Punjab Technical University
Kapurthala

Scheme and Syllabus
of
M.Sc. Mathematics

Batch 2012 onwards

By
Board of Studies (Mathematics)

M. Sc. Mathematics is a post graduate level course of the Department of Mathematics which is a 2 years course. It is consisting of semester system (4 semesters) with two semesters per year.

Programme Code: MMS *(Masters in Mathematical Sciences)*

Eligibility: B.A/B.Sc. with Honours in Mathematics or B.A./B.Sc. (pass course) with Mathematics as one of the subjects having at least 50% marks in aggregate and at least 55% marks in Mathematics subject.

First Semester **Contact Hours: 26 Hrs.**

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
MMS-101	Algebra-I	4	1	0	50	100	150	5
MMS-102	Real Analysis-I	4	1	0	50	100	150	5
MMS-103	Complex Analysis	4	1	0	50	100	150	5
MMS-104	Ordinary Differential Equations & Special functions	4	1	0	50	100	150	5
MMS-105	Fundamentals of Computer and C Programming	4	0	0	50	100	150	4
MMS-106	Fundamentals of Computer and C Programming Lab	0	0	2	50	-	50	1
	Total	**20**	**04**	**02**	**300**	**500**	**800**	**25**

Second Semester **Contact Hours: 27 Hrs.**

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
MMS-201	Algebra-II	4	1	0	50	100	150	5
MMS-202	Real Analysis-II	4	1	0	50	100	150	5
MMS-203	Mechanics	4	1	0	50	100	150	5
MMS-204	Tensors and Differential Geometry	4	1	0	50	100	150	5
MMS-205	Numerical Analysis	4	1	0	50	100	150	5
MMs-206	Numerical Analysis Lab	0	0	2	50	-	50	1
	Total	**20**	**05**	**02**	**300**	**600**	**800**	**26**

Third Semester **Contact Hours: 27 Hrs.**

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
MMS-301	Topology	4	1	0	50	100	150	5
MMS-302	Operations Research	4	1	0	50	100	150	5
MMS-303	Mathematical Statistics	4	1	0	50	100	150	5
MMS-304	Functional Analysis	4	1	0	50	100	150	5
MMS-XXX	Elective –I	4	0	0	50	100	150	4
MMS-305	Seminar	0	0	2	50	-	50	1
	Total	**20**	**05**	**02**	**300**	**500**	**800**	**25**

Fourth Semester **Contact Hours: 27 Hrs.**

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	Internal	External	Total	
MMS-401	Discrete Mathematics	4	1	0	50	100	150	5
MMS-402	Mathematical Methods	4	1	0	50	100	150	5
MMS-403	Partial differential equations	4	1	0	50	100	150	5
MMS-YYY	Elective –II	4	1	0	50	100	150	5
MMS-ZZZ	Elective –III	4	0	0	50	100	150	4
MMS-404	Seminar	0	0	2	50	-	50	1
	Total	**20**	**05**	**02**	**300**	**500**	**800**	**25**

Elective –I MMS XXX (Any one subject to be opted)

MMS-501 Fluid Mechanics
MMS-502 Solid Mechanics
MMS-503 Coding Theory
MMS-504 Advanced Complex Analysis

Elective –II & Elective –III MMS YYY & MMS ZZZ (Any two subjects to be opted)

MMS-505 Advanced Operations Research
MMS-506 Advanced Fluid Mechanics
MMS-507 Advanced Solid Mechanics
MMS-508 Number Theory and Cryptography
MMS-509 Theory of Linear Operators
MMS-510 Advanced Numerical Methods
MMS-511 Topological Vector Spaces
MMS-512 Fractional Calculus

Note:

Instructions for paper setters and candidates:

(a) Eight questions are to be set preferably two questions from the each unit.

(b) The students are required to attempt any five questions. All questions carry equal marks.

(c) Duration of examination is three hours.

MMS-101: ALGEBRA-I

Unit-I

Review of basic concept of groups, automorphisms and inner automorphisms of a group, Normalizer and Centralizer, Conjugate elements and conjugacy classes, class equation of a finite group and its applications, Cauchy's theorem, Sylow's theorems, Review of Permutation Groups, Alternating Group A_n, simplicity of A_n, Direct Products, fundamental theorem of finitely generated abelian groups, Invariants of finite abelian groups.

Unit-II

Normal and sub normal series, Composition series, Zassenhaus's Lemma, Scherer's refinement theorem and Jordan-Holder theorem, Derived group, Solvable groups, Nilpotent groups, fundamental theorem of arithmetic.

