 0)
		Total	**18(18 + 0)**

Elective Courses

Semester III			
S. N	**Course Code**	**Course Title**	**Credit Hours**
1	MATH-424	Vector and Tensor analysis	3(3+0)
2	MATH-425	Fluid Mechanics-I	3(3+0)
3	MATH-441	Mathematical Statistic	3(3+0)
4	MATH-433	Measure Theory	3(3+0)
5	MATH-326	Dynamics	3(3+0)
Semester IV			
S. N	**Course Code**	**Course Title**	**Credit Hours**
1	MATH-423	Numerical Analysis-II	3(3+0)
2	MATH-434	Introduction to Fixed Point Theory	3(3+0)
3	MATH-429	Fluid Mechanics-II	3(3+0)
5	MATH-427	Mathematical Modeling	3(3+0)
6	MATH-426	Fluid dynamics	3(3+0)

COURSE CONTENTS 1st SEMESTER

MATH-351: Advanced Calculus

Prerequisite(s): Mathematics A, and B at BA/BSc level
Credit Hours: 3 + 0

Course Outline:

The real numbers, algebraic and order properties of R, the completeness property, cluster points, open and closed sets in R, Sequences, the limit of a function, limit theorems, Continuous functions on intervals, boundedness theorem, maximum-minimum theorem and the intermediate value theorem, uniform continuity, The derivative, the mean value theorem, Taylor's theorem. Functions of several variables, Limit and continuity of functions of two and three variables, partial derivatives, differentiable functions, Multiple Integrals, regions in the x-y plane, iterated integrals, double integrals, change in the order of integration, and transformation of double integrals.

Recommended Book:

- R. G. Bartle, and D. R. Sherbert, Introduction to Real Analysis, John Wiley & Sons 1994
- D. V. Widder, Advanced Calculus, Prentice-Hall, 1982
- W. Rudin, Principles of Real Analysis, McGraw-Hill, 1995
- S.C. Malik Mathematical Analysis

MATH-336: Linear Algebra

Prerequisite(s): Mathematics B at BA/BSc level
Credit Hours: 3 + 0

Course Outline:

Vector spaces, sums and direct sums of subspaces of a finite dimensional vector space, dimension theorem, linear transformation, null space, image space of linear transformation, rank and nullity of a linear transformation, relation between rank, nullity and dimension of the domain of a linear transformation, matrix of linear transformation, change of basis, inner product spaces, projection of a vector along another vector, norm of a vector, Cauchy Schwartz inequality, orthogonal and orthonormal basis, similar matrices and diagonalization of a matrix, Home (V,W), dimension and basis of Home (V,W), dual space and dual basis, annihilators, Eigen values and Eigen vectors and minimal polynomials.

Recommended Book:

- G.E. Shilov, Linear Algebra, Dover Publication, Inc., New York, 1997
- D.G. Zill, and M. R. Culle, Advanced Engineering Mathematics, PWS
- Herstein, Topics in Algebra, John-Wiley, 1975
- A. M. Trooper, Linear Algebra, Thomas Nelson and Sons, 1969

MATH-333: General Topology

Prerequisite(s): Mathematics B at BA/BSc level
Credit Hours: 3 + 0

Course Outline:

Motivation and introduction to sets and their operations, countable and uncountable sets, Topological spaces, open and closed sets, interior, closure and boundary of a set, neighborhoods and neighborhood systems, isolated points, some topological theorems, limit points, the derived and perfect sets, dense sets and separable spaces, Bases and sub bases, continuous maps, open and closed maps, Metric spaces, topology induced by a metric, equivalent topologies, formulation with closed sets, Cauchy sequence, complete metric spaces, characterization of completeness, Cantors intersection theorem, the completion of metric space, metrizable spaces. Continuous functions, various characterizations of continuous functions, homeomorphisms, open and closed continuous functions, topological properties and homeomorphisms, Separation axioms, T1 and T2 spaces, regular and normal spaces, Compact spaces their characterization and some theorems, construction of compact spaces, compactness in metric spaces, compactness and completeness, local compactness. Connected spaces, topological product of connected spaces, locally connected spaces, concept of category and Bair's category theorem.

Recommended Book:

- J. R. Munkres, Topology A First Course, Prentice - Hall, Inc. London
- G. F. Simon, Introduction to Topology and Modern Analysis McGraw-Hill, New York
- W. J. Pervin, Foundation of General Topology, Academic Press, London, 2nd, ed
- Dr. A. Majeed, Introduction to Topology and Functional Analysis

MATH-322: Ordinary Differential Equations

Prerequisite(s): Mathematics A at B.A/B.Sc level

Credit Hours: 3 + 0

Course Outline:

Definitions and occurrence of differential equations, remarks on existence and uniqueness of solution, First order and simple higher order differential equations, special equations of 1st order, Elementary applications of 1st order differential equations, Theory of linear differential equations. Linear equations with constant coefficients, Methods of undetermined coefficients and variation of parameters, Sturm-Liouville boundary value problems. Fourier series, Series solution of differential equations, The Bessel modified Bessel Legendre, Hermit, Hyper geometric, Lauguere equations and their solutions.

