

**SARDAR BEANT SINGH STATE UNIVERSITY,
GURDASPUR**

DEPARTMENT OF APPLIED MATHEMATICS

M.Sc. Mathematics

Scheme & Syllabus for M.Sc.-Mathematics

Semester 1

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	External	Internal	Total	
MSMT-21101	Real Analysis-I	4	1	0	100	50	150	5
MSMT-21102	Algebra-I	4	1	0	100	50	150	5
MSMT-21103	Complex Analysis	4	1	0	100	50	150	5
MSMT-21104	Ordinary Differential Equations and Special Functions	4	1	0	100	50	150	5
MSMT-21105	Mathematical Methods	4	1	0	100	50	150	5
MSMT-21106	Computer Programming with C	2	0	4	100	50	150	4
Total		22	5	4	600	300	900	29

Semester 2

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	External	Internal	Total	
MSMT-21201	Real Analysis-II	4	1	0	100	50	150	5
MSMT-21202	Algebra-II	4	1	0	100	50	150	5
MSMT-21203	Linear Algebra	4	1	0	100	50	150	5
MSMT-21204	Partial Differential Equations	4	1	0	100	50	150	5
MSMT-21205	Numerical Analysis	4	1	0	100	50	150	5
MSMT-21206	Computational Numerical Analysis Lab	0	0	4	100	50	150	2
Total		20	0	4	600	300	900	27

Scheme & Syllabus for M.Sc.-Mathematics

Semester 3

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	External	Internal	Total	
MSMT-21301	Topology	4	1	0	100	50	150	5
MSMT-21302	Functional Analysis-I	4	1	0	100	50	150	5
Elective/Optional Courses (choose any three courses)								
MSMT-21303	Probability and Mathematical Statistics-I	4	1	0	100	50	150	5
MSMT-21304	Discrete Mathematics-I	4	1	0	100	50	150	5
MSMT-21305	Operations Research-I	4	1	0	100	50	150	5
MSMT-21306	Mechanics-I	4	1	0	100	50	150	5
MSMT-21307	Differential Geometry	4	1	0	100	50	150	5
MSMT-21308	Classical Mechanics and Calculus of Variations	4	1	0	100	50	150	5
Total		20	0	0	600	300	900	25

Semester 4

Course Code	Course Title	Load Allocation			Marks Distribution			Credits
		L	T	P	External	Internal	Total	
MSMT-21401	Number Theory	4	1	0	100	50	150	5
MSMT-21402	Functional Analysis-II	4	1	0	100	50	150	5
Elective/Optional Courses (choose any three courses)								
MSMT-21403	Probability and Mathematical Statistics-II	4	1	0	100	50	150	5
MSMT-21404	Discrete Mathematics-II	4	1	0	100	50	150	5
MSMT-21405	Operations Research-II	4	1	0	100	50	150	5
MSMT-21406	Mechanics-II	4	1	0	100	50	150	5
MSMT-21407	Fractional Calculus	4	1	0	100	50	150	5
MSMT-21408	Fourier Analysis	4	1	0	100	50	150	5
MSMT-21409	Measure Theory	4	1	0	100	50	150	5
Total		20	0	0	600	300	900	25

MSMT-21101 Real Analysis-I

Internal Marks: 50

L T P

External Marks: 100

4 1 0

Total Marks: 150

1. Finite, Countable and Uncountable sets, Metric spaces, Compact sets, Perfect sets, Connected sets, Convergent sequences, Sub sequences, Cauchy sequences, Power series, Absolute convergence, Algebra of series, Rearrangements of elements in a series. **(10)**
2. Limits of functions, Continuous functions, Compactness, Connectedness, Monotonic functions, Infinite limits and Limits at infinity. **(10)**
3. The Riemann-Stieltjes integral: Definition and existence of the Riemann-Stieltjes integral, Properties of the integral, Integration and differentiation, Integration of vector-valued functions, Rectifiable curves. **(10)**
4. Sequences and series of functions: Interchanging order of limits for sequences of functions, Uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation, Equicontinuous families of functions, Stone Weierstrass Theorem. **(15)**

Suggested Books:

1. Walter Rudin :Principles of Mathematical Analysis (3rd Edition) McGraw-Hill Ltd.
2. Simmons : Introduction to Topology and Modern Analysis, McGraw- Hill Ltd.
3. Shanti Narayan & P.K. Mittal : A Course of Mathematical Analysis.
4. S.C. Malik & Savita Arora : Mathematical Analysis, Wiley Eastern Ltd

MSMT-21102 Algebra-I

Internal Marks: 50

L T P

External Marks: 100

4 1 0

Total Marks: 150

1. Groups, Subgroups, Equivalence relations and partitions, generators and relations, Homomorphisms, Cosets, Normal subgroups, Simple groups, Quotient groups, Group actions, Lagrange's theorem, Conjugate elements, the Class equation, Isomorphism theorems, Cyclic Groups, Cauchy's theorem. (15)

2. Composition series, the Jordan Holder theorem, Groups of automorphisms, Inner automorphisms, Symmetric groups, Alternating groups, Sylow's theorems, p-groups. (10)

3. Nilpotent groups, Simplicity of A_n $n \geq 5$, Cayley's theorem, the imbedding theorem, Commutator subgroup, Characteristic subgroup, Solvable groups, Sequences of subgroups. (10)

4. Direct product and semi direct product of groups, Fundamental theorem of finitely generated Abelian groups, Free groups, groups of symmetries, Groups of small order. (10)

Suggested Books:

1. M. Artin : Algebra, Prentice-Hall
2. D.S. Dummit : Abstract Algebra, John-Wiley & Sons, Students Edition- 1999 & Foote
3. Surjit Singh, and Qazi Zameerudin : Modern Algebra.
4. J. Gallian : Contemporary Abstract Algebra

