छत्रपति शाहू जी महाराज विश्वविद्यालय, कानपुर

CHHATRAPATI SHAHU JI MAHRAJ UNIVERSITY, KANPUR

(पूर्ववर्ती कानपुर विश्वविद्यालय कानपुर)

Formerly Kanpur University, Kanpur – 208024

A Documentary Support

For

Metric No. – 1.1.1

Programme Outcomes & Course Outcomes

Under the

Criteria - I

(Curriculum Design and Development)

Key Indicator - 1.1

In

Metric No. – 1.1.1

M.Sc. Mathematics

Co-ordinator
Internal Quality Assurance Cell
CSJM University, Kanpur

(Registrar)
C.S.J.M.University
Kanpur

REGISTRAR
C.S.J.M. UNIVERSITY
KANPUR

DEPARTMENT OF MATHEMATICS, SCHOOL OF BASIC SCIENCES, UIET, CSJM UNIVERSITY, KANPUR

Vision:

- To develop logical, analytical and Mathematical thinking power in the minds of students in order to cater the Mathematical needs of the society.

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Mission:

- To offer globally-relevant, industry-linked, research-focused, technology-enabled seamless education at the graduate, postgraduate and research levels in various areas of Mathematical sciences keeping in mind that the manpower so spawned is excellent in quality, is relevant to the global scientific and technological needs, is motivated to give its best and is committed to the growth of the Nation.

M.Sc. in Mathematics (2 year duration)
Department of Mathematics, School of sciences
CSJM University, Kanpur

Program Outcomes of M.Sc. (Mathematics), School of Basic Sciences:

1. **Mathematical Knowledge**

Various branches of Mathematics are so selected and designed for M.Sc. Mathematics course aiming at mathematical reasoning, sophistication in thing and acquaintance with enough number of subjects including application oriented ones to suit the present needs of various allied branches in Engineering and Science as well as provision of opportunities to pursue research in higher mathematics.

2. **Problem Solving Skills**

This programme also offers training in problem solving skills.

3. **Analytical& Logical Thinking**

The student will be able to develop logical reasoning techniques and Techniques for analysing the situation.

4. **Analysis**

The student shall get an insight in the behaviour of curves defined on a closed and bounded interval and some important properties of continuous, monotonic, and differentiable functions defined on a closed and bounded interval and also their metric space an alogues.

5. **Numerical Techniques.**

The student will be able to learn some useful approximation and interpolation techniques in Mathematics.

6. **Advanced Discrete Mathematics.**

The student will learn concepts like finite state machine, Boolean algebra, lattice which develops more useful logic in the development of theories of electronic computers, networks, switching circuits that are applicable in Physics.

7. **Learning Number theoretical concepts.**

Student will learn some important concepts in Number theory that are useful in Cryptography related to the advanced area of research namely Network security.

8. **Understanding Ability.**

Student will develop ability for generation of mathematical model to a given real life situation as well as learning new areas of mathematics in future either for teaching or for research.

9. **Getting Abilities**

The student shall acquire capability to evaluate hypothesis, methods and evidence with in their proper contexts in any situation.

10. Evaluating capability

The student shall acquire capability to evaluate hypothesis, methods and evidence within their proper contexts in any situation.

11. Application of knowledge

The student shall able to apply the knowledge acquired in mathematics in science, technology as well as research and its extensions.

12. Qualify national level tests like NET/GATE etc.

Program Specific Outcomes:

1. Understanding of the fundamental axioms in mathematics and capability of Developing ideas based on them.
2. Inculcate mathematical reasoning.
3. To develop one's own learning capacity.
4. Prepare and motivate students for research studies in mathematics and related fields.
5. Develop abstract mathematical thinking
6. Assimilate complex mathematical ideas and arguments.
7. To inculcate innovative skills, team work, ethical practices among students so as to meet societal expectations.

Program Educational Objectives:

1. The M.Sc. Mathematics programme aims to prepare students with a deep understanding of mathematical concepts, research oriented attitude and skill of application of mathematical and computational tools and techniques in formulation and solution of global, regional, National and Local problem.
2. It is specially designed to prepare students for a successful career in academic institution, research institution and industry.

3. Students will be able to communicate mathematical ideas with clarity and coherence, both written and verbally.

4. They will be able to conduct independent research in specialized areas of mathematics, teach courses in mathematics or subjects with high mathematical content at school and college level, and work in industry involving applications of mathematics.

5. The graduates will engage in professional activities to enhance their own stature and simultaneously contribute to the profession and the society at large.

Global Need National Need Regional Need Local Need

Semester-wise Course Structure (M. Sc. Mathematics)

1st Year–Semester I

Sl. No.	Course Code	Course Title	L	T	P	Credits	Internal Marks	External Marks	Total Marks
1.	MMA-101	Linear Algebra	3	1	0	4	25	75	100
2.	MMA-102	Real Analysis	3	1	0	4	25	75	100
3.	MMA-103	Ordinary Differential Equations	3	1	0	4	25	75	100
4.	MMA-104	Complex Analysis	3	1	0	4	25	75	100
5.	MMA-105	Programming in Python	3	0	2	5	25	75	100
		Total	**15**	**4**	**2**	**21**	**125**	**375**	**500**