Recommended Book:

- M. Morris, and O. E. Brown, Differential Equations, Englewood Cliffs, Prentice-Hall
- M. R. Spiegel, Applied Differential Equations, Prentice-Hall
- L. Brand, Differential and Difference Equations, John-Wiley
- D. G. Zill, and M. R. Cullen, Advanced Engineering Mathematics PWS, Publishing Co.

MATH-361: Mathematical Computing Tools

Prerequisite(s): *None*

Credit Hours: 2+1

Specific Objectives of the Course:

The purpose of this course is to teach students the use of mathematical software's like MATLAB, MAPLE, and MATHEMATICA for solving computationally-difficult problems in mathematics. The students shall become well-versed in using at least one mathematical software and shall learn a number of techniques that are useful in calculus as well as in other areas of mathematics.

Course Outline:

The contents of the course are not fixed, however the following points should be kept in mind while teaching the course. The course should be taught in a computer lab setting. Besides learning to use the software, the students must be able to utilize the software to solve the computationally difficult problems in calculus and other areas of mathematics. At the end of the course, the students should have a good command on at least two of the three programs mentioned above.

Recommended Books:

- DM. Etter, D, Kuncicky, D. Hull, *Introduction to MATLAB*, Prentice Hall, Englewood Cliffs,NJ, USA, 2001
- F. Garven, *The Mapple Book*, Chapman & Hall/CRC, 2002
- S. Kaufmann, *Mathematica As a Tool, An Introduction with Practical Examples*, Springer, New York, 1994

2nd SEMESTER

MATH-331: Real Analysis

Prerequisite(s): Advanced Calculus
Credit Hours: 3 + 0

Course Outline:

The Riemann Integral: Upper and lower sums, definition of a Riemann integral, integrability criterion, classes of integrable functions, properties of the Riemann integral, Infinite Series, Review of sequences, the geometric series, tests for convergence, conditional and absolute convergence, Regrouping and rearrangement of series. Power series, radius of convergence, Uniform Convergence: Uniform convergence of a sequence and a series, the M-test, properties of uniformly convergent series, Weierstrass approximation theorem, Improper Integrals, Classification, tests for convergence, absolute and conditional convergence, convergence of $f(x)\sin xdx$, the gamma function, Uniform convergence of integrals, the M-text, properties of uniformly convergent integrals.

Recommended Book:

- R. G. Bartle, and D. R. Sherbert, Introduction to Real Analysis, John Wile Sons
- D. V. Widder, Advanced Calculus, Prentice Hall
- W. Rudin, Principles of Real Analysis, McGraw-Hill
- S. C. Malik Mathematical Analysis

MATH-332: Group Theory

Prerequisite(s): *None* ***Credit Hours:*** *3 + 0*

Course Outline:

Introduction to Sets and Structures, Motivation for groups, Finite groups, Product of Subgroups, Permutations and cyclic groups, Homomorphism of a group, kernel of Homomorphism, Concept of an Isomorphism of a group, Isomorphism between Cyclic groups, Cosets, Normal groups, Factor groups and Simple groups, Concept of Normalizer and Centralizers, Centre of a group, Series of groups.

Recommended Book:

- J. B. Fraleigh, A First Course in Algebra, Addison-Wesley
- M. Hamermesh, Group Theory, Addison-Wesley
- N. Herstein, Topics in Algebra, John Wiley

MATH-424: Vector and Tensor Analysis

Prerequisite(s): Advanced Calculus, Ordinary Differential Equations
Credit Hours: 3 + 0

Course Outline:

Vectors in 3 dimension, the dot and the cross products, Triple products, vector differentiation, vector integration, the gradient, divergence and curl, and their applications, the divergence theorems of Gauss, Stokes's theorem, and Green's theorem in the plane, curvilinear coordinates, introduction to tensor analysis, summation convention, kronecker delta, contra variant and covariant vectors and tensor, Fundamental operations with tensors, symmetric, and skew symmetric tensors, Metric tensor, conjugate or reciprocal tensors, christoffel's symbols,

Geodesics, Geodesics equation, Covariant derivatives, permutation symbols and tensors, tensors form of gradient, divergence and Curl.

Recommended Book:

- D. E. Bourne, P. C. Kendall, Vector Analysis and Cartesian Tensors (2nd edition)
- N. A. Shah, Vector and Tensor Analysis, 2005, A-One Publishers, Lahore
- G. D. Smith, Vector Analysis, Oxford University Press, Oxford

M. R. Spiegel, Vector Analysis, 1974, McGraw Hill, New York

MATH-324: Complex Analysis

Prerequisite(s): Advanced Calculus
Credit Hours: 3 + 0

Course Outline:

Algebra of complex numbers, analytic functions, C-R equations, harmonic functions, elementary functions, branches of log z, complex exponents, Integrals: Contours, Cauchy-Goursat theorem, Cauchy integral formula, Moreras theorem, Liouvilles theorem, Series: Convergence of sequences and series, Taylor series, Laurent series, zeros of analytic function, Residues and poles: the residue theorem, evaluation of improper integrals, integrals involving trigonometric functions, integration around a branch point, Special Functions: Gamma, Beta, Hyper geometric and Legendre polynomial.