MSMT-21103 Complex Analysis

External Marks: 100
Internal marks: 50
Total Marks: 150

L T P
4 1 0

1. Functions of complex variables, limit, continuity and differentiability, Analytic functions, Conjugate function, Harmonic function, Cauchy Riemann equations (Cartesian and Polar form), Construction of analytic functions. **(10)**
2. Complex line integral, Cauchy's theorem, Cauchy's integral formula and its generalized form. Cauchy's inequality. Poisson's integral formula, Morera's theorem, Liouville's theorem, Power Series and its circle of convergence. **(15)**
3. Taylor's theorem, Laurent's theorem. Zeros and Singularities of an analytic function, Residue at a pole and at infinity, Cauchy's Residue theorem, Integration round unit circle, Evaluation of integrals of the type $\int_{-\infty}^{\infty}$. **(10)**
4. Jordan's lemma, Fundamental theorem of algebra, Argument principle, Rouché's theorem, Conformal transformations, Bilinear transformations, critical points, fixed points, cross ratio, Problems on cross ratio and bilinear transformation. **(10)**

Suggested Books:

1. Copson, E.T.: Theory of functions of complex variables.
2. Ahlfors, D. V.: Complex analysis.
3. Titchmarsh, E.C. :Theory of functions of a complex variable.
4. Conway, J.B. :Functions of one complex variable
5. Kumar, R.R. : Complex Analysis, Pearson Education.

MSMT-21104 Ordinary Differential Equations and Special Functions

External Marks: 100

L T P

Internal marks: 50

4 1 0

Total Marks: 150

1. Review of linear differential equations with constant & variable coefficients, Fundamental existence and uniqueness theorem for system and higher order equations (Picard's and Piano theorems), System of linear differential equations, an operator method for linear system with constant coefficients, Phase plane method. **(10)**

2. Homogeneous linear system with constant coefficients, Eigenvalues and eigen functions, orthogonality of eigen functions, Complex eigenvalues, repeated eigenvalues, Ordinary differential equations of the Sturm-Liouville problems, Expansion theorem, Extrema properties of the eigen values of linear differential operators, Formulation of the eigen value problem of a differential operator as a problem of integral equation, Linear homogeneous boundary value problems. **(10)**

3. Power series solution of differential equations: about an ordinary point, solution about regular singular points, the method of Frobenius, Bessel equation and Bessel functions, Recurrence relations and orthogonal properties., Series expansion of Bessel Coefficients, 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. **(15)**

4. The Hermite polynomials, Chebyshev's polynomial, Lagrange's polynomial: Recurrence relations, generating functions and orthogonal properties. **(10)**

Suggested Books:

1. Ross, S.L., Differential Equations, 3rd Edition. John Wiley & Sons, 2004.
2. Boyce, W.E. and Diprima, R.C., Elementary Differential Equations and Boundary Value problems, 4th Edition. John Wiley and Sons, 1986.
3. Sneddon, I.N., Special Functions of Mathematical Physics and Chemistry. Edinburg: Oliver & Boyd, 1956.
4. Bell, W.W., Special Functions for Scientists and Engineers. Dover, 1986.

MSMT-21105 Mathematical Methods

External Marks: 100

L T P

Internal marks: 50

4 1 0

Total Marks: 150

1. Laplace Transforms: Laplace Transform, Properties of Laplace Transform, Inverse Laplace Transform, Convolution theorem, Laplace transform of periodic functions, unit step function and impulsive function, Application of Laplace Transform in solving ordinary and partial differential equations and Simultaneous linear equations **(10)**

2. Fourier Transforms: Fourier transform, properties of Fourier transform, inversion formula, convolution, Parseval's equality, Fourier transform of generalized functions, application of Fourier transforms in solving heat, wave and Laplace equation. Fast Fourier transform. **(10)**

3. Integral Equations: Relations between differential and integral equations, Green's function, Linear equations in cause and effect, Integral equations of Fredholm and Volterra type, solution by successive substitution and successive approximation, integral equations with degenerate kernels. **(10)**

4. Integral equations of convolution type and their solutions by Laplace transform, Fredholm's theorems, integral equations with symmetric kernel, Solutions with separable kernels, Characteristic numbers, Resolvent kernel, Eigen values and Eigen functions of integral equations and their simple properties. **(15)**

Suggested Books:

1. Sneddon, I.N., The Use of Integral Transforms. McGraw Hill.
2. Goldberg, R.R., Fourier Transforms. Cambridge University Press.
3. Smith, M.G., Laplace Transform Theory. Van Nostrand Inc..
4. Elsegolc, L., Calculus of Variation. Dover Publications.
5. Kenwal, R.P., Linear Integral Equation; Theory and Techniques. Academic Press.
6. Hildebrand, F.B., Methods of Applied Mathematics (Latest Reprint). Dover Publications.
7. Pal, S. and Bhunia, S.C., Engineering Mathematics. Oxford University Press.

MSMT-21106 Computer Programming With C

External Marks: 100

L T P

Internal marks: 50

0 0 4

Total Marks: 150

1. Basic Structure of C-Program, constants, variables, Data types, Assignments, console I/O statements, Arithmetical, Relational and logical operators, Control statements: if, switch.
2. While, do while, for, continue, goto and break. Function definition and declaration, Arguments, return values and their types, Recursion. One and two-dimensional arrays, Initialization, Accessing array elements, Functions with arrays.
3. Address and pointer variables, declaration and initialization, pointers and arrays, pointers and functions.
4. Structure initialization, structure processing, nested structure, Array of structures, structure and functions. Union, defining and opening a file, closing a file, Input/Output operations on files.

Laboratory Assignments (do any Six from the list below)

1. Find average of N numbers.
2. Calculate the real roots of quadratic equation.
3. To check the given number is even and odd.
4. Input / Output using nested loops.
5. Input / Output with array using loop structures.
6. Find the average of any N numbers using linear array.
7. Find sum of two numbers using argument with return.
8. Find solution of linear equation using return.

Instructions for students :

Students are required to give written exam during practical examination.

Suggested Books:

1. Norton Peter: Introduction to Computers, Tata McGraw Hill .
2. Kerningham B.W. and Ritchie D.M.: The C programming language, PHI
3. Rajaraman V.: Fundamentals of Computers, PHI.
4. R. Singh and I. Singh,: Expert C++ programming, Khanna Book Publisher.
5. Byron S. Gottfried: Programming with C (Schaum's outline series).
6. Yashavant Kanetkar: Let us C.
7. E Balagurusamy: Programming in ANSI C.