Unit-III

Rings, Subrings, ideals, Sum and direct sum of ideals, Maximal, Prime, Nilpotent & Nil ideals, Statement of Zorn's Lemma, Rings of Fractions, Field of quotients of an integral domain.

Unit-IV

Factorization Theory in Integral Domains, Divisibility, Rings of Gaussian integers, Unique Factorization Domain (UFD), Principal Ideal Domain (PID), Euclidian Domain(ED) and their relationships, Polynomial rings over unique factorization domains.

Suggested Readings/ Books:

1. Bhattacharya, P.B., Jain, S.K. & Nagpal, S.R.: Basic Abstract Algebra, Cambridge University Press, 1997.
2. Surjeet Singh, Quzai Zameeruddin: Modern Algebra, Vikas Publishing House , New Delhi,8th edition,2006.
3. I.N. Herstein: Topics in Algebra, 2nd edition, Wiley Eastern, 1975.

MMS-102: REAL ANALYSIS-I

UNIT-I

Elementary set theory, finite, countable and uncountable sets. Metric spaces: definition and examples, open and closed sets, compact sets, elementary properties of compact sets, k- cells, compactness of k cells, compact subsets of Euclidean space R^k. Perfect sets, Cantor set, separated sets, connected sets in a metric space, connected subsets of real line.

UNIT-II

Convergent sequences (in Metric spaces), Cauchy sequences, subsequences, complete metric space, Cantor's intersection theorem, category of a set and Baire's category theorem. Examples of complete metric space, Banach contraction principle.

UNIT-III

Limits of functions (in Metric spaces), continuous functions, continuity and compactness, continuity and connectedness, discontinuities, monotonic functions, uniform continuity.

UNIT-IV

Riemann Stieltje's Integral : definition and existence of integral, properties of integral, integration and differentiation, Fundamental theorem of Calculus, $1^{st}$and 2^{nd} mean value theorems for Riemann Stieltje's integral

Suggested Readings/ Books:

1. Walter Rudin, Principles of Mathematical Analysis, 3^{rd} edition, McGraw Hill, Kogakusha, 1976, International student edition

2. H. L. Royden, Real Analysis, 3^{rd} edition, Macmillan, New York & London 1988.

3. Tom M. Apostol, Mathematical Analysis, Addition –Wesley.

4. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Ltd (2008).

MMS 103: COMPLEX ANALYSIS

Unit-I

Function of complex variable, continuity and differentiability, analytic functions, conjugate function, harmonic function. Cauchy Riemann equation (Cartesian and polar form).Construction of analytic functions.Stereographic projection and the spherical representation of the extended complex plane.

Unit-II

Complex line integral, cauchy's theorem, cauchy's integral formula and it's generalized form. cauchy's inequality, Poisson's integral formula, Morera's theorem, Liouville's theorem, power series, Taylor's theorem, Laurent's theorem. Fundamental theorem of algebra and Rouche's theorem, Maximum modulus principle, Schwarz lemma.

Unit-III

Zero's, Singularities, residue at a pole and at infinity. Cauchy's Residue theorem, Jordan's lemma, integration round unit circle, Evaluation of integrals.

Unit-IV

Conformal transformations, bilinear transformations, critical points, fixed points, Problems on cross-ratio and bilinear transformation.

Suggested Readings/ Books:

1. Complex Analysis (2nd Edition) – L. V. Ahlfors, McGraw-Hill International Student Edition, 1990.
2. An Introduction to the Theory of functions of a complex Variable – E. T. Copson, Oxford university press, 1995.
3. An Introduction To Complex Analysis – A. R. Shastri, Macmillan India Ltd., 2003.
4. Complex Variables and Applications – S. Ponnusamy, and H. Silverman, Birhkäuser, 2006.
5. Complex Variables and Applications- R Churchill R, Brown J.W: 6^{th} edition , New york, McGraw-Hill 1996.

MMS 104: ORDINARY DIFFERENTIAL EQUATIONS AND SPECIAL FUNCTIONS

UNIT-I

Review of linear differential equations with constant & variable coefficients, Power series solution of differential equation about an ordinary point, Solution about regular singular points: The method of Frobenius, System of linear differential equations, An operator method for linear system with constant coefficients, Phase plane method.

UNIT-II

Homogeneous Linear systems with constant coefficients, Complex eigenvalues, repeated eigenvalues, Fundamental Existence and Uniqueness theorem, existence and Uniqueness theorem for system and Higher order equations, Linear homogeneous boundary value problems: Eigenvalues and eigen functions.