Recommended Books:

- R Churchill, Verhey and Brown R., Complex Variables and Applications McGraw-Hill
- J. E. Marsden, Basic Complex Analysis, W.H.Freeman and Co
- E. Hille, Analytic Function Theory, Vols.I and II, Chelsea Publishing Co. New York

MATH-326: Mathematical methods

Prerequisite(s): Basic Numerical Analysis at BA/B.Sc level
Credit Hours: 3 + 0

Course Outline:

Number Systems and Errors; Loss of significance and error propagation, condition and instability; error estimation; floating point arithmetic; loss of significance and error propagation, Interpolation by Polynomials; Existence and uniqueness of the interpolating polynomial, Lagrangian interpolation, the divided difference table, Error of the interpolating polynomial; interpolation with equally spaced data, Newton's forward and backward difference formulas, Bessel's interpolation formula, Solution of non-linear Equations, Bisection method, iterative methods, secant and regula falsi methods; fixed point iteration, convergence criterion for a fixed point iteration, Newton-Raphson method, order of convergence of Newton-Raphson and secant methods, System of Linear Equations: Gauss elimination methods, triangular factorization, Crout method, Iterative methods, Jacobi method, Gauss-Seidel method, SOR method, convergence of iterative methods, Numerical Differentiation: Numerical differentiation formulae based on interpolation polynomials, error estimates, Numerical Integration: Newton-Cotes formulae; trapezoidal rule, Simpsons formulas, composite rules, Error estimation of integration formulas.

Recommended Book:

- R. L. Burden, J.D, Faires, Numerical Analysis, 9th edition
- D. D. McCracken, A guide to Fortran IV programme, Second Edition
- S. D. Conte, and C. Boor, Elementary Numerical Analysis, McGraw-Hill
- F. Ahmad, and M. A. Rana, Elements of Numerical Analysis, National Book Foundation

MATH-428: Partial Differential Equations
Pre-requisite(s)**:** Ordinary Differential Equations
Credit Hours: 3+0

Course Outline:

Basics concepts of PDEs, origin of PDEs, Derivations of PDEs, solution of linear differential equations of order one using Lagrange's method and its different types, integral surface passing through a given curve, surface orthogonal to a given system of surfaces, linear PDEs with n dependent variables and its solutions, linear homogeneous and non-homogeneous PDEs with constant coefficients and its solutions, PDEs of order two with variable coefficients and its solutions, solution of equations under given geometrical conditions, canonical forms of different kinds of PDEs especially Heat, Wave and Laplace equations, Riemann method of solutions of general linear hyperbolic equations of order two, Monge's method of integration, solution of non-linear PDEs of order one using different techniques, Charpit method for solution of PDEs of order one and of any degree, special methods of solution of PDEs applicable to certain standard forms, the Jacobi method for solution of PDEs with three or more independent variables.

Recommended Books:

- M. D. Raisinghania, Ordinary and Partial Differential Equations, 2006, S Chand Group
- M. D. Raisinghania, Advanced Differential Equations, S Chand Group
- D. G. Zill, M. R. Cullen, Differential Equations with Boundary-Value Problems
- K.Sankara Rao, Introduction to Partial Differential Equations
- A.K. Sharma, Advanced Differential Equations, Discovery Publishing House

COURSE CODE	**COURSE TITLE**	**PREREQUISITES**
MATH-431	**FUNCTIONAL ANALYSIS-I**	

SPECIFIC OBJECTIVES OF COURSE:

This course extends methods of linear algebra and analysis to spaces of functions, in which the interaction between algebra and analysis allows powerful methods to be developed. The course will be mathematically sophisticated and will use ideas both from linear algebra and analysis.

COURSE OUTLINES:

Metric Spaces: Further Examples of metric spaces, Open set, closed set, neighborhood, convergence, Cauchy sequences, completeness, Examples- completeness proofs, completion of metric spaces,

Normed Spaces, Banach space : Vector space, Normed space, Banach space, Further properties of Normed spaces, Finite dimensional Normed spaces and subspaces, Compactness and finite dimension, Linear operators, bounded and continuous linear operators, Linear functionals, Linear operators and functionals on finite dimension spaces, Normed spaces of operators, dual space.

Recommended Books

1. E. Kreyszig, Introductory functional Analysis with applications, john Wiley and sons 1978.
2. A. E. Taylor and D. C. Lay, Introduction to Functional Analysis, John Wiley & sons, 1980
3. G. F. Simmons, Introduction to topology and Modern Analysis, (Revised Edition)

McGraw Hill Book Compeny.
4. R. F. Ourtain, A. J. Pritched, Functional Analysis in Modern Applied Mathematics, Academic, Press, New York.
5. A. Friechmen, Foundations of Modern Analysis, 1982, Dover

COURSE CODE	COURSE TITLE	PREREQUISITES
MATH-432	FUNCTIONAL ANALYSIS-II	

SPECIFIC OBJECTIVES OF THE COURSE:

This course extends methods of linear algebra and analysis to spaces of functions, in which the interaction between algebra and analysis allows powerful methods to be developed. The course will be mathematically sophisticated and will use ideas both from linear algebra and analysis.