MSMT-21201 Real Analysis-II

External Marks: 100

L T P

Internal marks: 50

4 1 0

Total Marks: 150

1. Differentiation of Real functions, Mean value theorems, Taylor's theorem, Differentiation of vectorvalued functions, Functions of several variables: Linear transformations, Differentiation, Contraction principle, The Inverse function theorem, The implicit function theorem.

(10)

2. Lebesgue Measure: Introduction, Lebesgue outer measure, Measurable sets and Lebesgue measure, non-measurable set, Measurable functions, Borel and Lebesgue measurability, Littlewood's three principles.

(10)

3. Lebesgue Integral: The Riemann integral, The Lebesgue integral of a bounded function over a set of finite measure, the integral of a nonnegative function, The general Lebesgue integral, Convergence in measure.

(10)

4. Differentiation and Integration: Differentiation of monotone functions, The Four derivatives, Functions of bounded variation, differentiation of an integral, Lebesgue Differentiation Theorem. Absolute continuity. Convex Functions.

(15)

Suggested Books:

1. Royden, H.L. and Fitzpatrick, P.M.: Real Analysis, 4th Edition. New Delhi: Pearson
2. Barra, G. de.: Measure Theory and Integration, New Delhi: Woodhead Publishing
3. Rudin, W.: Principles of Mathematical Analysis, 3rd Edition. New Delhi: McGraw-Hill Inc.
4. Carothers, N. L.: Real Analysis, Cambridge University Press, 2000.
Apostol, T.M.: Mathematical Analysis –A modern approach to Advanced Calculus. New Delhi: Narosa Publishing House.

MSMT-21202 Algebra-II

External Marks: 100

Internal marks: 50

Total Marks: 150

L T P

4 1 0

1. Rings, Subrings, Ideal, Factor Rings, Homomorphisms, Integral domains, Maximal and Prime Ideals, The field of quotients of an integral domain, Chinese Remainder Theorem, Simple Rings, Ideals of Matrix rings. **(10)**

2. Principal Ideal domains, Euclidean rings, The ring of Gaussian Integers, Unique factorization domains, Gauss Lemma, Polynomial rings, Division algorithm, factorization in polynomial rings over unique factorization domains. **(10)**

3. Modules, submodules, free modules, quotient modules, Homomorphism theorems, direct sums, finitely generated modules, Simple modules, cyclic modules, differences between modules over rings and vector spaces. **(13)**

4. Modules over PID's, structure theorem of modules over PID's, Torsion modules, Torsion free modules, Artinian and Noetherian Modules, Artinian And Noetherian rings, modules of finite length. **(12)**

Suggested Books:

1. Fraleigh, J.B. : A First Course in Abstract Algebra 7th edition, Narosa Publishing House, New Delhi.
 2. Singh, S. and Zameeruddin, Q.: Modern Algebra, Vikas Publishing House, New Delhi.
 3. Dummit, D.S. and Foote, R.M.: Abstract Algebra, John-Wiley & Sons, Student Edition.
 4. Bhattacharya, P.B., Jain, S.K., Nagpal, S.R.: Basic Abstract Algebra, Cambridge University Press.
- Musili, C.: Rings and Modules, Narosa Publishing House, New Delhi

MSMT-21203 Linear Algebra

External Marks: 100

Internal marks: 50

Total Marks: 150

L T P

4 1 0

1. Vector spaces, Subspaces, Quotient Spaces, Basis and Dimension Theorems, Sum of subspaces, Direct sum decompositions, Linear transformations, The Algebra of linear transformations. (10)

2. Matrices associated with linear transformations, effect of change of ordered bases on the matrix of linear transformations, Elementary matrix operations and Elementary matrices, Row rank, Column rank and their equality, system of linear equations (10)

3. Eigen values and Eigen vectors of linear operators, Characteristic and minimal polynomials, companion matrix, subspaces invariant under linear operators, triangulation, Diagonalization, Linear Functionals, Dual Spaces and dual basis, the double dual. (13)

4. Inner Product Spaces, The Gram-Schmidt Orthogonalization, Orthogonal Complements, The Adjoint of a linear operator on an inner product space, Normal and Self-Adjoint Operators, Unitary and Normal Operators, Spectral Theorem (12)

Suggested Books:

1. Hoffman, K. and Kunze, R. : Linear Algebra, Second Edition, Prentice Hall.
2. Axler, S.: Linear Algebra Done Right, Second Edition, Springer-Verlag.
3. Friedberg, S.H., Insel, A.J and Spence, L.E. : Linear Algebra, Fourth Edition, Prentice Hall.
4. Lang, S.: Linear Algebra, Third Edition, Springer-Verlag.
Sahai, Vivek and Bist, Vikas: Linear Algebra, Narosa Publishing House.

MSMT-21204 Partial Differential Equations

External Marks: 100
Internal marks: 50
Total Marks: 150

L T P
4 1 0

1. First Order PDE: Partial differential equations; its order and degree; origin of first-order PDE; determination of integral surfaces of linear first order partial differential equations passing through a given curve; surfaces orthogonal to given system of surfaces; non-linear PDE of first order, Cauchy's method of characteristic; compatible system of first order PDE; Charpit's method of solution, solutions satisfying given conditions, Jacobi's method of solution. **(15)**
2. Second and Higher Order PDE: Origin of second order PDE; linear second and higher order PDE with constant and variable coefficients; characteristic curves of the second order PDE; Monge's method of solution of non-linear PDE of second order. **(10)**
3. Separation of Variable Method: Separation of variables for PDE; wave, diffusion and Laplace equations and their solutions by Separation of variables method; Elementary solutions of Laplace equations. **(10)**
4. Applications of PDE: Vibrations governed by one and two-dimensional wave equations; vibrations of string and membranes; three dimensional problems; diffusion equation; resolution of boundary value problems for diffusion equations and elementary solutions of diffusion equations. **(10)**

Suggested Books:

1. Sneddon, I.N., Elements of Partial Differential Equation, 3rd Edition. McGraw Hill Book Company.
2. Copson, E.T., Partial Differential Equations, 2nd Edition. Cambridge University Press.
3. Strauss, W.A., Partial Differential Equations: An Introduction, 2 nd Edition.
Sharma, J.N. and Singh, K., Partial differential equations for engineers and scientists, 2 nd Edition. New Delhi: Narosa Publication House.

