SIDHO-KANHO-BIRSHA UNIVERSITY, PURULIA
DEPARTMENT OF MATHEMATICS

Effective from the Academic Session 2019-2020

Syllabus for Post Graduate Course in Mathematics

(Choice Based Credit System)

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(Choice Based Credit System)

SYLLABUS OVERVIEW

P.G. course of studies in Mathematics shall be of two years duration divided into four Semesters: Semester I, II, III and IV each of six months duration and the Term End Examinations will be conducted at the end of each semester. Syllabus for P.G. course in Mathematics is hereby framed based on the following schemes and structures.

Using the guidelines of the University, Choice Based Credit System is offered. Core Courses should compulsorily be studied by all the students of the department. The major elective courses will run in Semester III and in Semester IV. For major elective courses a student would choose from a pool of courses (offered by the department divided in groups) from his/her main subject of study. In case of open elective course, a student would choose from a pool of courses from other department(s). The Outreach Programme is one kind of extension activity towards the society which will be helpful for a student in skill development and direct communication to the society. For Add-on Course students have to choose a course from a pool of courses.

Total marks are 1200 of which each semester is of 300 marks. 20% marks are allotted for Internal Assessment for each theoretical paper. There is only one practical paper which is in Semester II. In Semester III, the first two theoretical papers are general and there is also two special papers, the last but one theoretical paper is open elective paper and the last one is "Outreach Programme". In Semester IV, the first two theoretical papers are general and the next two papers are special papers, the fifth paper is the Add on Course. The project work/dissertation paper is last paper in this semester and the marks distribution for this is as follows: 20 Marks for written submission, 20 Marks for Seminar presentation and 10 Marks for Viva-Voce. Faculty members of the department will supervise the students for project work. In Semester III the department will offer a cluster of special papers divided into groups and the students will have to choose special papers according to the norms to be decided by the Department. The corresponding papers are to be continued as special papers in Semester IV also.

PROGRAMME OUTCOMES

Mathematics is the mother of all sciences. It is the language of expressing science. The PG course under CBCS is so designed to make the learners to master in the subject. The learners can learn almost all areas of pure and applied mathematics. A number of special papers are offered to cover the recent research areas so that the students have the chance for research. The syllabus is highly oriented to the NET/SET/GATE and other competitive examinations and the learners will be able to crack the National and International level of examinations after completion of the course. We are offering special papers which have huge industrial, business and engineering applications and also research scopes. After completion of the course the students will not only earn the PG degree but they will be able to crack several examinations like, SSC, PSC, UPSC, RAIL, NBHM, etc. A paper on C programming with practical will help the students to be the experts in programming. The Outreach Programme will help the students to understand the outreach peoples to make them understand the usage of mathematics. The Add-on-Course includes the computer applications which will be helpful to develop their skills. In the project paper the students will be given some advanced topics as their dissertation paper and they will be oriented for research activities. They will learn the type settings, presentation skill and interaction methods.

COURSE STRUCTURE

SEMESTER-I				
Code	**Course Title**	**Credit**	**Marks**	**No. of Class Hours /Week**
MMATCCT101	Modern Algebra-I	4	40+10	4
MMATCCT102	Real Analysis	4	40+10	4
MMATCCT103	Complex Analysis	4	40+10	4
MMATCCT104	Ordinary Differential Equations & Special Functions	4	40+10	4
MMATCCT105	Numerical Analysis and Computer Programming in C++	4	(24+16)+(6+4)	4
MMATCCT106	Topology	4	40+10	4

SEMESTER-II				
Code	**Course Title**	**Credit**	**Marks**	**No. of Class Hours/Week**
MMATCCT201	Modern Algebra-II	4	40+10	4
MMATCCT202	Partial Differential Equations & Integral Transforms	4	(24+16)+(6+4)	4
MMATCCT203	Classical Mechanics & Integral Equations	4	(24+16)+(6+4)	4
MMATCCT204	Differential Geometry & Calculus of Variations	4	(24+16)+(6+4)	4
MMATCCT205	Operations Research	4	40+10	4
MMATCCS206	Computer Lab: C & C++ Programming and Computational method using MATLAB	4	50	8

SEMESTER-III				
Code	**Course Title**	**Credit**	**Marks**	**No. of Class Hours /Week**
MMATCCT301	Functional Analysis	4	40+10	4
MMATCCT302	Continuum Mechanics & Elements of Dynamical System	4	(24+16)+(6+4)	4
MMATMET303	Spl. Paper 1	4	40+10	4
MMATMET304	Spl. Paper 2	4	40+10	4
MMATOET305	Statistical Methods	4	50	8
MMATOPP306	Outreach Programme	4	50	8

SEMESTER-IV				
Code	**Course Title**	**Credit**	**Marks**	**No. of Class Hours /Week**
MMATCCT401	Measure Theory	4	40+10	4
MMATCCT402	Fuzzy Mathematics & Soft Computing	4	(24+16)+(6+4)	4
MMATMET403	Spl. Paper 3	4	40+10	4
MMATMET404	Spl. Paper 4	4	40+10	4
MMATACT405	Add-on-Course: Computer Applications and Graph Theory	4	50	4
MMATMEP406	Project/Dissertation	4	50	8

Detailed Syllabus

SEMESTER-I

MMATCCT 101: Modern Algebra-I

Group Theory: A brief idea of Group isomorphism theorems, automorphism groups, Inner automorphisms, Normal subgroups and correspondence theorem for groups and Direct product (internal and external). Generalised Caley's theorem. Group action on a set, Conjugacy classes and class equation, p-groups, Cauchy's theorem, converse of Lagrange's theorem for finite commutative groups, Sylow theorems and their applications, Normal and subnormal series, composition series, solvable series, solvable and Nilpotent groups, Jőrdan-Holder Theorem, Finitely generated Abelian groups(statement only), Free Abelian groups.

Rings: Prime ideal, maximal ideal, primary ideal, Euclidean domain, Principal ideal domain, Unique factorization domain, Gauss' theorem, Polynomial rings, Rings with chain conditions-Noetherian and Artinian Rings;, Jacobson's radical, Hilbert basis theorem, Cohen's Theorem.

Linear Algebra: Determinant divisors and invariant factors, description of minimal polynomial in terms of invariant factors.

Canonical form, similarities of linear transformation, Reduction to Triangular Forms, Diagonalization, diagonalization of symmetric and Hermitian matrices. Jordan Blocks and Jordan Canonical Forms, Invariant Factors, Rational Canonical Forms, Smith Normal Form, Nilpotent transformations.

References

1. Herstein, I. N., Topics in Algebra (Vikas).
1. Dammit & Fote, Abstract algebra
2. Hungerford, T. W., Algebra (Springer).
3. Malik, Mordeson & Sen, Fundamentals of Abstract Algebra (Tata MaGraw-Hill)
4. Sen, Ghosh & Mukhopadhyay, Topics in Abstract Algebra (University Press).
5. Cohn, P. M., Basic Algebra.
6. Lang, S., Algebra.
7. Fraleigh, J.B., A First Course in Abstract Algebra
8. Gallian, J. A., Contemporary Abstract Algebra,
9. Lang, S., Linear Algebra.
10. Hoffman & Kunze, Linear Algebra (Prentice Hall).
11. Kumareson, S., Linear Algebra.
12. Rao & Bhimsankaran, Linear algebra.
13. Friedberg & Spence, Linear Algebra
14. Curtis, Linear Algebra

MMATCCT102: Real Analysis

Definition of Equipotent sets-Schroeder-Bernstein theorem; Cantor's theorem, Continuum hypothesis, Zorn's Lemma, Axiom of choice, cardinal and ordinal number.

Functions of bounded variation and their properties, Continuity and differentiation of a function of bounded variation; absolutely continuous function; Representation of an absolutely continuous function by an integral.

Rectifiable Curves. Riemann-Stieltjes integral. Change of variable in a Riemann-Stieltjes integral, Reduction to Riemann integral, Riemann-Stieltjes integral when integrator is of bounded variation, necessary as well as sufficient conditions for existence of Riemann-Stieltjes integrals, Lebesgue's criterion for existence of Riemann integrals.