COURSE OUTLINE:

Inner product spaces, Hilbert spaces

Inner product space, Hilbert space, Further properties of Inner product spaces, Orthogonal complements and direct sums, Orthonormal sets and sequences, total orthonormal sets and sequences, representation of functional on Hilbert spaces, Hilbert adjoint operators, self adjoint, unitary and normal operators.

Fundamental Theorem for Normed and Banach spaces

Zorn's lemma, Hahn Banach theorem, Hahn Banach theorem for complex vector spaces and Normed spaces, Adjoint operator, reflexive spaces, Category theorem, Uniform bounded ness theorem, Open mapping theorem, Closed linear operators, Closed graph theorem.

Recommended Books

1. E. Taylor and D. C. Lay, Introduction to Functional Analysis, John Wiley & sons, 1980
2. G. F. Simmons, Introduction to topology and Modern Analysis, (Revised Edition) McGraw Hill Book Company.
3. R. F. Ourtain, A. J. Pritched, Functional Analysis in Modern Applied Mathematics, Academic, Press, New York.
4. A. Friechmen, Foundations of Modern Analysis, 1982, Dover
5. E. Kreyszig, Introductory functional Analysis with applications, john Wiley and sons 1978.

COURSE CODE	COURSE TITLE	PREREQUISITES
MATH-421	NUMERICAL ANALYSIS-I	

SPECIFIC OBJECTIVES OF COURSE:

This course is designed to teach the students about numerical methods and their theoretical bases. The course aims at inculcating in the students the skill to apply varioustechniques in numerical analysis, understand and do calculations about errors that can occur in numerical methods and understand and be able to use the basics of matrix analysis.

COURSE OUTLINE:

Errors, Relative error, Absolute error, inherent error, round-off error, truncation error, significant digits and numerical instability, Bisection method with examples, Secant and

Regula- Falsi methods with examples, Newton- Raphson method with examples, Rate of convergence of Secant method, Regula Falsi method and Newton-Raphson Method, Partial pivoting, complete pivoting, Gauss elimination method with examples, Gauss-Jordan Elimination Method with examples, Triangularization Method, Doolittle's method. Crout's method, Cholesky method with examples, Jacobi iteration method with examples, Gauss-Seidel Iteration method with examples, Successive over relaxation method(SOR) method with examples, Iterative method to determine the inverse of a matrix ($\mathbf{A}^{-1}$), Eigenvalues and Eigenvectors, Faddeev-Leverrier method with examples, Power method with examples and inverse power method with examples, Taylor Series, interpolation, Lagrange and Newton Interpolations, Linear Interpolation. Lagrange interpolation, Newton's Divided difference interpolation, iterated interpolation, Newton's divided difference interpolation, finite difference operators with examples.

Recommended Books

1 C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, Singapore, 2005.
2 R. L. Burden and J. D. Faires: Numerical Analysis, latest edition, PWS Pub. Co.
3 MK Jain, SRK Iyengar, RK Jain, Numerical Methods for scientific and engineering computation 6th edition, New age international Publishers
4 S. C. Chapra and R. P. Canale: Numerical Methods for Engineers, 6th edition, McGraw .

COURSE CODE	COURSE TITLE	PREREQUISITES
MATH-423	NUMERICAL ANALYSIS-II	

SPECIFIC OBJECTIVES OF THE COURSE:

This course is designed to teach the students about numerical methods and their theoretical bases. The students are expected to know computer programming to be able to write program for each numerical method. Knowledge of calculus and linear algebra would help in learning these methods.

COURSE OUTLINE:

Numerical differentiation, Methods based on interpolation, non-Uniform nodal points, linear interpolation, Quadratic interpolation, Uniform nodal points. Linear interpolation, quadratic interpolation, method based on finite differences, Method based on undetermined coefficients, extrapolation methods, Numerical integration, methods based on interpolation, Newton-Cotes methods, open type integration rules, Gauss Quadrature methods, Gauss-Legender Integration Method, Gauss-Chebyshev integration Methods, Composite integration methods, Trapezoidal rule, simpson's rule, ordinary differential equations, initial value problems, Reduction of higher order equations to the system of first order differential equations, existence and uniqueness, system of first order differential equations with constant coefficients with examples, numerical methods, local truncation error, convergence, stability, Euler method with examples, Backward Euler Method with examples, Mid-point method, Taylor Series method, Runge Kutta Methods, Explicit Runge kutta Method, second order methods, Third order Methods, fourth order methods, Runge kutta method for system of two equations, Shooting method for second order linear differential equations

Recommended Books

1. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, Singapore, 2005.
2. R. L. Burden and J. D. Faires: Numerical Analysis, latest edition, PWS Pub. Co.
3. MK Jain, SRK Iyengar, RK Jain, Numerical Methods for scientific and engineering computation 6^{th} edition, New age international Publishers
4. S. C. Chapra and R. P. Canale: Numerical Methods for Engineers, 6th edition, McGraw.