MSMT-21205 Numerical Analysis

External Marks: 100

Internal marks: 50

Total Marks: 150

L T P

4 1 0

1. Numerical computation and Error analysis: Numbers and their accuracy, Floating point arithmetic, Errors in numbers, Error estimation, General error formulae, Error propagation in computation. Inverse problem of error analysis and Numerical instability. Algebraic and transcendental equations: Bisection method, Iteration method, Regula-Falsi method, Secant method, Newton-Raphson's method. Convergence of these methods. Lin-Bairstow's method, Muller's method, Graeffe's root squaring method, Solution of system of nonlinear equations, Complex roots by Newton-Raphson's method. **(15)**

2. System of linear algebraic equations: Gauss elimination method without pivoting and with pivoting, Gauss-Jordan 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 vectors: Rayleigh Power method, Given's method and Householder's method. **(10)**

3. Interpolation: Finite differences, Newton's interpolation formulae, Gauss, Stirling's and Bessel's formulae, Lagrange's, Hermite's 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, Boole's and Weddle' rules of integration with errors, Romberg integration, Gaussian integration, Double integration by Trapezoidal and Simpson's rules. **(10)**

4. Ordinary differential equations: Taylor series and Picard's methods, Euler's and modified Euler methods, Runge-Kutta methods, Predictor-Corrector methods: Adams-Bashforth's and Milne's methods. Error analysis and accuracy of these methods. Solution of simultaneous and higher order equations, Boundary value problems: Finite difference and Shooting methods. **(10)**

Suggested Books:

1. Sharma, J.N.: Numerical Methods for Engineers and Scientists, 2nd Edition. Narosa Publ. House New Delhi/Alpha Science International Ltd., Oxford UK.
2. Jain, M.K., Iyengar, S.R.K. and Jain, R.K.: Numerical Methods for Scientific and Engineering Computation, 5th Edition. New Age International Publ. New Delhi
3. Bradie, B.: A Friendly Introduction to Numerical Analysis. Pearson Prentice Hall.
4. Atkinson, K.E.: Introduction to Numerical Analysis, 2nd Edition. John Wiley.
5. Scarborough, J.B.: Numerical Mathematical Analysis. Oxford & IBH Publishing Co.

MSMT-21206 Computational Numerical Analysis Lab

External Marks: 100

L T P

Internal marks: 50

0 0 4

Total Marks: 150

Laboratory Assignments (do any eight programs from the list below)

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.
16. To compute the solution of Boundary value problems of Ordinary Differential Equations by using Finite Difference method.
17. To compute the solution of Boundary value problems of Ordinary Differential Equations by using Shooting method.

Suggested Books:

1. R. Singh and I. Singh,,: Expert C++ programming, Khanna Book Publisher.
2. Byron S. Gottfried: Programming with C (Schaum's outline series).
3. Balagurusamy, E., Object Oriented Programming with C++. New Delhi: Tata McGraw Hill, 1999. R.S. Salaria: Application Programming in C
4. Conte, S.D. and Boor, C.D., Numerical Analysis. New York: McGraw Hill.

MSMT-21301 Topology

Internal Marks: 50	L T P
External Marks: 100	4 1 0
Total Marks: 150	

1. Topological spaces, Continuous functions, Homeomorphisms, Countability axioms Product spaces, Quotient spaces, Topological groups. **(10)**
2. Connectedness, Intermediate value theorem and uniform limit theorem, Local connectedness. **(10)**
3. Compactness, Finite intersection property (F.I.P.), Cantor's intersection theorem, Uniform continuity, Bolzano-Weierstrass Property, Local compactness, Metrizable topological spaces, The Tychonoff Theorem. **(10)**
4. Separation axioms, Hausdorff spaces, Regular Spaces, Normal spaces, Urysohn's Lemma, Completely regular spaces, Urysohn's Metrization Theorem, The Tietze extension theorem, Completely normal spaces. **(10)**

Suggested Books:

1. J. R. Munkres : Topology, Prentice Hall of India, 2007 (Indian reprint)
2. J. L. Kelley : General Topology, 2008 (Indian reprint).
3. K. Janich, Topology, Springer-Verlag, 2004.

MSMT-21302 Functional Analysis-I

Internal Marks: 50	L T P
External Marks: 100	4 1 0
Total Marks: 150	

1. Normed linear spaces, Banach spaces, subspaces, quotient spaces. Continuous linear transformations. (10)
2. Equivalent norms. Finite dimensional normed linear spaces and compactness, Riesz Lemma, The conjugate space N^* . (10)
3. The Hahn-Banach theorem and its consequences. The natural imbedding of N into N^{**} , reflexivity of normed spaces.
Open mapping theorem, projections on a Banach space, closed graph theorem, uniform boundedness principle. (10)
- 4 Conjugate operators. L_p -spaces: Holder's and Minkowski's Inequalities, completeness of L_p -spaces. (10)

Suggested Books:

1. G.F. Simmons: Introduction to Topology and Modern Analysis, Ch. 9, Ch.10 (Sections 52-55), McGraw-Hill International Book Company, 1963.
2. Royden, H. L. Fitzpatrick, P.M.: Real Analysis, Ch 6 (Sections 6.1 -6.3), Macmillan Co. 1988.
3. Erwin Kreyszig: Introduction to Functional Analysis with Applications, John Wiley &
4. Balmohan V. Limaye: Functional Analysis, New Age International Limited.
5. P.K.Jain and O.P Ahuja : Functional Analysis, New Age International (P) Ltd, Publishers, 2010.
6. K. Chanrashekhra Rao: Functional Analysis, Narosa, 2002
7. D. Somasundram: A First Course in Functional Analysis, Narosa, 2006.