Matrix form of Chain rule. Mean value theorem for vector valued functions. A sufficient condition for differentiability. A sufficient condition for equality of mixed partial derivatives. Taylor's Formula for functions from $R^n \rightarrow R$; Functions with non-zero Jacobian determinant, the inverse function theorem, the implicit function theorem as an application of Inverse function theorem.

Extrema of Real-valued functions of several variables; Extremum problems with side conditions – Lagrange's necessary conditions as an application of Inverse function theorem.

Riemann integral of a bounded function defined on a compact interval in R^n. Evaluation of multiple integral by iterated integration, Mean value theorem for multiple integral.

References

1. Natanson, I. P., Theory of Functions of a Real Variable, Vol. I
2. Goffman, C., Real Functions
3. Burkil & Burkil, Theory of Functions of a Real Variable
4. Goldberg, Real Analysis
5. Royden, Real Analysis
6. Lahiri & Roy, Real Analysis
7. Apostol, Mathematical Analysis
8. Titchmarsh, Theory of Functions
9. Scwarz, C., Measure, Integration and Functions Spaces.
10. Rudin, Principles of Mathematical Analysis.

MMATCCT103: Complex Analysis

Riemann's sphere, point at infinity and the extended complex plane.

Functions of a complex variable, continuity and Differentiability. Analytic functions, Cauchy-Riemann equations, Branch of a logarithm and multivalued function, Harmonic functions, The Milne-Thompson Method.

Power Series: Infinite series, uniform convergence, Behaviour of Power series on a circle of convergence, Analyticity of Power Series.

Maximum and Minimum Modulus theorem. Some consequences of Maximum Modulus theorem. Open Mapping Theorem.

Complex Integration: Curves and Contours, Simply connected region, Complex Integration, Cauchy-Goursat theorem, Cauchy's integral formula. Liouville's theorem. Fundamental theorem of algebra., Morera's theorem. Idea of winding number.

Taylor Series, Laurent's series and classification of singularities: Taylor and Laurent's series, classification singularities. Casorati-Weierstrass's theorem. Cauchy's Residue theorem and evaluation of certain integrals.

Meromorphic Functions: Introduction. Argument principle, Rouche's theorem its application.

Conformal mapping, Bilinear transformation. Idea of analytic continuation.

References

1. Markushevich, A. I., Theory of Functions of a Complex Variable(Vol. I, II and III).
2. Churchill, R. V. and Brown, J. W., Complex Variables and Applications.
3. Titchmarsh, E. C., The Theory of Functions.
4. Copson, E. T., An Introduction to the Theory of Functions of a Complex Variable.
5. Conway, J. B., Functions of One Complex Variable.
6. Ahlfors, L. V., Complex Analysis.
7. Punoswamy, Functions of Complex Variable
8. Ganguly S. and Mondal, D., Lecture course on Complex Analysis, Academic Publishers

MMATCCT104: Ordinary Differential Equations & Special Functions

Preliminaries – Concepts of local existence, existence in the large and uniqueness of solutions with examples.

Picard – Lindelof theorem: Peano's existence theorem and corollary. Maximal intervals of existence. Existence theorem and corollaries.

Differential inequalities and uniqueness – Gronwall's inequality, Maximal and Minimal solutions, Differential inequalities. Uniqueness theorem (Nagumo's and Osgood's criteria)

Green's Function: Green's function and its properties, Green's functions for ordinary differential equations and its application to boundary value problems.

Eigen Value Problem: Adjoint and self-adjoint equations, Ordinary differential equations of the Strum Liouville type, Properties of Strum Liouville type, Application to Boundary Value Problems. Eigenvalues and eigenfunctions, Orthogonality theorem, Expansion theorem .

System of Linear Differential Equations: Systems of First order equations and the Matrix form, Representation of nth order equations as a system, Existence and uniqueness of solutions of system of equations, Wronskian of vector functions.

Special Functions: Ordinary point and singularity of a second order linear differential equation in the complex plane, Fuch's theorem, Series Solution about an ordinary point, Regular singularity, Frobenius' method, Series Solution about a regular singularity.

Hypergeometric equation, Hypergeometric functions, Series solution near zero, one and infinity. Integral formula for the hypergeometric function, Differentiation of hypergeometric function.

Legendre polynomial and its generating function, Rodrigue's formula, Recurrence relations and differential equations satisfied by it, Its orthogonality, Expansion of a function in a series of Legendre Polynomials, Legendre functions of first kind and second kind.

Bessel's equation, Bessel's function, Series solution of Bessel's equation, Generating function, Integral representation of Bessel's function, Recurrence relations.

References

1. Codington, E.A. and Leinson, N., Theory of Ordinary Differential Equation, McGraw-Hill.
2. Simmons, G.F., Differential Equations, Tata McGraw Hill
3. Ross, S.L., Ordinary Differential Equations, John Wiley & Sons
4. Sneddon., I.N. , Special Functions of Mathematical Physics and Chemistry, Oliver and Boyd, London.
5. Rainville, E.D., Special Functions, Macmillan.
6. Lebedev, N.N., Special Functions and Their Applications.
7. Burkhill, J.C., Theory of Ordinary Differential Equation.
8. Ince, E.L., Ordinary Differential Equation, Dover.

MMATCCT105: Numerical Analysis & Computer Programming in C++

Polynomial interpolation, Errors and minimizing errors, Hermite's interpolation, Piecewise polynomial approximation, Cubic spline interpolation, Approximations with orthogonal polynomials, Chebyshev polynomials.

Richardson extrapolation and Romberg's integration, Gaussian quadrature, Gauss-Legendre and Gauss-Chebyshev integration rule, Quadrature formula for singular integrals.

Solution of second order ordinary differential equations and simultaneous first order ordinary differential equations using fourth order R-K method. Milne's predictor-corrector method for the solution of initial value problems.

Solution of second order boundary value problems by finite difference method and Shooting method.

Determination of extreme eigenvalues and related eigenvectors by Power method, Jacobi's method for all eigenvalues.

Finite difference approximations to partial derivatives, Schmidt explicit and Crank-Nicolson implicit method for the solution of parabolic equations in one space co-ordinate, Implicit finite difference method for solution of Hyperbolic equation in one space co-ordinate, Solution of elliptic equation in two variables, convergence and stability analysis.

Computer Programming in C++

Introduction: Basic structures, Character set, Keywords, Identifiers, Constants, Variable-type declaration.

Operators: Arithmetic, Relational, Logical, assignment, Increment, decrement, Conditional. Operator precedence and associativity, Arithmetic expression.

Statement: Input and Output, Define, Assignment, User define, Decision making (branching and looping) – Simple and nested IF, IF – ELSE, LADDER, SWITCH, GOTO, DO, WHILE – DO, FOR, BREAK AND CONTINUE Statements. Arrays- one and two dimensions, user defined functions.

String Manipulation functions: String Manipulation functions in C, Operations and characters. Pointer: Declarations, Address operator, pointer as functions-call by value, call by reference, pointer arithmetic.

References

1. Hildebrand, F. B., Introduction to Numerical Analysis.
2. Isacson and Keller, Analysis of Numerical methods.
3. Jain, M.K., Numerical solution of differential equations.
4. Atkinson, Numerical Analysis, John Wiely & Sons, Singapore, 1989.
5. Gupta, A and Basu, S.C., Numerical Analysis.
6. Jain, Iyenger and Jain, Numerical Methods for Scientific and Engineering Computation, 4th Ed, New Age International (P) Ltd., New Delhi, 2003.
7. Sastry, S.S., Introductory methods of Numerical Analysis, Prentice Hall India Pvt. Ltd., New Delhi, 1999.
8. Bjarne Stroustrup, A Tour of C++
9. Yashavant Kanetkar, Let Us C
10. Stephen Prata, C++ Primer Plus
11. B. S. Grewal, Numerical Methods in Engineering & Science: with Programs in C and C++
12. B.H. Flowers, An Introduction to Numerical Methods in C++
13. Shah Nita H., Numerical Methods with C++ Programming

14.Oliver Aberth, Precise Numerical Methods Using C++
15.Xavier, C., C Language and Numerical Methods, (New Age Intl (P) Ltd. Pub.)
16.Gottfried, B. S., Programming with C (TMH).
17.Balaguruswamy, E., Programming in ANSI C (TMH).
18.Scheid, F., Computers and Programming (Schaum's series)
19.Jeyapoovan, T., A first course in Programming with C.
20.Litvin and Litvin, Programming in C++.