OPTIONAL COURSES

MATH-422: Integral Equations

Prerequisite(s): Differential equations and Real Analysis
Credit Hours: 3 + 0

Course Outline:

Introduction to integral equation, there origin and classification, some important identities, Laplace, Fourier and other Transforms, Volterra Integral equation: Volterra Integral equation of first kind and second kind, Numerical solution of Volterra integral equation, Fredholm Integral equation; Fredholm Integral equation with degenerate kernel, with symmetric Kernel, Fredgholem Integral equation with of the second kind numerical Solution, the Green's function of Fredholm Integral equation and the Green's function existence of the solution, Basic fixed point theorem.

Recommended Books:

- F. Smith, Integral equations, Cambridge University Press
- B. Noble, Methods based on the Wiener-Hopf technique, Pergamon Press
- J. Jerri., Introduction to integral equations with applications, Marcel Dekker Inc

MATH-335: Rings and Fields

Prerequisite(s): Group Theory
Credit Hours: 3 + 0

Course Outline:

Introduction to Ring theory and Field and their structure, Quotient Rings, Integral domain, Homomorphism of a Ring, Kernel of a Ring, Isomorphism of a Ring, Maximal ideals, Prime ideals, Euclidian rings, or Euclidian domain, Polynomial rings over a unique factorization domain, the field of quotients of an integral domain, Field structure, Ordered ring and field, introduction to extension field, Algebraic extensions, Finite field.

Recommended Books:

- J. A. Fraleigh, A First Course in Abstract Algebra, Addision Wesley Publishing
- N. Herstein, Topies in Algebra, John Wiley & Sons
- S. Lang, Algebra, Addison Wesley
- B. Hartley, and T. O. Hawkes, Ring, Modules and Linear Algebra, Chapman and Hall

MATH:425 Fluid Mechanics

Prerequisite(s): Differential equations and Analytical Mechanics
Credit Hours: 3 + 0

Course Outline:

Real and ideal fluids, Force , Pressure, Density, Specific volume, Specific weight, Stress and strain, Young's modulus, Viscosity, Surface tension, Steady and unsteady flow, turbulent flow, laminar flow, two-dimensional flow, three-dimensional flow, Eulerian and Lagrangian Flow Descriptions, Pathline, Streamline, streamtube, Stream filament, Stream surface, Streakline, The equation of continuity, The acceleration field, The Euler equation, The total derivative, Bernoulli's theorem, Flow of dry water continued, Flux, Vorticity and rotation, The velocity potential, Laplace's equation, Uniform flow, Source and sink, Viscosity, Deformation, The

equations of motion for viscous (wet) fluids, The Navier-Stokes equation, Viscous, incompressible, laminar flow, A. channel flow (2D counterpart of pipe flow), No-Slip Condition, Channel flow, Laminar flow in a pipe, Viscous flow past a circular cylinder, Reynolds number, Reynolds number.

Recommended Books:

- Buffler, Introduction to fluid mechanics PHY2009S, Deptt. of Physics
- Kundu and Cohen, Fluid Mechanics, 4th Edition
- G. K. Batchelor, An Introduction to Fluid Dynamics, 2nd Edition
- F. Chorlton, Textbook of fluid Dynamics

MATH-422: Mathematical Statistics
Prerequisite(s): Mathematics A at B.Sc level
Credit Hours: 3 + 0
Course Outline:

Frequency distributions, Measure of central tendency, Measure of dispersion, Moments, Kurtosis, Probability, Conditional and Marginal Interpretations of Probability, Bays formula and Bay's theorem of Probability, Random variable, Discrete and continuous Random variable, Mathematical expectation, Discrete distribution: Moment generating and cumulative distributions, Discrete probability distribution, The Binomial distribution, Hyper geometric distribution, Negative Binomial distribution, the Poisson distribution, Geometric distribution, Uniform distribution, Continuous distribution: Uniform distribution, the normal exponential distributions, Gamma and Beta distributions, Cauchy distribution, Log-Normal distribution, Weibull distribution.

Recommended Books:

- M. H. Degroot, Probability and Statistics, 2nd Edition
- K. V. Mardia, J. T. Kent, and J. M. Bibby, Multivariate Analysis
- Freund J-1962, Mathematical Statistics, Prentice Hall
- Mathematical Statistics Schaum's outline series
- M. R. Spiegel, J. Schiller, R. A. Srinivasan, Probability and Statistics
- J. N. Kapur and H. C. Sexena S. Mathematical Statistics

MATH-433: Measure Theory and Integrations
Prerequisite(s): *Real Analysis*
Credit Hours: 3 + 0
Course Outline:

Foundation of Analysis, A development of integral, relational, real and complex number system from the Peano axioms, Denumerable and no Denumerable sets, Cardinal and ordinal number, Partial ordered sets and Totally ordered sets, well order sets, Transfinite induction, axiom of choice and well ordering theorem, theory of set of points, covering theorems, theory of Measure, Measurable functions, the Lebesgue integral convergence theorem, the fundamental theorem of the integral calculus, derivative, non-differentiable functions, function of bounded variation, the Lebesgue class L^p, strong convergence, simple treatment of Riemann-Stieltjes and Lebesgue-

Stieltjes integral.