MSMT-21303 Probability and Mathematical Statistics-I

External Marks: 100

L T P

Internal marks: 50

4 1 0

Total Marks: 150

1. Nature of Data and methods of compilation: Measurement scales, Attribute and variable, Discrete and continuous variables. Collection, Compilation and Tabulation of data.. Representation of data: Histogram, Frequency Polygon, Frequency Curve, Ogives. **(10)**

2. Measures of central tendency: Mean, Median, Mode, Geometric Mean, Harmonic Mean and their properties.
Measuring variability of data: Range, Quartile deviation, Deciles and Percentiles. Standard deviation, Central and non-central moments, Sample and Population variance. Skewness and Kurtosis, Box and Whisker plot. **(10)**

3. Probability: Intuitive concept of Probability, Combinatorial problems, conditional probability and independence, Bayes' theorem and its applications.

Random Variables and Distributions: Discrete and Continuous random variables. Probability mass function and Probability density function. Cumulative distribution function. Expectation of single and two dimensional random variables. Properties of random variables. Moment generating function and probability generating functions. **(10)**

4. Distributions: Bernoulli distribution. Binomial distribution. Poisson distribution, Negative Binomial and Hypergeometric distributions. Uniform, Normal distribution. Normal approximation to Binomial and Poisson distributions. Beta, Gamma, Chi-square and Bivariate normal distributions. Sampling distribution of mean and variance (normal population).

Chebyshev's inequality, weak law of large numbers, Central limit theorems. **(10)**

Suggested Books:

- 1 Goon, A.M., Gupta, M.K., Dasgupta, B: Fundamentals of Statistics, Vol-I & Vol-II (7th Ed. 1998).
- 2 Sheldon Ross : A First Course in Probability, 6th edition, Pearson Education Asia (2002).
- 3 Meyer, P.L: Introductory Probability and Statistical Applications.
- 4 Hogg, R.V. and Craig, T.: Introduction to Mathematical Statistics (MacMillan 2002).

MSMT-21304 Discrete Mathematics-I

External Marks: 100
Internal marks: 50
Total Marks: 150

L T P
4 1 0

1. Mathematical Logic: Properties and logical operations, Truth function, Logical connections, logically equivalent statements, tautology and contradiction, algebra of proposition, arguments, duality law, Quantifiers, inference rules for quantified statements, predicates calculus, interference theory of predicate logic, valid formula involving quantifiers. **(10)**

2. Boolean Algebra: Boolean Algebra and its properties, Principle of duality in Boolean Algebra, Algebra of Classes, Isomorphism, Partial Order, Boolean switching circuits, Equivalence of two circuits, simplification of circuit, Boolean polynomial, Boolean expression & function, Fundamental forms of a Boolean function. Disjunctive normal form, Complement function of a Boolean function. **(10)**

3. Lattices: Partial ordered sets, Hasse diagrams, isomorphism, External elements of partially ordered set, lattices, lattices as algebraic system, sub-lattices, direct product and homomorphism. **(10)**

4. Graph Theory: Simple Graphs, Incidence and degree, regular graph, isolated vertex, pendent vertex, Null graph, Diagraph, isomorphism's, Eulerian graph, planner and dual graph, planner graph representations, Thickness and crossing numbers, adjancy matrix, incideme metrix, cycle matrix. **(10)**

Suggested Books:

1. Trambley, J.P. and Manohar,R: Discrete Mathematical Structures with Applications to Computer Science.
2. Liu C.L.: Elements of Discrete Mathematics.
3. Alan Doerr and Kenneth Levasseur: Applied Discrete Structures for Computer Science

MSMT-21305 Operations Research-I

External Marks: 100

Internal marks: 50

Total Marks: 150

L T P

4 1 0

1. Mathematical formulation of linear programming problem, properties of a solution to the linear programming problem, generating extreme point solution, simplex computational procedure, development of minimum feasible solution, the artificial basis techniques, a first feasible solution using slack variables. (10)
2. Two phase and Big-M method with artificial variables , General Primal-Dual pair, formulating a dual problem, primal-dual pair in matrix form, Duality theorems, complementary slackness theorem, duality and simplex method, economic interpretation of primal-dual problems. (10)
3. The General transportation problem, transportation table, duality in transportation problem, loops in transportation tables, linear programming formulation, solution of transportation problem, test for optimality, degeneracy, transportation algorithm (MODI method), time minimization transportation problem. (10)
4. Assignment Problems: Mathematical formulation of assignment problem, the assignment method, typical assignment problem, the traveling salesman problem. Game Theory: Two-person zero sum games, maximin-minimax principle, games without saddle points (Mixed strategies), graphical solution of $2 \times n$ and $m \times 2$ games, dominance property, arithmetic method of $n \times n$ games, general solution of $m \times n$ rectangular games. (15)

Suggested Books:

1. Gass, S. L.: Linear Programming
2. Hadley, G.: Mathematical Programming
3. Kambo, N. S.: Mathematical Programming
4. Swarup, Kanti Gupta, P.K. & Man Mohan: Operations Research
5. R.Panneerselvam: Operations Research
6. Taha, H.A.: Operations Research

MSMT-21306 Mechanics-I

External Marks: 100

L T P

Internal marks: 50

4 1 0

Total Marks: 150

1. Functional and its properties, Variation of a functional, Motivating problems: Brachistochrone, isoperimetric, Geodesics. Fundamental lemma of calculus of variation, Euler's equation for one dependent function of one and several variables. Generalization to n dependent functions and dependence on several derivatives. Invariance of Euler's equation, Moving end points problem, extremum under constraints. **(10)**

2. Constraints, Generalized coordinates, Generalized velocity, Generalized force, Generalized potential, D'Alembert principle, Lagrange's equation of first kind and second kind, uniqueness of solution, Energy equation for conservative field. Examples based on solving Lagrange's equation. **(10)**