MMATCCT 106: Topology

Fundamentals of Topological spaces:
Topological spaces. Bases and sub-bases. Closure & interior; exterior, boundary, accumulation points, derived sets, dense set, G_δ and F_σ sets. Neighbourhood system. Order Topology.

Subspace topology and its properties; Alternative way of defining a topology using Kuratowski closure operator, interior operator and neighbourhood systems; Continuous Functions, Open maps, Closed maps and Homeomorphisms, metric topology, Quotient topology;

Countability axioms: 1^{st} and 2^{nd} countability axioms, Separability and Lindeloffness. Characterizations of accumulation points, closed sets, open sets in a 1^{st} countable space w.r.t. sequences. Heinei's continuity criterion.

Separation Axioms: T_i spaces (i = 0, 1, 2, 3, 3½, 4, 5), their characterizations and basic properties.
Urysohn's lemma and Tieze's extension theorem (statement only) and their applications.

Compactness: Compactness and its basic properties, Alexander subbase theorem, Continuous functions and compact sets. Compactness of R. Sequential compactness, BW Compactness and countable compactness. Lebesgue Number. Local compactness, compactness in metric space, totally bounded space, Ascoli-Arzela theorem.

Connectedness: Connected and disconnected spaces, Path Connected Spaces, Connected Sets in R, $R^n(n>1)$, Local connectedness, Components and Path Components, quasi-components.

Product spaces: Product and box topology, Projection maps. Tychonoff product theorem. Separation axioms, Countability axioms and Connectedness in product spaces.

References

1. Kelley, J. L. and Nostrand, V., General Topology
2. Willard, S., General Topology, Addison-Wesley
3. Dugundji, J., Allyn and Bacon, Topology
4. Munkres, J., Topology, A first course, Prentice Hall, India
5. Simmons, G. F., Introduction to topology and modern analysis, McGraw Hill
6. Joshi, K. D., Introduction to General topology, Wiley Eastern Ltd.
7. Engelking, General Topology, Polish Scientific Publishers, Warszawa
8. Steen L. and Seebach, J., Counter examples in Topology
9. Chatterjee, B. C., Ganguly S. and Adhikari, M., A text book of Topology, Asian Books
10. Thron, W. J., Topological Structures

SEMESTER-II

MMATCCT 201: Modern Algebra-II

Field Extensions: Field extension, finite extension, simple extension, algebraic and transcendental extension and their characterizations.

Splitting field, algebraic closure and algebraically closed field. Separable and normal extension.

Construction with straight –edge and compass, finite fields and their properties,

Galois group, Galois theory, Solvability by radicals, insolvability of the general equations degree five (or more) by radicals.

Module: Module over ring, submodule, cyclic module, Anihilators, fundamental structure theorem for finitely generated module over a PID and its applications to finitely generated abelian groups.

References

1. Herstein, I. N., Topics in Algebra (Vikas).
2 Dammit & Fote, Abstract algebra
3. Hungerford, T. W., Algebra (Springer).
4. Malik, Mordeson & Sen, Fundamentals of Abstract Algebra (Tata MaGraw-Hill)
5. Cohn, P. M., Basic Algebra.
6. Lang, S., Algebra.
7. Fraleigh, J.B., A First Course in Abstract Algebra
8. Gallian, J. A., Contemporary Abstract Algebra

MMATCCT202: Partial Differential Equations and Integral Transforms

Partial Differential Equations (30)

Classification and reduction of a second order linear PDE to normal form, Solutions of equation with constant coefficients, Solutions of nonlinear equations of second order by Monge's method.

Dirichlet's and Neumann's interior and exterior problems.

The equation of vibration of a string, Mixed initial and boundary value problem, Existence, uniqueness and continuous dependence of the solution, D'Alembert's solution, Generalized solution, Domain of dependence and domain of influence, Method of separation of variables for the solution of the problem of a vibrating string. Riemann's method of solution.

Laplace's equation, Fundamental solutions of Laplace's equation in two and three dimensions, Minimum-maximum theorem and its consequences, Uniqueness theorem, Mean value theorem, Boundary value problems. Method of separation of variables for the solution of Laplace's equations in two or three dimensions. Green's function for the Laplace equation in two and three dimensions, Dirichlet's principle, Rayleigh-Ritz method.

Heat equation in two independent variables, First boundary value problem, Maximum-Minimum theorem and its consequences, Continuous dependence of the solution and existence of it, Uniqueness and stability of solution, solution of Cauchy problem using Dirac-Delta function.

Integral Transforms (20): Fourier integral theorem, Definition of Fourier Transforms, Algebraic and analytic properties of Fourier Transform, Fourier sine and cosine Transforms, Fourier Transforms of derivatives, Fourier Transforms of some useful functions, Inversion formula of Fourier Transforms, Convolution Theorem, Parseval's relation, Applications of Fourier transforms in solving ordinary and partial differential equations.
Henkel transform, Melin Transform.
Fast Fourier transform.

References:

1. Sneddon, I.N., Elements of Partial Differential Equations, McGraw Hill.
2. Miller, Partial Differential Equations.John, F., Partial Differential Equations.
3. Amarnath, T., An Elementary Course in Partial Differential Equations, Narosa Pub.
4. Prasad, P., Ravindran R., Partial Differential Equations, New Age International (p) Ltd.
5. Williams,W.E., Partial Differential Equations.
6. Petrovsky, I.G., Lectures on Partial differential equations.
7. Courant & Hilbert., Methods of Mathematical Physics, Vol-I, II.
8. Sneddon, I.N., Fourier Transforms, McGraw-Hill Pub, 1995.
9. Sneddon, I.N., Use of Integral Transforms, McGraw-Hill Pub.
10. Andrews, L.C., Shivamoggi, B., Integral Transforms for Engineers, PHI.
11. Debnath, L., Bhatta,D., Integral Transforms and Their Applications, CRC Press, 2007.
12. Tricomi, F.G., Integral Equation, Interscience Publishers, 1985.

MMATCCT203: Classical Mechanics & Integral Equations (Marks: 50)

Classical Mechanics (30 marks)
Generalised co-ordinates, Constraints and the forces responsible for it, Types of Constraints, Degrees of freedom, Dynamical system and its classification, Virtual Work, D'Alembert principle, Generalised forces and generalised momentum, Kinetic energy, Lagrange's equation of motion (first kind).

Lagrange's equations of motion (second kind) for holonomic and non-holonomic systems, Lagrange's equations of motion (second kind) for velocity dependent potential field, Dissipative forces and dissipation function. Configuration space and system points, Action Integral; Hamilton's principle; Lagrange's equations by variational methods; Hamilton's principle for non-holonomic system; Symmetry properties and conservation laws; Noether's theorem. Point transformations. Cyclic co-ordinates, Routh's process for the ignoration of co-ordinates and its applications, Legendre dual transformation, Hamilton's canonical equations of motion, Principle of least action, Principle of energy.

Generating functions, Canonical transformations and its properties, Condition for canonicality, Infinitesimal canonical transformations, Lagrange and Poisson brackets and their properties, Invariance of Poisson and Lagrange brackets, Representation of Hamilton's equations of motion in terms of Poisson bracket, Jacobi's identity. Hamilton Jacobi Theory.
Motion of a rigid body rotating about a fixed point, Expressions for velocity, angular momentum and kinetic energy, Euler's dynamical equations and their solutions, Euler angles, Angular velocity in terms of Euler angles, Motion of a top in a perfectly rough floor and its stability, Corioli's force

Integral Equations (20 marks)

Linear integral equations of first and second kinds, Fredholm and Volterra types integral equations, Reduction of boundary value problem of an ordinary differential equation to an integral equation and vice-versa.

Existence and uniqueness of solutions of Fredholm and Volterra's integral equations of second kind, Solution by the method of successive approximations, Neumann series, Solution by Resolvent kernel method and iterated kernel method.

Integral equations with degenerate kernels, Fredholm theorem, Fredholm alternatives, Eigenvalue and eigenfunction of integral equation and their elementary properties. Hilbert-Schmidt theorem.

Integral equations with symmetric kernels, Properties of symmetric kernels. Singular integral equations, Abel integral equation and its solution.