Recommended Books:

- Natonson, Theory of Functions of Real Variables
- Burkill, Lebesgue Integral
- Edmon Landou, Foundation of the Analysis
- Inder k. Rana. An Introduction to Measure and Integration 2nd Ed. Narosa

MATH- General Partial Differential Equations

Prerequisite(s): Differential Equations

Credit Hours: 3 + 0

Contents:

Review of ordinary differential equation in more than one variables, Partial differential equations (P.D.E) of the first order, Nonlinear P.D.E. of first order Applications of 1st order partial differential equations, Partial differential equations of second order: Solution of heat, Laplace and wave equations, Classification of 2nd order P.D.E. Boundary and initial conditions, Reduction to canonical form and the solution of 2nd order P.D.E. Technique of separation of variable for the solution of P.D.E with special emphasis on Heat, Laplace and wave equations, Laplace, Fourier transforms for the solution of P.D.E and their application to boundary value problems.

Recommended Book:

- I. N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill Book Company
- R. Ennemyer, Introduction to Partial Differential Equations and Boundary Value Problems, McGraw-Hill Book Company
- M. Humi, and W. B. Miller, Boundary Value Problems and Partial Differential Equations, PWS-Kent Publishing Company, Boston
- C. R. Chester, Techniques in Partial Differential Equations
- R. Haberman, Elementary Applied Partial Differential Equations

MATH- Advanced Mathematical Statistics

Prerequisite(s): Mathematical Statistics

Credit Hours: 3 + 0

Course Outline:

Bivariante distribution, Bivariante Normal distribution, Correlation and Regression, Correlation Ratio, Correlation ranks, Intraclass Correlation, Multiple and Particle Correlation, Linear Regression Model, Fitting of curves of the type $y = ab^x$, $y = ax^b$, Degree parabola, Distribution of function of random variable, M.g.t, Commutative and transformation methods,

Sampling, Laws of large Samples, Estimations methods of point estimation, Maximum likelihood Methods, Properties of maximum likelihood estimators, Methods of Moments, Methods of least square, Properties of maximum likelihood estimates, interval estimate, Sampling distributions, The chi square distribution. Its properties, Students T-distributions,F-distribution, Interrelation between T and F distributions.

Recommended Books:

- M. Mood, F. A. Graybill, and D. C. Boes, Introduction to the Theory of Statistics
- M. H. Degroot, Probability and Statistics, 2nd Edition
- K. V. Mardia, J. T. Kent, and J. M. Bibby, Multivariate Analysis
- J. Freund, Mathematical Statistics, Prentice Hall
- M. R. Spiegel, J. Schiller, R. A. Srinivasan, Probability and Statistics

MATH- Advanced Differential Geometry

Prerequisite(s): Differential Geometry

Credit Hours: 3 + 0

Course Outline:

Definition and examples of manifolds; Differential maps; Submanifolds; Tangents; Coordinate vector fields; Tangent spaces; Dual spaces; Multilinear functions; Vector fields; Tensor fields; Integral curves; Flows; Lie derivatives; Brackets; Differential forms; Introduction to integration theory on manifolds; Riemannian and semi-Riemannian metrics; Flat spaces; Affine connextions; Parallel translations; Covariant differentiation of tensor fields; Curvature and torsion tensors; Connexion of a semi-Riemannian tensor; Killing equations and Killing vector fields; Geodesics; Sectional curvature.

Recommended Books:

- R. L. Bishop, and S. I. Goldberg, Tensor Analysis on Manifolds, Dover Publications
- M. P. Docarmo, M. P, Riemannian geometry, Birkhauser, Boston
- D. Lovelock, and H. R. Tensors., Differential Forms and Variational Principles
- D. Langwitz, Differential and Riemannian geometry, Academic Press
- R. Abraham, J. E. Marsden, and T. Ratiu, Manifolds, Tensor Analysis and Applications

MATH- Analytical Dynamics

Prerequisite(s): Analytical Mechanics

Credit Hours: 3 + 0

Course Outline:

Constraints, generalized co-ordinates, generalized forces, general equation of dynamics, Lagrange's equations, conservation laws, ignorable co-ordinates, Explicit form of Lagranges equation in terms of tensors, Hamiltons principle, principle of least action, Hamiltons equations of motion, Hamilton-Jacobi Method, Poisson Brackets (P.Bs); Poissons theorem; Solution of mechanical problems by algebraic technique based on (P.Bs), Small oscilations and normal modes, vibrations of straings, transverse vibrations, normal modes, forced vibrations and damping, reflection and transmission at a discontinuity, Iongitudinal vibrations, Rayleighs principle.