3. Legendre transformation, Hamilton canonical equation, cyclic coordinates, Routhian procedure, Poisson bracket, Poisson's identity, Jacobi-Poisson theorem, Hamilton's principle, Principle of Least action, Small oscillations of conservative system, Lagrange's equation for small oscillations, Nature of roots of frequency equation, Principle oscillations. Normal coordinates. **(10)**

4. Canonical transformations, Hamilton-Jacobi equation. Method of Separation of variables, Lagrange's bracket, Hamilton's equations in Poisson bracket, Canonical character of transformation through Poisson bracket. Invariance of Lagrange's bracket and Poisson's bracket. Action-Angle Variables. **(10)**

Suggested Books:

- 1 Elsegolc, L.D., *Calculus of Variation*, Dover Publication, 2007.
- 2 Gantmacher, F., *Lectures in Analytic Mechanics*, Moscow: Mir Publisher, 1975.
- 3 Goldstien, H., Poole, C. and Safco, J.L., *Classical Mechanics, 3rd Edition*. Addison Wesley, 2002.
- 4 Landau, L.D. and Lipshitz, E.M., *Mechanics*, Oxford: Pergamon Press, 1976.
- 5 Marsden, J.E., *Lectures on Mechanics*, Cambridge University Press, 1992.
- 6 Biswas, S. N., *Classical Mechanics*, Books and Applied (P) Ltd., 1999.

MSMT-21307 Differential Geometry

External Marks: 100

L T P

Internal marks: 50

4 1 0

Total Marks: 150

1. **Curves in R^3 :** A simple arc, curves and their parametric representation, arc length, Contact of curves, tangent line, osculating plane, curvature, principal normal, binormal, Normal Plane, rectifying plane. **(10)**

2. Curvature and torsion, Serret-Frenet Formule, Helics, Evolute and Involute of a parametric curve, Osculating circle and osculating sphere, spherical curves. **(10)**

3. Einstein's Summation Convention, Transformation of coordinates, tensor's law for transformation, Contravariant, covariant and mixed Tensors, addition, outer product, contraction, inner product and quotient law of tensors, Metric Tensor and Riemannian metric, christoffel symbols, Covariants differentiation of tensors. **(10)**

4. **Surfaces in R^3 :** Implicit and Explicit forms for the equation of the surface, two fundamental forms of a surface, Family of surfaces, Edge of regression, Envelops, Ruled surface, Developable and skew surfaces, Gauss and Weingarten formulae. **(10)**

Suggested Books:

1. Pressley: Elementary Differential Geometry, Springer, 2005.
2. T.J. Willmore: Introduction to Differential Geometry
3. Martin M. Lipschutz: Differential Geometry
4. U.C. De; A.A. Shaikh & J. Sengupta: Tensor Calculus
5. M.R. Spiegel: Vector Analysis
6. D. Somasundaram: Differential Geometry – A First course, Narosa Publishing House

MSMT-21308 Classical Mechanics and Calculus of Variations

External Marks: 100

L T P

Internal marks: 50

4 1 0

Total Marks: 150

1. Generalized coordinates and generalized velocities, virtual work, generalized forces, Lagrange's equations for a holonomic dynamical system, conservative system, holonomic dynamical system for impulsive forces and their applications. **(10)**

2. Kinetic energy as a quadratic function of velocities, theory of small oscillations. Functional, variation of functional and its properties, fundamental lemma of calculus of variation, Euler's equations, necessary and sufficient conditions for extremum, The Brachistochrone problem, Functionals dependent on higher order derivatives and several dependent variables **(10)**

3. Variational problems with fixed boundaries, Transversality conditions, Orthogonality conditions. Sturm-Liouville's theorem on extremals, One sided variations, Hamilton's principle, The principle of least action, Lagrange's equations from Hamilton's principle. **(10)**

4. Variational Methods, The Ritz method, Kantorovich Method for Boundary value problems in ODE's & PDE's, Isoperimetric Problems. **(10)**

Suggested Books:

1. Chorlton, F.: Text Book of Dynamics.
2. Elsgolts, L: Differential Equations and the Calculus of Variations.
3. Gelfand, I.M. and Fomin, S.V.: Calculus of Variations.

MSMT-21401 Number Theory

External Marks: 100

Internal marks: 50

Total Marks: 150

L T P

4 1 0

1. The sum of non-negative divisors of an integer, Number of divisors of an integer, Multiplicative functions, The Mobius function, Mobius Inversion formula, The greatest integer function, Euler's Phi-function and its properties. **(10)**

2. The order of an integer modulo n , primitive roots for primes, Composite Numbers having primitive roots, theory of indices and its applications to solving congruences. **(10)**

3. Quadratic residues modulo a prime, Euler's criterion, The Legendre symbol and its properties, Gauss Lemma, Quadratic reciprocity law, Jacobi's symbol and its properties, Pythagorean triplets, Insolvability of the Diophantine Equations: $x^4 + y^4 = z^4$, $x^4 - y^4 = z^2$ in positive integers. **(10)**

4. Representation of an integer as a sum of two squares and sum of four squares, Finite and Infinite continued fractions, convergents of a continued fraction and their properties, Pell's equation. **(10)**

Suggested Books:

1. David M. Burton: Elementary Number Theory, Mc Graw Hill 2002.
2. Hardy G.H. and Wright E.M.: An Introduction to the Theory of Numbers.

MSMT-21402 Functional Analysis-II

External Marks: 100

L T P

Internal marks: 50

4 1 0

Total Marks: 150

1. Inner product spaces, Hilbert spaces, orthogonal complements, orthonormal sets. (10)
2. The conjugate space H^* , Strong and weak convergence in finite and infinite dimensional normed linear spaces, Weak convergences in Hilbert spaces, weakly compact set in Hilbert spaces. (10)
3. The adjoint of an operator, self adjoint operators, positive operators, normal operators, Unitary operators, Projections on a Hilbert space (10)
4. Spectral Theorem for normal operators, Compact linear operators on normed spaces, properties of compact linear operators. (10)

Suggested Books:

1. Simmons, G.F.: Introduction to Topology and Modern Analysis Ch. X (Sections 56-59), Ch.XI (Sections 61-62), Mc Graw- Hill (1963)International Book Company.
2. Erwin Kreyszig: Introduction to Functional Analysis with Applications, John Wiley & Sons (1978).
3. Limaye, Balmohan V.: Functional Analysis, New Age International Limited, 1996.
4. Jain, P.K. & Ahuja, O.P.: Functional Analysis, New Age International (P) Ltd. Publishers, 2010.
5. Chandrasekhra Rao, K.: Functional Analysis, Narosa, 2002.
6. Somasundram, D.: A First Course in Functional Analysis, Narosa, 2006.