References

1. Goldstein. H, Classical Mechanics, Narosa Publ., New Delhi, 1998.
2. Rana and Joag, Classical Mechanics, Tata McGraw Hill, New Delhi, 2002.
3. Gantmacher. F, Lectures in Analytical Mechanics, Mir Publ., 1975.
4. Kibble and Berkshire, Classical Mechanics, 4th ed., Addison-Wesley Longman, 1996.
5. Chetaev.N.G, Theoretical Mechanics, Springer-Verlag, 1990.
6. Calkin. M, Lagrangian and Hamiltonian Mechanics, World Sci. Publ., Singapore, 1996.
7. Synge and Griffith, Principles of Mechanics, McGraw Hill, Singapore, 1970.
8. Taylor. J.R, Classical Mechanics, University Science Books, California, 2005.
9. Landau and Lifshitz, Mechanics, 3rd ed., Pergamon Press, 1982.
10. Chorlton, F., Dynamics.
11. Synge and Graffith, Principle of Mechanics, Mc. Graw-Hill Book Co. 1960 .
12. Green Wood, D.T., Classical Dynamics, Dover Publication, 2006.
13. Gupta, K. C., Classical Mechanics of Particles and Rigid Bodies, John Wiley & Sons Inc., 1988.
14. Torok, Analytical Mechanics.
15. Sneddon, I.N., Fourier Transforms, McGraw-Hill Pub, 1995.
16. Tricomi, F.G., Integral Equation, Interscience Publishers, 1985.
17. Mikhlin, S.G., Integral Equation, Pergamon Press, 1960.
18. Chakraborti, A., Applied Integral Equation, Vijay Nicole Imprints Pvt Ltd.
19. Lovit, W.V., Linear Integral Equations, Dover Publishers, 2005.

MMATCCT 204: Differential Geometry and Calculus of Variations

Differential Geometry

Curves in Space: Parametric representation of curves, Helix , Curvilinear coordinates in E^3, Intrinsic differentiation. Tangent and first curvature vector, Serret- Frenet formulas for curves in space, Frenet formulas for curve in E^n. Parallel vector fields, Geodesic.

Surfaces: Regular surfaces in R^3. Tangent space to a surface at a point, Equivalent definitions, Smooth functions on a surface, Differential of a smooth function defined on a surface, Orientable surfaces. Parametric representation of a surface, Tangent and Normal vector field on a surface. Angle between two curves on a surface, The first and second fundamental form of surface, Geodesic curvature of a surface curve, The third fundamental form, Gaussian curvature , Isometry of surfaces, Developable surfaces, Weingarten formula, Equation of Gauss and Codazzi , Principal curvature, Normal curvature, Meusnier's theorem.

Calculus of Variations:
Variation, Linear functional, Deduction of Euler-Lagrange differential equation and some special cases of it, Euler-Lagrange differential equation for multiple dependent variables, Functional dependent on higher order derivatives, Functional dependent on functions of several variables. Application of Calculus of variations for the problems of shortest distance, minimum surface of revolution, Brachistochrone problem, geodesic, Isoperimetric problem, Calculus of variations for problems in parametric form, Variational problems with moving boundaries.

References

1. Weatherburn, C. E., Differential Geometry
2. Postrikov, M., Lectures in Geometry, Linear Algebra and Differential Geometry
3. De, U. C., Differential Geometry of Curves and Surfaces in E3, Anamaya Publi., 2007.
4. M. Majumdar and A. Bhattacharya, Differential geometry, Books and Allied Publishers.
5. O'Neill, B., Elementary Differential Geometry
6. Rutter, Geometry of Curves
7. M. DoCarmo, Differential geometry of curves and surfaces, Princeton University Press, 1976.
8. S. Montiel and A. Ros, Curves and Surfaces, AMS Graduate Studies in Mathematics, 2009.
9. A. Pressley, Elementary Differential Geometry, Springer UTM, 2009.
10. J. Thorpe, Elementary Topics in Differential Geometry, Springer UTM, 2007.
11. Gupta, A. S., Calculus of Variations with Applications, Prentice –Hall of India, 1996.
12. Gelfand, I. M. and Fomin, S.V., Calculus of Variations, Prentice Hall Inc, 2012.
13. Elsgots, Calculus of Variations, Mir Publ.

MMATCCT205: Operations Research (Marks: 50)

Introduction: Definition of O.R., Drawbacks in definition, Scope of O.R., O.R. and decision making, Application of O.R. in different sectors, Computer application in O.R.

Standard forms of revised simplex method, Computational procedure, Comparison with simplex method. Dual Simplex method.

Post Optimality Analysis: Discrete changes in the cost vector, requirement vector, coefficient matrix. Addition of a variable and a constraint, Parameterization of the cost vector and the requirement vector
Bounded variable method.

Non-linear Programming: Local and global minima and maxima, convex functions and their properties, Method of Lagrange multiplier, The Kuhn Tucker conditions. Convex programming.
Quadratic Programming: Wolfe's Modified Simplex method, Beale's method.
Integer Programming: Introduction, Cutting plane method, Branch and bound technique, Binary linear programming, Travelling salesman problem.

Separable convex programming, Separable Programming Algorithm.
Inventory control Models: Classification of Inventories, Advantage of Carrying Inventory, Features of Inventory System, Deterministic inventory models including price breaks.

References

1. Wagner – Principles of Operations Research (PH)
2. Sasievir, Yaspan, Friedman – Operations Research: Methods and Problems (JW)
3. Sharma J K – Operations Research – Theory and Applications
4. Hillie & Lieberman – Introduction to Operations Research
5. Swarup, Gupta & Manmohan – Operations Research

6. Kapoor V.K. -- Operations Research
7. Hadley G., -Linear Programming, Narosa Publishers, 1987
8. Hillier & Lieberman—Introduction to Operations Research, 7/e, TMH

MMATCCT206: Computer Lab: C & C++ Programming and Computational method using MATLAB **(Problems: 40 marks; Lab. note book and viva: 10)**

On Numerical Problems:

1. Solution of a system of linear equations by Gauss–Seidel method.
2. Integration by Romberg's method and Gauss-Legendre quadrature method.
3. Solution of an Initial Value problem of first order O.D.E. by Milne's method.
4. Solution of an Initial Value problem of second order O.D.E. and first order simultaneous equations by 4th order Runge–Kutta method.
5. B.V.P. for second order O.D.E. by finite difference method.
6. Solution of parabolic equation in two variables by explicit Schmidt formula and implicit Crank-Nicolson's method.
7. Solution of one dimensional wave equation by finite difference method.
8. Solution of elliptic type PDE.

On Statistical Problems:

1. On bivariate distribution: Correlation coefficient, Regression lines, Curve fitting.
2. Multiple regression.
3. Simple hypothesis testing.

On Searching and Sorting Problems: Linear and binary search, Bubble, Insertion, Selection techniques.
String manipulation: No of occurrence of a letter in a given string, Palindrome nature of string, Rewrite the name with surname first, Print a string in a reverse order, String searching, Sorting of names in alphabetic order, Find and replace a given letter or word in a given string, Combinations of letters of a word, Conversion of name into abbreviation form, Pattern matching.

Computational Method using MATLAB

1. **Working with matrix:** Generating matrix, Concatenation, Deleting rows and columns. Symmetric matrix, matrix multiplication, Test the matrix for singularity, magic matrix. Matrix analysis using function: norm, normest, rank, det, trace, null, orth ,rref, subspace, inv, expm, logm, sqrtm, funm.
2. **Array:** Addition, Subtraction, Element-by-element multiplication, Element-by-element division, Element-by-element left division, Element-by-element power. Multidimensional Arrays, Cell Arrays, Characters and Text in array,
3. **Graph Plotting:** Plotting Process, Creating a Graph, Graph Components, Figure Tools, Arranging Graphs Within a Figure, Choosing a Type of Graph to Plot, Editing Plots,

Plotting Two Variables with Plotting Tools, Changing the Appearance of Lines and Markers, Adding More Data to the Graph, Changing the Type of Graph, Modifying the Graph Data Source, Annotating Graphs for Presentation, Exporting the Graph.