Recommended Books:

- F. Chorlton, Textbook of dynamics, Van Nostrand
- W. Chester, Mechanics, George Allen and Unwin Ltd., London
- H. Goldstein, Classical Mechanics, Cambridge, Mass Addison-Wesley
- G. L. Meirovitch, Methods of Analytical Dynamics, McGraw-Hill,

MATH- Modeling and Simulations

Prerequisite(s): Differential Equations

Credit Hours: 3 + 0

Course Outline: Concepts of model, modeling and simulation Functions, linear equations, linear-differential equations, nonlinear differential equations and integral equations as models, introduction to simulation techniques Ordinary-Differential Equations: Modeling with first order differential Equations: Newton's law of cooling; radioactive decay; motion in a Gravitational field; population growth; mixing problem; Newtonian Mechanics. Modeling with second order differential equations: vibrations; Modeling with periodic or impulse forcing functions, Modeling with systems of first order differential equations; Partial-Differential Equations: Methodology of mathematical modeling; objective, background, approximation and idealization, model validation, compounding, Modeling wave phenomena (wave equation); Modeling the heat equation and some application to heat conduction problems in rods, Modeling the potential equation (Laplace equation), Applications in fluid mechanics, gravitational problems, Equation of Continuity.

Recommended Books:

- F. R. Giordano, M. D. Weir, Differential Equations: A Modeling Approach
- K. K. Tung, Topics in Mathematical Modeling
- U. T. Myint, L. Debnath, Partial Differential Equations for Scientists and Eng. N. H. Amsterdam
- S. Robert, An Introduction to Programming and Numerical Methods in MATLAB
- D.G. Zill, M.R. Cullen, Differential Equation with boundary Value Problem
- Erwin Kreszig, Advance Engineering Mathematics (John Willey and Sons)

MATH- Quantum Mechanics

Prerequisite(s): Analytical Mechanics

Credit Hours: 3 + 0

Course Outline:

Wave-Particle, Plan-Einstein relation, Debroglie relations, Schrodinger equation, Normalization of wave function, Waves-Pocket, Heisenberg indeterminacy or UIXCER Taint principal, Phase velocity, Group velocity, Stationary states, Properties of a waves function, Linear operators, Orthogonal basis in waves equation, Closure relation, Parseval relation, Orthonormalization relation, Delta functions, Ketand Bro vectors, the adjoint operators, Eigen value equations and observables, Projection operation, Basic postulates of Quantum theory, Implementations of the Schrödinger Equations, Conservative system, Angular momentum, Time-Energy Uncertainty, Raising operators, Spin Observable, Hormonic oscillator, Hydrogenic atoms, Pauli Exclusion Principal.

Recommended Books:

- Richard L. Liboff Introductory Quantum Mechanics 4^{th} edition
- David J. Griffith. Introduction to Quantum Mechanics 2^{nd} edition
- Quantum Mechanics Schaum outline series

MATH- Electromagnetic Theory
Prerequisite(s): Analytical Mechanics
Credit Hours: 3 + 0

Course Outline:

The electromagnetic law of force, Potential and field for several charges, Equipotential and lines of force, Gauss's flux theorem, electronics potential energy of a system of charges, energy of a system of conductors, dielectrics, the magneto static law of forces, magnetic doublets, magnetic shells, forces on magnetic doublets, magnetic induction, electric current, conductivity, resistance, Kirchhoff's laws, maximum energy theorem, magnetic field and energy law of electromagnetic induction, Current of A.C. Maxwell's equations in free space and in material, media and their solution in simple cases, Electromagnetic waves, reflection, refraction and polarization.

Recommended Books:

- Ferroro, Electromagnetism Theory
- S. Ramsy, Electricity and Magnetism

MATH- Optimization Theory
Prerequisite(s): Linear Algebra, Real Analysis
Credit Hours: 3 + 0

Course Outline:

Linear programming: simplex method, duality theory, dual and primal-dual simplex methods, Unconstrained optimization: optimality conditions, one-dimensional problems, multi-dimensional problems and the method of steepest descent. Constrained optimization with equality constraints: optimality conditions, Lagrange multipliers, Hessians and bordered Hessians. Inequality constraints and the Kuhn-Tucker Theorem, The calculus of variations, the Euler-Lagrange equations, functional depending on several variables, variational problems in parametric form, transportation models and networks.

Recommended Books:

- L. Elsgolts, Differential Equations and the Calculus of Variations
- B. S. Gotfried, J. Weisman, Introduction to Optimization Theory
- D. G. Luenberger, Introduction to Linear and Non-Linear Programming

MATH- Advanced Functional Analysis
Prerequisite(s): Functional Analysis.
Credit Hours: 3 + 0

Course Outline:

Bounded linear operators in Hilbert spaces and their various characterizations. Self ad joint, normal, unitary and projection operators. Compact operators, spectral theory of bounded linear operators along with elementary spectral theory. .Introduction to Banach Fixed point theorem and its applications. Reflexive spaces, Hahn-Banach Theorem for real and complex version. Weak and strong topologies and the Banach-Alouglu theorem.