MSMT-21403 Probability and Mathematical Statistics-II

External Marks: 100

L T P

Internal marks: 50

4 1 0

Total Marks: 150

1. Point and Interval Estimation: General concept of Point estimation, unbiasedness, consistency, efficiency and Sufficiency. Factorization theorem, completeness, Rao-Blackwell theorem, Cramer-Rao inequality. **(10)**

2 Maximum likelihood method of estimation and method of moments. Interval estimation, confidence intervals for means, difference of means and variances. **(10)**

3. Hypothesis Testing: The basic idea of significance test. Null and alternative hypothesis, Type-I and Type-II errors. Uniformly most powerful tests, Likelihood Ratio tests. t, Chi-square and F-distributions. Tests of significance based on t, Chi-square and F. One way and two way Analysis of Variance (ANOVA). **(10)**

4. Non-Parametric Tests: Sign test, Wilcoxon signed rank test, Mann-whitney test. **(10)**

Suggested Books:

- 1 Goon, A.M., Gupta, M.K., Dasgupta, B: Fundamentals of Statistics, Vol-I (7th Ed. 1998).
- 2 Dudewicz, E.J and Mishra, S.N: Modern Mathematical Statistics (1988).
- 3 Goon, A.M., Gupta, M.K., Dasgupta, B: Fundamentals of Statistics, Vol-II (7th Ed. 1998).
- 4 Deniel, W.W: Applied Nonparametric Statistics (1999).
- 5 Rohtagi, V.K and Saleh A.K.M.E.: An Introduction to Probability Theory Mathematical Statistics (2000).

MSMT-21404 Discrete Mathematics-II

External Marks: 100

L T P

Internal marks: 50

4 1 0

Total Marks: 150

1. Graph Theory: Tree, rooted tree, binary tree, spanning trees, minimal spanning tree, kruskal's algorithm, Chromatic number, four-column problem (statement only) (10)
2. Directed Graphs: Directed paths, directed cycles, acyclic graph, network flow, Max flow, min-cut theorem, K-flow. (10)
3. Recurrence relation & Generating functions: Order & Degree of recurrence relation, telescopic form, recursion theorem, solution of linear recurrence relation, Homogenous solution, closed form expression, Generating function, solution of recurrence relation using generating function. (10)
4. Combinatorics: Principle of Mathematics Induction, the basic of counting, inclusion and exclusion principle, pigeonhole principles, Polya's counting theorem. (10)

Suggested Books:

1. Trambley, J.P. and Manohar,R: Discrete Mathematical Structures with Applications to Computer Science.
2. Liu C.L.: Elements of Discrete Mathematics.
3. Alan Doerr and Kenneth Levasseur: Applied Discrete Structures for Computer Science
4. Narsingh Deo: Graph Theory with Applications to Engineering and Computer Sciences Ram, Babu, Discrete Mathematics, Pearson Education, 2007.
5. Harary, F., Graph Theory, Narosa, 1995
6. Anami, B.S and Madalli, V.S., Discrete Mathematics, University Press, 2016.

MSMT-21405 Operations Research-II

External Marks: 100
Internal marks: 50
Total Marks: 150

L T P
4 1 0

1. **Queueing Theory:** Introduction, Queueing System, elements of queueing system, distributions of arrivals, inter arrivals, departure service times and waiting times, Classification of queueing models, Queueing Models: (M/M/1): (∞ /FIFO), (M/M/1): (N/FIFO), Generalized Model: Birth- Death Process, (M/M/C): (∞ /FIFO), (M/M/C) (N/FIFO). **(10)**

2. **Inventory Control:** The inventory decisions, costs associated with inventories, factors affecting Inventory control, Significance of Inventory control, economic order quantity (EOQ), Deterministic inventory problems without shortage and with shortages, EOQ problems with price breaks, Multi item deterministic problems. **(10)**

3. **Replacement Problems:** Replacement of equipment/Asset that deteriorates gradually, replacement of equipment that fails suddenly, Mortality Theorem, recruitment and promotion problem, equipment renewal problem. **(10)**

4. **Simulation:** Need of simulation, methodology of simulation. Simulation models, event- type simulation, generation of random numbers, Monte Carlo simulation. Simulation of inventory problems, queueing system, maintenance problems and job sequencing **(10)**

Suggested Books:

1. R.Panneerselvam: Operations Research
2. Taha, H.A.: Operations Research
3. Chaddrasekhara, Rao & Shanti Lata Mishra: Operations Research
4. Kanti Swarup, Gupta, P.K. & Man Mohan: Operations Research
5. Mustafi, C.K.: Operations Research

MSMT-21406 Mechanics-II

External Marks: 100

L T P

Internal marks: 50

4 1 0

Total Marks: 150

1. Tensors: Introduction, Range and Summation Conventions, Free and dummy suffixes, results in vector algebra and matrix, the symbol δ_{ij} & ϵ_{ijk} , Coordinate transformations, cartesian tensors, Properties of tensors, Isotropic tensors, Isotropic tensor of order four, Tensors as linear operators, Transpose of a tensor. **(10)**

2. Tensor Continued: Symmetric and skew tensors, Dual vector of a skew tensor, Invariants of a tensor, Deviatoric tensors, Eigenvalues and eigenvectors, Polar decomposition **(10)**

3. Scalar, vector and tensor functions, Comma notation, Gradient of a scalar, divergence and curl of a vector, Gradient of a vector, divergence and curl of a tensor, Integral theorems for vectors and tensors. **(10)**

4. Continuum Hypothesis: Notation of a continuum, Configuration of a continuum, Mass and density, Descriptions of motion, Deformation: Material and special coordinates, Deformation gradient tensor, Stretch and rotation, Strain tensors, Strain-displacement relations, Infinitesimal strain tensor, Infinitesimal stretch and rotation, Compatibility conditions., Principal strains, Strain-deviator. **(10)**

Suggested Books:

- 1 Jog, C.S., Foundations and Applications of Mechanics: Volume-I Continuum Mechanics. Narosa Publishing House, New delhi.
- 2 Chandrasekharaiah, D.S. and Lokenath, D., Continuum Mechanics, Academic Press, London (Prism Books Pvt. Ltd., Bangalore-India).