4. **Using Basic Plotting Functions:** Creating a Plot, Plotting Multiple Data Sets in One Graph, Specifying Line Styles and Colors, Plotting Lines and Markers, Graphing Imaginary and Complex Data, Adding Plots to an Existing Graph, Figure Windows, Displaying Multiple Plots in One Figure, Controlling the Axes , Adding Axis Labels and Titles, Saving Figures.
5. **Data Analysis:** (i) Preprocessing Data : Loading the Data, Missing Data, Outliers, Smoothing and Filtering, (ii)Summarizing Data: Measures of Location, Measures of Scale, Shape of a Distribution, (iii) Visualizing Data: 2-D Scatter Plots, 3-D Scatter Plots, Scatter Plot Arrays, Exploring Data in Graphs, (iv) Modeling Data: Polynomial Regression, General Linear Regression,
6. **Linear Algebra:** Systems of Linear Equations, Inverses and Determinants, Factorizations, Powers and Exponentials, Eigenvalues, Singular Values.
7. **Polynomials:** Polynomial functions in the MATLAB® environment, Representing Polynomials, Evaluating Polynomials, Roots , Derivatives, Convolution, Partial Fraction Expansions, Polynomial Curve Fitting, Characteristic Polynomials.

SEMESTER-III

MMATCCT 301: Functional Analysis (Marks: 50)

Review of continuity, completeness and compactness in metric spaces. Hölder and Minkowski inequalities (statement only). Baire's space, Baire's (category) theorem, Banach's fixed point theorem, applications to solutions of certain systems of linear algebraic equations, Fredholm's integral equation of the second kind.

Normed linear spaces, Banach spaces and their examples; Quotient space of normed linear space and completion of normed spaces; finite dimensional normed space and its properties, equivalent norms, compactness of normed space, Riesz lemma and its application,

Bounded linear operators and its norm. Spaces of bounded linear operators and its completeness. Inverse of an operator. Hahn-Banach theorem and some of its applications.

Linear functionals, Dual spaces, Examples, Weak & weak* convergence, Separability of the Dual space, Reflexive spaces, Examples, Uniform boundedness principle and its simple applications, The Open mapping Theorem & the Closed graph Theorem.

Inner product space, Hilbert space, examples, completion of inner product space, parallelogram law, polarization identity, C-S inequality, Pythagorean theorem, orthogonal complement, direct sum, Projection theorem, orthonormal sets and its properties, Bessel's inequality, Gram Schimdt orthogonalization process, complete orthonormal sets, Parseval identity. Riesz-Fischer Theorem. The Riesz representation theorem. Projections, Characterizations of Orthogonal Projections among all the Projections. Adoint and self adjoint operators and their properties, Norm of Self Adjoint Operators, Sum & Product of Projections, Invariant Subspaces.

References

1. E. Kreyszig, Functional Analysis.
2. W. Rudin, Functional Analysis
3. George F. Simmons, Introduction to Topology and Modern Analysis
4. B.Choudhary, S. Nanda, Functional Analysis With Applications
5. Lusternik and Sovolev, Functional Analysis.
6. Siddiqui, A.H. Functional Analysis with applications, TMG Publishing Co. Ltd, New Delhi.
7. Jha, K.K., Functional Analysis, Student's Friends,1986.
8. Vulikh, Functional Analysis.
9. Bachman, G. & Narici, L., Functional Analysis, Academic Press,1966.
10. Taylor, A.E., Functional Analysis, John wiley and Sons, New York,1958
11. B.V. Limaya, Functional Analysis
12. B.K. Lahiri, Elements of Functional Analysis

MMATCCT302: Continuum Mechanics & Elements of Dynamical System

Continuum Mechanics (30)

Continuous media, Deformable bodies, Body and surface forces, Cauchy's stress principle, Stress tensor, Equation of equilibrium, Symmetry of stress tensor, Principal stresses and principal direction of stresses, Stress invariants, Stress quadric of Cauchy, Maximum normal and shearing Stresses.

Deformation: Deformation Gradients, Finite strain tensor, Infinitesimal strain components, Geometrical interpretation of infinitesimal strain components, Principal strain and principal axes of strain, Compatibility of strain components.

Lagrangian and Eulerian approaches to study the motion of continua, Material derivative of a volume integral, Equation of continuity, Equation of motion, Equation of angular momentum, Energy equation.

Velocity of fluid, Streamlines and path lines, Steady and unsteady flows, Velocity potential, Vorticity vector, Conservation of mass, Equation of continuity. Equations of motion of a fluid, Pressure at a point in fluid at rest, Pressure at a point in a moving fluid, Euler's equation of motion, Bernoulli's equation, Circle theorem, Blasius theorem, Theory of images and its applications to various singularities.

Elements of Dynamical System (20)

Dynamical Systems: Phase variables and Phase space, continuous and discrete time systems, flows(vector fields), maps (discrete dynamical systems), orbits, asymptotic states, fixed (equilibrium) points periodic points, concepts of stability, dynamical system as a group.
Linear systems: Fundamental theorem and its application. Properties of exponential of a matrix, generalized eigenvectors of a matrix, nilpotent matrix, stable, unstable and center subspaces, hyperbolicity, contracting and expanding behaviour.
Nonlinear Vector Fields: Stability characteristics of an equilibrium point. Liapunov and asymptotic stability. Source, sink, basin of attraction. Phase plane analysis of simple systems, homoclinic and heteroclinic orbits, hyperbolicity, statement of Hartmann-Grobman theorem.
Liapunov function and Liapunov theorem: Periodic solutions, limit cycles and their stability concepts. Statement of Lienard’s theorem and its application to vander Pol equation, Poincare-Bendixson theorem (statement and applications only), structural stability and bifurcation through examples of saddle-node, pitchfork and Hopf bifurcations.
References:

1. P. Glendinning – Stability, Instability and Chaos (Cambridge University Press 1994).
2. Strogartz – Non-linear Dynamics
3. M. W. Hirsch & S. Smale – Differential Equations, Dynamical Systems and Linear Algebra (Academic Press 1974)
4. L. Perko – Differential Equations and Dynamical Systems (Springer – 1991)
5. Arnold – Ordinary Differential Equation
6. Chung, T. J., Continuum Mechanics, Prentice-Hall.
7. Chatterjee, R. N., Mathematical Theory of Continuum Mechanics, Narosa Publishing House, New Delhi, 1999.
8. Fung, Y.C., A first course in continuum mechanics.
9. Eringen, A.C., Non-linear Theory of Continuous Media, McGraw-Hill.
10. Chorlton, F., A text book of Fluid Mechanics.
11. Sedov, L.I., A course in continuum mechanics, Vol-I.
12. Leigh, D.C., Non-linear Continuum Mechanics, McGraw-Hill.

MMATMET303: (Special paper-I)

A1: Advanced Complex Analysis-I

Convex function and Hadamard three-circle theorem, Phragmen-Lindelof theorem.

Harmonic function, Mean value property, Maximum principle for Harmonic function, Poisson Integral formula- for analytic and for Harmonic functions formula. Theorem of

Borel–Caratheodary. Boundary behavior of Poisson Integral. The Phragmen –Lindelof Method. Harnack's inequality & Harnack's Principle,

Conformal Mapping: preservation of angles, Linear fractional transformations, Normal families, The Riemann mapping Theorem. The class *S* of analytic and univalent functions on the Unit disk, Kobe one-quarter Theorem. Continuity at the boundary, Conformal Mapping of an Annulus.

Analytic Continuation: Regular Points and Singular Points, Continuation along Curves, The Monodromy Theorem, Special Functions: The gamma Function of Euler and the Zeta Function of Riemann. Euler's Product Formula. Functional Equation of Zeta Function, Riemann Hypothesis, Construction of a Modular Function. The Picard Theorem.

References

1. Conway, J. B., Functions of One Complex Variable
2. Ahlfors, L. V., Complex Analysis
3. Rudin, W., Real and Complex Analysis
4. Titchmarsh, E. C., Theory of Functions
5. Copson, E. T., Function of a Complex Variable
6. Boas, R. P., Entire Functions
7. Cartan, H., Analytic Functions
8. Markusevich, A. I., Theory of Functions of a Complex Variables, Vol. I & II.