Recommended Books:

- E. Kreyszing, Introductory Functional Analysis and Applications, John Wiley
- E. Taylor, and D. C. Lay, Introduction of Functional Analysis, John Wiley
- H. G. Heuser, Functional Analysis, John Wiley
- W. Groetsch, Elements of Applicable Functional Analysis, Marcel Dekker

MATH- Advanced Group Theory
Prerequisite(s): Group Theory
Credit Hours: 3 + 0

Course Outline:

Isomorphism Theorems, Conjugacy Classes, Generating Systems for finite Symmetric and Alternating groups, Endomorphism and Automorphism of a group, Characteristic and Fully invariant subgroups, Direct product of a group, Syllow theory and its applications, Simple group, simplicity of A_n for 5, Zessanhaus lemma, Normal series, Composition series, Jardon Holder theorem, Solvable groups, the derived series of a group, the lower and upper central series of a group and Nilpotent groups, Free group.

Recommended Books:

- J. S. Rose, A course on group theory, Cambridge University Press
- W. Magnus, A. Karrass, and Solitar., Combinatorial group theory
- Husain Taqdir., Introduction to topological groups

MATH- Theory of Modules
Prerequisite(s): Group Theory
Credit Hours: 3 + 0

Course Outline:

Elementary notions and examples, Modules, submodules, quotient modules, finitely generated and cyclic modules, exact sequences and elementary notions of homological algebra, Noetherian and Artinian rings and modules, radicals, semi simple rings and modules.

Recommended Books:

- J. Adamson, Rings and modules. Blyth, T.S., Module theory
- B. Hartley, and T. O. Hawkes, Rings, Modules and Linear algebra
- N. Herstein, Topics in Algebra, John Wiley and Sons

MATH- Advanced Complex Analysis
Prerequisite(s): Complex Analysis
Credit Hours: 3 + 0

Course Outline:

Conformal mapping, Preservation of mapping, Scale Factors, Local inverses, Harmonic Conjugates, Transformation of Harmonic functions, Transformation of boundary conditions, Application of conformal mapping, The Schwarz-Christoffel transformation, Integral formula, the Poisson type, Dirichlet problem for a disk, Schwarz integral formula, Neumann problems, mapping by elementary functions, linear frictional transformation, linear functional, the function $\frac{1}{Z}$, the transformation $w = \exp(z)$ and $w = \sin z$ Analytic continuation.

Recommended Books:

- R. V. Churchill, R. Brown, Complex Variables and Applications McGraw-Hill
- J. E. Marsden, Basic Complex Analysis, W. H. Freeman
- E. Hille, Analytic Function Theory, Vols. I and II

MATH- **Advanced Number Theory**

Prerequisite(s): Number Theory

Credit Hours: 3 + 0

Course Outline:

Review of Basic Algorithm, Congruence, Residue classes and Euler's ϕ function, Linear Congruence and Congruence of higher degree, the theorem of Fermat's, Euler and Wilson's. Primitive roots and indices, Integers belonging to a given exponent, composite module, Indices, Quadratic Residues, Composite module, Legendre Symbols, laws of Quadratic reciprocity, the Jacobi symbol, Number theoretic functions, Mobius functions, Diophantine equation and Fermat's conjecture, for $N = 2,\ N = 4$, Algebraic number and integers, Units and primes R (V) Ideals, Arithmetic of Ideals, the norm of a prime Ideals, Unit of Algebraic number field. Applications to Rational Number Theory, Equivalence and Class number Cyclotomic field K. Fermat's equations, Kummer's Theorem, Pure Cubic field, Distribution of primes and Riemann function, the prime number theorem.

Recommended Books:

- W. J. Leveque, Topics in Number Theory Vol: I and II
- Hardy and Wright, Number Theory, Clarendon presses
- E. W. Grass, Topics from the theory of Numbers
- Niven, S. Herbert, Zuckerman and L. Hugh Montgomery, An Introduction to the Theory of Number
- K. C. Choudhary, A First Course in Number Theory, Asian Book Private Limited
- T. Koshy, Elementary Number Theory with Applications, Academic Press
- H. Rosen, Elementary Number Theory and its Applications

Programming Language C/C++ Prerequisite(s): *None*

Credit Hours: 2+1

Course Outline:

Introduction to C Programming, Variables, Input/Output, Operators, Comments Loops, The for loop, the While loop, the do while loop Decisions, The if statement, the if-else statement, the else-if construct, The switch statement, the Conditional Operator simple Functions, functions that Return a Value, Using Arguments to Pass Data to a Function, Using More Than One Functions, External Variables, Static Variables, Preprocessor Directives. Arrays, Declaring Arrays, Passing Arrays to Functions, Sorting Arrays, String Constants, String Variables, String Functions, structure.

Recommended Book:

- Robert Lafore, C Programming Using Turbo C^{++}, Sams, 1997
- Deitel & Deitel, C How to Program, Third Edition, Prentice Hall, 2000

Study Tour of Students

Study tours can vary from short term (3 days) to long term (01 week). The study tours have many positive outcomes one of it is a learning component, secondly it include numerous recreational and cultural activities within the country. The students shall develop their trend of research, academics, curricular and co-curricular activities of the visited centers/ institutions. Further, carrier counseling shall be arranged for the students in various institutions/ industries. Therefore, in 8^{th} semester of BS-Mathematics students shall be allowed a study tour by the University of Malakand. The cost includes transportation, food, accommodation and remuneration for the tour Incharge(s) by the University of Malakand.