MSMT-21407 Fractional Calculus

External Marks: 100

L T P

Internal marks: 50

4 1 0

Total Marks: 150

1. Special Functions of the Fractional Calculus. Gamma Function. Mittag-Leffler function, Fractional Derivatives and Integrals. Grunwald-Letnikov Fractional Derivatives. Riemann Liouville Fractional Derivatives. Some Other Approaches. **(10)**

2. Geometric and Physical Interpretation of Fractional Integration and Fractional Differentiation. Sequential Fractional Derivatives. Left and Right Fractional Derivatives. Properties of Fractional Derivatives. Laplace Transforms of Fractional Derivatives. Fourier Transforms of Fractional Derivatives. Mellin Transforms of Fractional Derivatives. **(10)**

3. Linear Fractional Differential Equations. Fractional Differential Equation of a General Form. Existence and Uniqueness Theorem as a Method of Solution. Dependence of a Solution on Initial Conditions. The Laplace Transform Method. Standard Fractional Differential Equations. Sequential Fractional Differential Equations. Fractional Green's Function. Definition and Some Properties. One-Term Equation. Two Term Equation. Three-Term Equation. Four-Term Equation. General Case: n-term Equation. **(15)**

4. Other Methods for the Solution of Fractional-order Equations. The Mellin Transform Method. Power Series Method. Babenko's Symbolic Calculus Method. Method of Orthogonal Polynomials. Numerical Evaluation of Fractional Derivatives. Approximation of Fractional Derivatives. Order of Approximation. Computation of Coefficients. Higher-order Approximations. **(10)**

Suggested Books:

1. Podlubny, I., Matrix approach to discrete fractional calculus vol. 3, Fractional Calculus and Applied Analysis, 2000.
2. Carpinteri A, Mainardi F, editors. *Fractals and fractional calculus in continuum mechanics*, New York, Springer-Verlag Wien, 1997.
3. Mandelbrot B.B., *The fractal geometry of nature*, New York, W. H. Freeman, 2000.
4. Miller K.S., Ross B., *An introduction to the fractional calculus*. New York, John Wiley, 1993.
5. Oldham KB, Spanier J., *The fractional calculus*, New York, Academic Press; 1974.

MSMT-21408 Fourier Analysis

External Marks: 100

L T P

Internal marks: 50

4 1 0

Total Marks: 150

1. Trigonometric Series, Basic Properties of Fourier Series, Riemann-Lebesgue Lemma, The Dirichlet and Fourier Kernels, Continuous and Discrete Fourier Kernels. **(10)**
2. Lebesgue's pointwise convergence theorem, Finite Fourier Transforms, Convolutions, the exponential form of the Lebesgue's theorem. **(10)**
3. Pointwise and Uniform, convergence of Fourier Series, Cesaro and Abel Summability, Fejer's Kernel, Fejer's theorem, a continuous function with divergent Fourier series, term wise integration, term wise differentiation. **(10)**
4. The Fourier Transforms and Residues, inversions of the trigonometric and exponential forms, Fourier Transformations of derivatives and integrals. **(10)**

Suggested Books:

1. R. Strichartz, A Guide to Distributions and Fourier Transforms, CRC Press.
2. E.M. Stein and R. Shakarchi, Fourier Analysis: An Introduction, Princeton University Press, Princeton 2003.
3. G. Bachman, L. Narici, E. Beckenstein; Fourier and Wavelet Analysis, (Universitext) Springer-Verlag, New York, 2000.

MSMT-21409 Measure Theory

External Marks: 100

Internal marks: 50

Total Marks: 150

L T P

4 1 0

1. Lebesgue Outer Measure, Measurable Sets and their properties, Non Measurable Sets, Outer and Inner Approximation of the Lebesgue Measurable Sets, Borel Sigma Algebra and The Lebesgue Sigma Algebra, Countable Additivity, Continuity and the Borel-Cantelli Lemma. **(10)**

2. The motivation behind Measurable Functions, various Characterizations and Properties of Measurable functions: Sum, Product and Composition, Sequential Pointwise Limits and Simple Approximations to Measurable Functions. Littlewood's three Principles. **(10)**

3. Lebesgue Integral: Lebesgue Integral of a simple function and bounded measurable function over a set of finite measure. Comparison of Riemann and Lebesgue Integral. Bounded Convergence Theorem, Integral of a non-negative measurable function, Fatou's Lemma, Monotone convergence Theorem. **(10)**

4. General Lebesgue Integral, Lebesgue Dominated Convergence Theorem, Countable Additivity and Continuity of Integration, Vitali Covers and Differentiability of Monotone Functions, Functions of Bounded Variation, Jordan's Theorem, Absolutely Continuous Functions, Absolute Continuity and the Lebesgue Integral. **(10)**

Suggested Books:

1. Royden, H.L. and Fitzpatrick, P.M.: Real Analysis (Fourth Edition), Pearson Education Inc. New Jersey, U.S.A.(2010).
2. R. A. Gordon, The integrals of Lebesgue, Denjoy, Perron and Henstock, Amer. Math. Soc. Providence, RI, (1994).
3. Barra, G. De. : Introduction to Measure Theory, Van Nostrand and Reinhold Company.
4. Jain, P.K. and Gupta, V.P.: Lebesgue Measure and Integration.