A2: Advanced Differential Geometry of Manifolds-I (Marks: 50)

Manifold: Topological manifold, Differentiable Manifold, Manifolds with boundary, Differentiable function and Differentiable Mapping, Diffeomorphism, Partial derivatives, Inverse Function theorem, Differentiable Curve, Tangent space, Rank of mapping, critical point, regular point, Immersion, Submmersion, Embedding, Differential of map, Vector Field, Integral curves, Lie Bracket, *f*-related Vector fields, One parameter group of transformations or flow, Local 1-paramater group of transformations or local flow, Existence theorem for ODEs.

Tensor fields: Tensors on a vector space, Tensor fields, mapping and covariant tensors, multiplication of tensor fields, Symmetrizing and alternating transformations, Exterior Algebra, Exterior Differentiation.

Differential Form: Differential 1-form, Characterisation of 1-form, Pullback of 1-form, Differential r-form, Pull-Back Differential r- Form.

Lie Groups and Lie Algebras: Lie Group, General Linear Groups, Left translation, Right translation, Invariant Vector Field, Invariant Differential form, Automorphism, One parameter subgroup of a Lie group, Lie Transformation Group (action of a Lie Group on a Manifold), Exponential Maps. Lie Algebra of Vector Fields, Lie derivatives.

References

1. Foundation of differential Geometry (vol-1): S. Kobayashi & K. Nomizu.
2. An Introduction to Differentiable Manifolds and Riemannian Geometry: W. M. Boothby.
3. Introduction to Differentiable Manifolds: L. Auslander & R. E. Mackenzie.
4. Lectures on Differential Geometry: S. S. Chern,W. H. Chen & K. S. Lam.
5. J.M.Lee- Differential Geometry

MMATMET304: (Special paper-II)
A3: Advanced Operations Research I (Marks: 50)

Unconstrained Optimization: Search method: Fibonacci search, Golden Section search; Gradient: Steepest descent Quasi-Newton's method, Davidon-Fletecher-Powell method, Conjugate direction method (Fletecher-Reeves method).
Replacement Problems: Introduction, Replacement policies for items whose efficiency deteriorates with time, Individual and group replacement, Replacement policies for items that fail completely.
Job sequences: Processing of n jobs through two machines, The Algorithm, Processing of n jobs through m machines

Project Network: Introduction, Basic differences between PERT and CPM, Steps of PERT/CPM Techniques, PERT/CPM network Components and Precedence Relationships, Critical Path analysis, Probability in PERT analysis, Project Crashing, Time cost Trade-off procedure, Updating of the Project.

Flow Network: Max-flow min-cut theorem, Generalized Max flow min-cut theorem, Linear Programming interpretation of Max-flow min-cut theorem, Minimum cost flows, Min-flow max-cut theorem.
Stochastic Inventory Models: Discrete and Continuous probabilistic inventory models, Safety stock and Buffer Stock, Concept of just in time inventory

References

1. Sharma J K – Operations Research – Theory and Applications
2. Taha – Operations Research
3. Schaum's Outline Series – Operations Research
4. Hillie & Lieberman – Introduction to Operations Research
5. Swarup, Gupta & Manmohan – Operations Research
6. Kapoor V.K. - Operations Research
7. Hillier & Lieberman—Introduction to Operations Research, 7/e (with CD),TMH
8. Rao S.S. –Optimization theory and Applications, Wiley Eastern Ltd., New Delhi.

A4: Advanced Computational Fluid Dynamics- I (Marks: 50)

Basic Aspect of Discritization: Finite difference method, Methods for Obtaining Finite-Difference Equations: Use of Taylor Series, Use of Polynomial Fitting, Integral Method and its applications to the model equations of parabolic, hyperbolic, elliptic types, Explicit and implicit schemes, Truncation error, consistency, convergence, stability (Von Neumann stability analysis only) of model equation with appropriate initial and boundary conditions.

Introduction to the Use of Irregular Meshes: Irregular Mesh Due to Shape of a Boundary, Irregular Mesh Not Caused by Shape of a Boundary.

Grid with Appropriate Transformations: Introduction, General Transformation of the Equations, Metrics and Jacobians, Form of the governing equations, Stretched Grids, Boundary-Fitted Co-ordinate System; Elliptic Grid Generation.

Some Simple CFD Techniques: Lax Method, Euler Implicit Method, Leap Frog Method, Lax-Wendroff Technique, Crank-Nicholson Scheme, Alternative Direct Implicit (ADI) Scheme, Thomas algorithm, Upwind scheme, Second-Order Upwind Scheme, Multi-grid method.

References

1. Chung, T.J., Computational Fluid Dynamics, Cambridge University Press, 2002
2. Anderson, Jr.,J.D., Computational Fluid Dynamics-The Basic with Applications, McGraw-Hill.
3. Niyogi, P., Chakraborty, S. K. and Laha, M. K., Introduction to Computational Fluid Dynamics, Pearson education, Delhi, 2005.

4. Thompson, J.F., Warsi, Z.U.A. and C.W. Martin, C.W., Numerical Grid Generation, Foundation and Applications, North Holland 1985.
5. Schlichting, H., Gersten, K., Boundary – Layer Theory, 8th Ed., Springer 2000
6. Fletcher, C. A. J., Computational Techniques for Fluid Dynamices, Vol-1 and Vol-II, Springer.
7. Peyret, R., and Taylor, T. D., Computational Methods for Fluid Flow, Springer 1983.
8. Tannehill, J.C, Anderson, D.A., and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer.
9. Hoffman, J. D. , Numerical methods for Engineers and scientific, McGraw-Hill.

MMATOET305: Statistical Methods (Marks: 50)

Introduction: Nature of Statistics, Uses of Statistics, Statistics in relation to other disciplines, Abuses of Statistics. Collection & Presentation of data: Primary data – designing a questionnaire and a schedule. Secondary data – its major sources. Complete enumeration. Controlled experiments, Sample Surveys, Construction of Tables with one or more factors of classification.

Probability Theory: Definition of probability: Classical and relative-frequency approach to probability, Kolmogorov's Axiomatic definition, limitations of Classical definition. Probability of union and intersection of events, Conditional probability and Independence of events, Bayes' Theorem and its applications. Examples based on classical approach and repeated trials.

Bivariate data: Scatter diagram, correlation coefficient and its properties, Correlation ratio, Correlation Index, Intraclass correlation, Concept of Regression, Principles of least squares, Fitting of polynomial and exponential curves.

Rank correlation – Spearman's and Kendall's measures.

Some Standard Sampling Distributions: $\chi 2$ distribution, distributions of the mean and variance of a random sample from a normal population, t and F distributions, distributions of means, variances and correlation coefficient (null case) of a random sample from a bivariate normal population.

Multivariate Analysis Multivariate data – multiple regression, multiple correlation and partial correlation – their properties and related results.

Analysis of Variance: One way classification. Assumptions regarding model. Two way classification with equal number of observations per cell.

References

1. Goon AM,Gupta MK,Dasgupta B.(1998):Fundamentals of Statistics (V-1),World Press
2. Yule G.U & Kendall M.G(1950): An Introduction to the Theory of Statistics, C.Griffin
3. Kendall M.G. & Stuart A. (1966): Advanced Theory of Statistics (Vols 1 & 2)
4. Snedecor & Cochran (1967): Statistical Methods (6th ed), Iowa State Univ. Press
5. Croxton F.E., Cowden D.J. & Klein (1969): Applied General Statistics, Prentice Hall.
6. Ross S.M. (1972): Introduction to Probability Models, Academic Press.
7. Bhattacharya GK & Johnson R. A. (1977): Concepts & Methods of Statistics, John Wiley.
8. Mukhopadhyay P. (1999): Applied Statistics

MMATOPP306: Outreach Programme (50)

Outreach Programme is one kind of extension activity towards the society which will be helpful for a student in skill development. The students will visit to the nearby villages to reach to the common people of the society. The students will prepare some useful topics for presentation to the people of different age groups in the villages. The topics will be selected according to the relevance in daily life. The students will be guided by the teachers of the department. The students will try to motivate the common people about the value of education and help them to make understand the usefulness of mathematics in daily life.