UNIT-III

Bessel equation and Bessel functions, Recurrence relations and orthogonal properties., Series expansion of Bessel Coefficients, Integral expression, Integral involving Bessel functions, Modified Bessel function, Ber and Bei functions, Asymptotic expansion of Bessel Functions , Legendre's differential equations, Legendre Polynomials , Rodrigue's formula, Recurrence relations and orthogonal properties.

UNIT-IV

The Hermite polynomials, Chebyshev's polynomial, Laugrre's polynomial: Recurrence relations, generating functions and orthogonal properties

Suggested Readings/ Books:

1. S L Ross, Differential Equations, Third Edition, John Wiley & Sons (2004)
2. W E Boyce, R C Diprima, elementary Differential Equations and Boundary Value problems, 4th Edition, John Wiely and Sons (1986)
3. I N Sneddon, Special Functions of Mathematical Physics and Chemistry, Edinburg, Oliver & Boyd (1956)
4. G Andrews, R Askey & R Roy, Special Functions, Cambridge (1999)
5. L Andrews, Special Functions for Engineers and Applied Scientists, Mcmillan (1985)
6. W W Bell, Special Functions for Scientists and Engineers, Dover, (1986)

MMS 105: FUNDAMENTALS OF COMPUTER AND C PROGRAMMING

Suggested Reading/s Books:

1. Computer Programming in C – V. Rajaraman, Prentice-Hall of India Pvt. Ltd., 2005.
2. Computer Applications of Mathematics and Statistics – A. K. Chattapadhyay and T. Chattapadhyay, Asian Books Pvt. Ltd., New Delhi, 2005.
3. The C Programming Language – B. W. Kernighan and D. M. Ritchie, Prentice Hall, India, 1995.
4. Primes and Programming – An Introduction to Number Theory with Programming – P. Goblin, Cambridge University Press, 1993.

MMS 106: FUNDAMENTALS OF COMPUTER AND C PROGRAMMING Lab

The following programs are to be practiced:

1. Determination of roots of quadratic equations, $Ax^2+Bx+C=0$,
2. Arranging given set of numbers in increasing/decreasing order, calculation of

1. Mean, Mode, Median.
2. Evaluation of sum of power series eg. e^x, sin x, cos x, log (1 + x).
3. Calculation of GCD/LCM of two integers.
4. Evaluation of factorial of a positive integer and evaluation of binomial coefficients.
5. Generation of twin primes, random numbers.
6. Calculation of Coefficient of Correlation.
7. Computation of scalar product of vectors.
8. Addition and multiplication of matrices.
9. Evaluation of Determinants.
10. Inversion of matrices.
11. Solution of System of linear equations.
12. Writing a given number in words using function.
13. Arranging a set of names in alphabetical order.

Suggested Readings/ Books:

1. Computer Programming in C – V. Rajaraman, Prentice-Hall of India Pvt. Ltd., 2005.
2. Computer Applications of Mathematics and Statistics – A. K. Chattapadhyay and T. Chattapadhyay, Asian Books Pvt. Ltd., New Delhi, 2005.
3. The C Programming Language – B. W. Kernighan and D. M. Ritchie, Prentice Hall, India, 1995.
4. Primes and Programming – An Introduction to Number Theory with Programming – P. Goblin, Cambridge University Press, 1993.

Candidates are required to perform at least 10-12 practicals

MMS-201: ALGEBRA-II

Unit-I

Modules, sub modules, free modules, Quotient modules, Isomorhism theorem, Direct sums, Modules associated with a linear operator, Cyclic modules, Noetherian and Artinian modules and rings.

Unit-II

Field extension: Finite, Algebraic and Transcendental extensions, Simple, Separable and inseparable Extensions, Algebraically Closed fields, Splitting fields, Existence & uniqueness, Normal Extensions, Finite Fields.

Unit-III

Galois extensions , Galois group of an extension and Fundamental theorem of Galois Theory

Unit-IV

Review of vector spaces, Dual space , Dual basis, Reflexivity ,Annihilators, inner product spaces, orthogonal and orthonormal basis ,Gram schmidth orthogonalisation process.

Suggested Readings / Books:

1. Bhattacharya, P.B., Jain, S.K. & Nagpal, S.R.: Basic Abstract Algebra, Cambridge University Press, 1997.
2. Surjeet Singh, Quzai Zameeruddin: Modern Algebra, Vikas Publishing House , New Delhi,8th edition,2006.
3. I.N. Herstein: Topics in Algebra, 2nd edition, Wiley Eastern, 1975.

MMS 202: REAL ANALYSIS-II

UNIT-I

Preliminaries, Lebesgue outer measure. Measurable sets. Regularity, Lebesgue measure, non-measurable sets. Measurable functions. Borel and Lebesgue measurability, Littlewood's three principles.

UNIT-II

The Lebesgue integral of a simple function and bounded function, comparison of Riemann and Lebesgue integral, Bounded convergence theorem, Integral of non -negative functions, Fatou's Lemma, Monotone convergence theorem, The general Lebesgue Integral, Lebesgue convergence theorem, Integration of series.

UNIT-III

Vitali,s Lemma, The Four derivates, continuous non differentiable functions. Functions of bounded variation. Lebesgue differentiation theorem. Differentiation and integration. The Lebesgue set

UNIT-IV

Convex functions, Jensen's inequality,The L^p-spaces, Holder and Minkowski inequalities. Convergence in mean, Completeness of L^p, Approximation in L^p spaces.

Suggested Readings/ Books

1. H.L. Royden, *Real Analysis*, Macmillan, New York, 1988.
2. G.de Bara, Measure Theory and Integration, Ellis Horwood Limited, England, 2nd Edition 2003.
3. G.B. Folland, *Real Analysis*, second edition, John Wiley, New York, 1999.
4. E. Kreyszig Introductory Functional Analysis with Applications, John Wiley, 1989.

MMS 203: MECHANICS

Unit-I

Generalized coordinates, Holonomic and non-holonomic systems scleronomic and rhenomic systems, Generalized potential, lagrange's equation of first kind and second kind uniqueness of solution, Energy equation for conservative field.

Unit-II

Hamilton variables, donkin's theorem ,Hamilton canonical equation, cyclic coordinates, Routh's equation , Poisson bracket , Poisson's identity , Jacobi -Poisson theorem, Hamilton's principle, principle of least action Poincare- Cartan integral invariant, whittaker's equations lee hwachung's theorem.

Unit-III

Small oscillations of conservative system Lagrange's equation for small oscillations, Nature of roots of frequency equation, Principle oscillations. Normal coordinates, Canonical transformations, free canonical transformations, Hamilton- Jacobi equation, and Jacobi theorem.

Unit-IV

Method of separation of variables, lagrange's bracket' condition of Canonical character of transformation in terms of Lagrange's bracket and Poisson's Bracket. Invariance of Lagrange's bracket and Poisson's bracket and canonical transformation, Lagrange's theorem on the stability of equilibrium position, Lyapunov theorem, Nadchetayev theorem, asymptotic stability of an equilibrium position.

Suggested Readings/ Books:

1. F. Gantmacher. Lectures in analytic mechanics . Mir Publisher , Moscow, 1975.
2. H. goldstien, c.ppoole and j.l. sofco, classical mechanics , third edition, Addison Wesely, 2002.
3. Mechanics – L. D. Landau and E. M. Lipshitz, Pergamon Press, Oxford, 1976.
4. Lectures on Mechanics – J. E. Marsden, Cambridge University Press, 1992.

MTS 204: TENSORS AND DIFFERENTIAL GEOMETRY

UNIT-I

Systems of Different orders - Summation Convention - Kronecker Symbols - Transformation of coordinates in Sn - Invariants - Covariant and Contravariant vectors - Tensors of Second Order - Mixed Tensors - Zero Tensor - Tensor Field - Algebra of Tensors - Equality of Tensors - Symmetric and Skew – symmetric tensors - Outer multiplication, Contraction and Inner Multiplication - Quotient Law of Tensors - Reciprocal Tensor of Tensor - Relative Tensor - Cross Product of Vectors.

UNIT-II

Riemannian Space - Christoffel Symbols and their properties ,Covariant Differentiation of Tensors - Riemann - Christoffel Curvature Tensor - Intrinsic Differentiation.

UNIT-III

Definition of a surface - curves on a surface - Surface of revolution - Helicoids - Metric - Direction coefficients - families of curves - Isometric correspondence - Intrinsic properties.

UNIT-IV

Geodesics - Canonical geodesic equations - Normal property of geodesics - Existence Theorems - Geodesic parallels - Geodesics curvature - Gauss - Bonnet Theorem - Gaussian curvature - surface of constant curvature.

Suggested Readings/ Books:

1. Struik, D.T. Lectures on Classical Differential Geometry, Addison - Wesley, Mass. 1950.
2. Kobayashi. S. and Nomizu. K. Foundations of Differential Geometry, Interscience Publishers, 1963.
3. Wilhelm Klingenberg: A course in Differential Geometry, Graduate Texts in Mathematics, Springer-Verlag 1978.
4. J.L.Synge and A.Schild, Tensor Calculus, Toronto, 1949.
5. A.S.Eddington. The Mathematical Theory of Relativity, Cambridge University Press, 1930.