SEMESTER-IV

MMATCCT 401: Measure Theory (50)

Outer Lebesgue Measure in E^* (starting with the concept of length of an interval); the properties of outer Lebesgue Measure m^*; Outer measure μ^* on S-where S is a space; Inner measure; the concept of μ-measurable sets with the help of μ^*. Necessary and sufficient condition for μ-measurability. Properties of **μ**-measurable sets. The structure of μ-measurable sets-the concept of σ-algebra; the σ-algebra of Lebesgue measurable sets.

Properties of Lebesgue measure , Vitali's theorem: The existence of an non-measurable set. The Borel sets & Lebesgue measurable sets- a comparison.

μ-measurable functions, their properties, characteristic functions; step functions.

Lebesgue Integration. Lebesgue's monotone convergence theorem; Fatou's lemma; the theorem on Dominated summability; Lebesgue's dominated convergence Theorem.

Necessary & Sufficient condition of Riemann integrability via measure; interrelation between the two modes of integration.

The Concept of L^p-spaces; Inequalities of Holder and Minkowski; Completion of L^p-spaces. Convergence in Measure, Almost Uniform Convergence, Pointwise Convergence a.e.; Convergence Diagrams, Counter Examples. Egoroff theorem.

Lebesgue Integral in the Plane. Product σ-algebra. Product Measure. Fubini's Theorem. Haar measure.

References:

1. P. R. Halmos, Measure Theory, Von Nostrand, New York,1950.
2. E. Hewitt & K. Stromberg, Real and abstract Analysis, Third edition, springer- verlag, Heidelber & New York, 1975.
3. G.D. Barra, Measure Theory & Integration, Wiley Eastern Limited, 1987.
4. W. Rudin, Real and Complex Analysis, Tata McGraw- Hill, New York, 1987
5. I. K. Rana, An introduction to Measure & Integration, Narosa Publishing House, 1997.
6. H. L.Royden, Real Analysis, Macmillan Pub. Co. Inc, New York, 1993.
7. J. F. Randolf, Basic Real and Abstract Analysis, Academic Press, New York, 1968.
8. C. D. Aliprantis and Owen Burkinshaw, Principles of Real Analysis, Academic Press, 2000.
9. K. R. Parthsarathy, introduction to Probaility and Measure, Macmillan Company of India Ltd., Delhi, 1977.
10. R.B. Bartle, Elements of Real Analysis

MMATCCT 402: Fuzzy Mathematics and Soft Computing (50)

Fuzzy Mathematics (30)

Fuzzy Sets- Basic definitions α-level sets. Convex fuzzy sets. Basic operations on fuzzy sets. Types of fuzzy sets. Cartesian products. Algebraic products. Bounded sum and difference t-norms and t-conorms.

The extension Principle – The Zadeh's extension principle. Image and inverse image of fuzzy sets. Fuzzy numbers. Elements of fuzzy arithmetic.

Possibility Theory-Fuzzy measures. Evidence theory. Necessity measure. Possibility measure. Possibility distribution. Possibility theory and fuzzy sets. Possibility theory versus probability theory

Defuzzification and the various defuzzification methods (the centre of area, the centre of maxima, and the mean of maxima methods)

Decision Making in Fuzzy Environment- Individual decision making. Multiperson decision making. Multicriteria decision making. Multistage decision making. Fuzzy ranking methods. Fuzzy linear programming

Soft Computing (20)
Introduction, Difference between Hard and Soft computing, Requirement of Soft computing, Major Areas of Soft Computing, Applications of Soft Computing.

Genetic Algorithm: History of Genetic Algorithms (GA), Working Principle, Various Encoding methods, Fitness function, GA Operators- Reproduction, Crossover, Mutation, Convergence of GA, Bit wise operation in GA, Multi-level Optimization.

Neural Networks: What is Neural Network, Learning rules and various activation functions, Single layer Perceptrons, Back Propagation networks, Architecture of Back propagation (BP) Networks, Back propagation Learning, Variation of Standard Back propagation Neural Network, Introduction to Associative Memory, Adaptive Resonance theory and Self Organizing Map, Recent Applications.

Ant colony optimization (ACO), and **Particle Swarm Optimization (PSO).**

Reference:

1. H. J. Zimmermann, Fuzzy set theory and its Applications, Allied Publishers Ltd New Delhi 1991
2. 2. G. J Klir and B. Yuan- Fuzzy sets and fuzzy logic, Prentice-Hall of India, New Delhi 1995
3. Evolutionary Computing : A Unified Approach K. A. De Jong (Prentice Hall Inc, USA) 2009
4. Evolutionary Algorithm for Solving Multi-objective Optimization Problems (2nd Edition) Collelo, Lament, Veldhnizer (Spring, 2010)
5. An Introduction to Genetic Algorithm Melanic Mitchell (MIT Press, 2000)

MMATMET403: Special paper-III

B1: Advanced Complex Analysis-II (Marks: 50)

Zeros of Holomorphic Functions: Infinite products, Necessary & Sufficient condition for convergence of Product, M-test for the convergence of Product. The Weierstrass factorization Theorem. Mittag- Leffler Theorem, Interpolation Problem, Jensen’s Formula, Zeros of Entire Functions. Blaschke Products, the Muntz-Szasz Theorem. Functions of several complex variables . Power series in several complex variables. Region of convergence of power series. Associated radii of convergence.

The philosophy and scope of fractal geometry, classical Fractals, Cantor set, Sierpinski triangle, Von Koch curve, Hilbert and Peano curves, Weierstrass function. Self-similarity, Scaling, Similarity dimension, Box-counting dimension, Information dimension, Capacity dimension. Foundations of iterated function systems (IFS), Classical fractals generated by IFS, Contractions mapping principle, Collage theorems, Fractal image compression, Image encoding and decoding by IFS. Iteration of quadratic polynomials, Julia sets, Fatou sets, Mandelbrot set, Characterization of Julia sets and Fatou sets, components of Fatou sets, dynamics of functions e^z , $\sin z$ and $\cos z$. Bifurcation and chaotic burst.

Software Support: MATLAB, MATHEMATICA, GNUPLOT

References:

1. M. F. Barnsley, Fractals Everywhere , 2nd edition, Academic Press, 1995.
2. Ning Lu, Fractal Imaging, Academic Press, 1997.
3. M. J. Turner et. al, Fractal Geometry in Digital Imaging, Academic Press, 1998.
4. A. F. Beardon, Iteration of Rational Functions, Springer Verlag, 1991.
5. L. Carleson and T.W. Gamelin, Complex Dynamics, Springer Verlag, 1993.

B2: Advanced Differential Geometry of Manifolds-II (Marks: 50)

Bundle: Tangent bundle, Vector bundle, Subbundle, fibre bundle, Bundle homomorphisms. Co-vector, Co-tangent Bundle.

Categoies and functors, Bump function and partition of unity, Riemannian manifolds as metric space: Riemannian distance function, tangent-cotangent isomorphism, Pseudo-Riemannian metric.

Differentiation on Riemannian manifolds: Differentiation of vector fields, Connections, Riemannian manifold, Riemannian connection, Fundamental theorem of Riemannian geometry.

Curvature: Curvature tensor, Riemann Curvature tensor, Sectional curvature, Schur's theorem, projective Curvature tensor, Ricci Curvature, scalar Curvature.

Geodesic in a Riemannian Manifold, Submanifolds and hypersurfaces.

References:

1. Kobayashi, S. & Nomizu, K., Foundation of differential Geometry, vol-1.
2. Boothby, W. M., An Introduction to Differentiable Manifolds and Riemannian Geometry.
3. Auslander, L. & Mackenzie, R. E., Introduction to Differentiable Manifolds.
4. Chern, S. S., Chen, W. H. & Lam, K. S., Lectures on Differential Geometry.
5. K.YANO,K.M.KON–Differentiable Manifold.
6. D.E.BLAIR–Contact Manifolds in Riemannian Geometry,Lecture Notes in Maths.
7. Loring W. Tu- Differential geometry
8. . J.M.Lee- Differential Geometry

B3: Advanced Operations Research II (Marks: 50)

Dynamic Programming: Characteristics of Dynamic Programming problems, Bellman's principle of optimality (Mathematical formulation)
Model –1: Single additive constraint, multiplicative separable return,
Model – 2: Single additive constraint, additively separable return,
Model – 3: Single a multiplicative constraint, additively separable return,
Multistage decision process – Forward and Backward recursive approach, Dynamic Programming approach for solving linear and non-linear programming problems, Application – Single-item N-period deterministic inventory model.
Geometric Programming: Elementary properties of Geometric Programming and its applications. Geometric programming for unconstrained objective function and constrained objective function.
Queuing Theory: Introduction, characteristic of Queuing systems, operating characteristics of Queuing system. Probability distribution in Queuing systems. Classification of Queuing

models. Poisson and non Poisson queuing models (M/M/1:∞/FCFS/∞), (M/M/C:∞/FCFS/∞), (M/M/1:N/FCFS/∞), (M/M/C:N/FCFS/∞).

Reliability theory: Definition, failure rate, Hazard rate, series arrangement, parallel arrangement, reliability evaluation.

Stochastic Programming: Stochastic Programming, Uncertainty and certainty equivalent and passive approach to Stochastic Programming, Chance constrained optimization Problem.

References:

1. Sharma, J. K., Operations Research – Theory and Applications
2. Taha, Operations Research
3. Schaum's Outline Series – Operations Research
4. Swarup, Gupta & Manmohan, Operations Research
5. Kapoor, V.K., Operations Research
6. Rao, S.S.,Optimization theory and Applications, Wiley Eastern Ltd., New Delhi.
7. Bector, Chandra and Dutta, Principles of optimization Theory, Narosa Publishing House.

B4: Advanced Computational Fluid Dynamics- II (Marks: 50)

Compact Scheme: Introduction, Higher Order Compact (HOC) Scheme, HOC Formulation, Convection Diffusion equations, HOC stream-function vorticity formulation, HOC wall boundary conditions, Coupled and Decoupled Forms, Error Analysis.

Governing Equations of Fluid Mechanics: Orthogonal Curvilinear Coordinates, Continuity Equation, Momentum Equation, Energy Equation, Equation of State, Chemically Reacting Flows, Vector Form of Equations, Nondimensional Form of Equations.

Boundary-Layer Equations: Background, Boundary-Layer Approximation for Steady Incompressible Flow.

Euler and Navier-Stokes' equations, Incompressible viscous flow field computation, Spatial and temporal discretization on collocated and on staggered grids, Stream function vorticity formulation, Implementation of boundary conditions.

References

1. Chung, T.J., Computational Fluid Dynamics, Cambridge University Press, 2002
2. Anderson, Jr.,J.D., Computational Fluid Dynamics-The Basic with Applications, McGraw-Hill.
3. Niyogi, P., Chakraborty, S. K. and Laha, M. K., Introduction to Computational Fluid Dynamics, Pearson education, Delhi, 2005.
4. Thompson, J.F., Warsi, Z.U.A. and C.W. Martin, C.W., Numerical Grid Generation, Foundation and Applications, North Holland 1985.
5. Schlichting, H., Gersten, K., Boundary – Layer Theory, 8th Ed., Springer 2000
6. Fletcher, C. A. J., Computational Techniques for Fluid Dynamices, Vol-1 and Vol-II, Springer.
7. Peyret, R., and Taylor, T. D., Computational Methods for Fluid Flow, Springer 1983.
8. Tannehill, J.C, Anderson, D.A., and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer.
9. Hoffman, J. D. , Numerical methods for Engineers and scientific, McGraw-Hill.

MMATACT405: Computer Applications and Graph Theory

Marks – 50 (Theory – 30 & Practical – 20)

Objectives: This paper is offered as the Add on Course in the CBCS system. This paper includes the useful topics like, Word processing, Excel spreadsheet, Power Point Presentation, Latex, Graph plotting using Excel.

In graph theory, the students will able to learn about the study about different types of graphs with real examples.

Syllabus Contents

Introduction of Computer: Computer and its components; Characteristics of Computer, Generation of Computer, Software, Hardware and Firmware. Types of Computer, Language data processing, Number system; Binary, Octal, Hexadecimal and decimal number system and their conversion, Binary Arithmetic: Addition, subtraction, multiplication, Division and I/O devices. Semiconductor Memory and its types – Primary V/s Secondary memory, Registers, RAM, DRAM, SRAM, ROM, PROM, EPROM, EEPROM, CACHE Memory, Secondary Memory, Magnetic tape, Magnetic disk, Compact disk.

Introduction to Word Processing: Advantages of word processing, Creating, Saving and Editing a document: Selecting, Deleting, Replacing Text, Copying text to another file. Formatting Text and Paragraph: Using the Font Dialog Box, Paragraph Formatting using Bullets and Numbering in Paragraphs, Checking Spelling, Line spacing, Margins, Space before and after paragraph. Handling Graphics, Creating Tables and Charts, Document Templates and Wizards. Page Design and Layout. Simple Mathematical Expressions. 2 columns writing, writing in portrait orientation.

Introduction to spreadsheet or Excel: Entering information: Numbers, Formula, Editing Data in a cell, Excel functions, Using a Range with SUM, Moving and copying data, Inserting and Deleting Row and Columns in the worksheet, Using the format cells Dialog box, Using chart wizard to create a chart.

PPT: Introduction of slide presentation, Slide show, Formatting, Creating a Presentation, Inserting clip Arts, Adding Objects, Applying Transitions, Animation effects, formatting and checking text. Adding Clip Art and other pictures, Designing Slide Shows, Running and Controlling a Slide Show, Printing Presentations.

Introduction to LATEX: Advantages of Latex, Formatting Text and Paragraph: using Bullets and Numbering in Paragraphs, Line spacing, Margins, Space before and after paragraph. Handling Graphics, Creating Tables and Charts, Document Templates and Wizards. Page Design and Layout. Simple Mathematical Expressions.

Graph Theory

Introduction: Definition-Graph, Subgraph, Complement, Walks, Paths, cycles, connected components, Cut vertices and cut edges, Distance, radius and center, Diameter, Degree sequence, and its application.

Trees: Trees-Cut vertices, Cut edges, Bond, Characterizations of Trees, Spanning trees, Fundamental cycles.

Eulerian and Semi Eulerian Graphs. Hamiltonian Graphs. Maximum edges in a non-hamiltonian graph, Hamiltonian graphs- Necessary condition, Dirac's theorem, Hamiltonian closure of a graph, Traveling salesman problem, Chinese postman problem.

Vertex and edge connectivity. Chromatic number, Bipartite graph. Broke’s Theorem, Mycielski Construction, Chromatic polynomial, edge colouring number.

Matrix Representation: Adjacency matrix, Incidence matrix, Cycle rank and co-cycle rank, Fundamental Cycles with respect to Spanning tree and Cayley’s theorem on trees.
Planar graphs: Statement of Kuratowski Theorem, Isomorphism of graphs, Euler’s formula, colour theorem. 4 colour theorem, Dual of a planar Graph.

References

1. Scheid, F., Computers and Programming (Schaum’s series)
2. Bondy and Murty, Graph Theory with Applications (Macmillan, 1976)
3. Deo, N., Graph Theory (Prentice-Hall, 1974)
4. Harary, F., Graph Theory (Addison-Wesley, 1969)
5. Pathasarthy, K. R., Basic Graph Theory (TMH., 1994).
6. J A Bondy and U. S R Murty, Graph Theory, GTM 244 Springer, 2008.
7. D.B.West, Introduction to Graph Theory, PHI, 2009.

Outcomes: The topics included in this paper are very interesting and of most useful and essential to all of the students. Along with the theory classes, the practical classes are also allotted to develop the practical skill of the students.

Using graph theory, the students will be able to learn and solve the problems of relating to real life.

MMATACT406: Term paper/Project/Dissertation (Marks: 50)

Objectives: ***The project work/term paper/dissertation is a compulsory paper to all students. Some advanced topics related to special papers or any advance topic or review work of research papers will be chosen by the students after discussion with their respective supervisor. The in depth study of the selected topic is needed and some advancement can be proposed in the concerned topic.***

The project work and/or group project work will be performed on some advanced topics related to special papers or any advance topic or review work of research papers. The marks distribution of project work is as follows: 20 marks are allotted for written submission, 20 marks are for seminar presentation and 10 marks are allotted for viva-voce examination.

Outcomes: The typing skill of the students will be developed so as to prepare the dissertation paper. To develop the communication skill and presentation skill are also the aim of this paper. There is a scope to publish the dissertation papers in journals also.