MTS 205: NUMERICAL ANALYSIS

Unit-I

Numerical Computation and Error Analysis: Numbers and their accuracy, Floating point arithmetic, Errors in numbers, error estimation, general error formulae, error propagation in computation. Algebraic and Transcendental Equations: Bisection method, iteration method, Regula- Falsi method, secant method, Newton- Raphson method. Convergence of these methods. Lin-Bairstow's method, Muller method , Graeffe's root squaring method , solution of system of nonlinear equations, complex roots by Newton – Raphson method.

Unit-II

System of Linear Algebraic Equations: Guass elimination method, Gauss – Jordon method , LU factorization method , Jacobi and Gauss-Seidal methods, Convergence of iteration methods, Round-off errors and refinement, ill- conditioning, Partitioning method, Inverse of Matrices. Eigen values and eigen vector: Rayleigh Power method , Given's method and House –Holder method.

Unit-III

Interpolation: Finite differences, Newton interpolation formulae, Gauss, Stirling and Bessel'sformulae, Lagrange's, Hermits and Newton's divided difference formulae. Numerical differentiation and integration: differentiation at tabulated and non-tabulated points, maximum and minimum values of tabulated function, Newton-Cotes formulae-Trapezoidal, Simpson's, Booles and Weddle rules of integration , Romberg integration , Gaussian integration, Double integration by Trapezoidal and Simpson rules.

Unit-IV

Ordinary Differential Equations: Taylor series and Picard's methods, Euler and modified Euler methods, Runge –Kutta methods, Predictor- Corrector methods: Adam-Beshforth and Miline methods. Error analysis and accuracy of these methods. Solution of simultaneous and higher order equations, Boundary values problems: Finite difference and shooting methods

Suggested Readings/ Books:

1. V. Rajaraman, Computer Oriented Numerical Analysis, Prentice-Hall of India Pvt. Ltd., 2002.
2. J.N. Sharma, Numerical Methods for Engineers and Scientists(2^{nd} edition), Narosa Publ. House New Delhi/Alpha Science international, Ltd, Oxford UK 2007.
3. E. Balagurusamy, Numerical Methods, Tata McGraw Hill, New Delhi, 1999.

4. B. Bradie: A friendly introduction to Numerical Analysis.Pearson Prentice Hall 2006
5. K. E. Atkinson, Introduction to Numerical Analysis (2nd edition), John Wiley,1989.
6. S. D. Conte and C. De Boor, Elementary Numerical Analysis: An Algorithmic Approach (3rd edition), McGraw Hill, New York, 1980.
7. J. B. Scarborough,Numerical Mathematical Analysis, Oxford & IBH Publishing Co., 2001.

MTS 206: NUMERICAL ANALYSIS Lab

The following programs of following methods are to be practiced:

1. To find a real root of an algebraic/ transcendental equation by using Bisection method.
2. To find a real root of an algebraic/ transcendental equation by using Regula-Falsi method.
3. To find a real root of an algebraic/ transcendental equation by using Newton-Raphson method.
4. To find a real root of an algebraic/ transcendental equation by using Iteration method.
5. Implementation of Gauss- Elimination method to solve a system of linear algebraic equations.
6. Implementation of Jacobi's method to solve a system of linear algebraic equations.
7. Implementation of Gauss-Seidel method to solve a system of linear algebraic equations.
8. To find differential coefficients of 1st and 2nd orders using interpolation formulae.
9. To evaluate definite integrals by using Newton - Cotes integral formulae.
10. To evaluate definite integrals by using Gaussian Quadrature.
11. To evaluate double integrals by using Trapezoidal and Simpson method.
12. To compute the solution of ordinary differential equations with Taylor's series method.
13. To compute the solution of ordinary differential equations by using Euler's method.
14. To compute the solution of ordinary differential equations by using Runge -Kutta methods.
15. To compute the solution of ordinary differential equations by using Milne-Simpson method.

Suggested Readings/ Books:

1. E. Balagurusamy, Object Oriented Programming with C++, Tata McGraw Hill, New Delhi, 1999.
2. J N Sharma, Numerical Methods for engineers and Scientists (2nd Edn) Narosa Publishing House, New
3. Delhi/ Alpha Science International Ltd. Oxford UK, 2007.
4. Conte and de Boor, Numerical Analysis, McGraw Hill, New York, 1990
5. John H. Mathews, Numerical Methods for Mathematics, Science and Engineering (2nd Edn.), Prentice
6. Hall, New Delhi, 2000

Instructions for paper setters and candidates:

Candidates are required to atleast perform at least 10-12 Practical's are to be completed in a semester