1st Year–Semester II

Sl. No.	Course Code	Course Title	L	T	P	Credits	Internal Marks	External Marks	Total Marks
1.	MMA-201	Abstract Algebra	3	1	0	4	25	75	100
2.	MMA-202	Numerical Method	3	1	0	4	25	75	100

3.	MMA-203	Partial Differential Equations	3	1	0	4	25	75	100
4.	MMA-204	Integral Transforms	3	1	0	4	25	75	100
5.	MMA-205	Probability and Statistics	3	1	0	4	25	75	100
		Total	**15**	**5**	**0**	**20**	**125**	**375**	**500**

2ndYear–SemesterIII

Sl. No.	Course Code	Course Title	L	T	P	Credits	Internal Marks	External Marks	Total Marks
1.	MMA- 301	Discrete Mathematics	3	1	0	4	25	75	100
2.	MMA-302	Number Theory	3	1	0	4	25	75	100
3.	MMA-303	Topology	3	1	0	4	25	75	100
4.	MMA-304	Integral Equation and Calculus of Variation	3	1	0	4	25	75	100
5.	**Elective–I** MMA-305(A) MMA-305(B) MMA-305(C) MMA-305(D)	Mathematical Statistics Graph Theory Mechanics Special Function	3	1	0	4	25	75	100
		Total	**15**	**5**	**0**	**20**	**125**	**375**	**500**

2nd Year–Semester IV

Sl. No.	Course Code	Course Title	L	T	P	Credits	Internal Marks	External Marks	Total Marks
1.	MMA- 401	Fluid dynamics	3	1	0	4	25	75	100
2.	MMA-402	Cryptography	3	1	0	4	25	75	100
3.	MMA-403	Operations Research	3	1	0	4	25	75	100
4.	Elective -II MMA-404 (A) MMA-404 (B) MMA-404 (C) MMA-404 (D)	Functional Analysis Measure Theory Optimization Techniques Theory of Linear Operators	3	1	0	4	25	75	100
5.	MMA-405	Project and Seminar	4	0	0	4	25	75	100
		Total	**16**	**4**	**0**	**20**	**125**	**375**	**100**

Total Credits– 81.

Detailed Syllabus

Semester- I

Course Code: MMA-101 **Total Marks: 100, Credit: 4**
Course Name: Linear Algebra

Course out comes (CO): At the end of the course, the student will be able to:

CO1	Find rank, nullity of linear transformation and its row space and column space.
CO2	Understand notion of dual space and dual of dual space.
CO3	Understand concepts of bilinear forms, adjoint operators and spectral theorem.
CO4	Find geometric and algebraic multiplicity of Eigen values and its relation with diagonalization of matrix.
CO5	Apply the above concepts to other disciplines.

Course Details:

Unit -I: Vector space, Direct sum, linear transformation, Range & null space of linear transformation, Matrix representation of linear transformation, Inverse linear transformation, Change of basis matrix.

Unit-II: Eigen values and Eigen vectors, Cayley-Hamilton Theorem, Diagonalization, Geometric and algebraic multiplicity, minimal & characteristic polynomial of Block matrices.

Unit III: Inner products, Cauchy-Schwartz Inequality, orthogonality, orthonormal sets, projections, Gram-Schmidt orthogonalization, Bessel's inequality.

Unit-IV:Linear functional, and Dual space , Dual basis, Annihilators, transpose of linear mapping, Bilinear form, matrices of bilinear form, alternating bilinear form, diagonalization algorithm, Symmetric bilinear form, Law of Inertia, positive definite, orthogonal projections.

Text and Reference Books:

1. Linda Gilbert and Jimmie Gilbert, Elements of Modern Algebra, Seventh edition, Cengage Learning, 7th Edition, 2009.

2. Herstein, I.N, Topics in Algebra, 7th edition, John Wiley & Sons, 2004

3. Hoffman, K and Kunze, R, Linear Algebra, Pearson Education (Asia) Pvt. Ltd/Prentice Hall of India, 2004

4. Leon, S.J, Linear Algebra with Applications, 8th Edition, Pearson, 2009.

Semester -I

Course Code: MMA-102 **Total Marks: 100, Credit: 4**

Course Name: Real Analysis

Course out comes (CO): At the end of the course, the student will be able to:

CO1	Describe the fundamental properties of the real numbers that underpin the formal development of real analysis
CO2	Demonstrate an understanding of the theory of sequences and series, continuity, differentiation and integration
CO3	Demonstrate skills in constructing rigorous mathematical arguments
CO4	Apply the theory in the course to solve a variety of problems at an appropriate level of difficulty.
CO5	Demonstrate skills in communicating mathematics.

Course Details:

Unit –I: Elementary set theory, Countable and Uncountable sets, Real number system and its order completeness, Dedekind's theory of real numbers, Construction of real field from the field of rational numbers,

Unit –II: Definition and existence of Riemann-Stieltjes integral, Properties of the integral integration and differentiation, Fundamental theorem of integral calculus, Riemann- Stieljes integration, integration of vector valued functions, Rectifiable curves,.

Unit –III: Sequences and series of functions Point wise and uniform convergence of sequences of functions, Equicontinuity, Weierstrass approximation theorem, Power Series, Uniqueness theorem for power series, Abel's theorems. Arzelà-Ascoli Theorem, Dini's Theorem, Stone-Weierstrass Theorems.

Unit –IV: Functions of several variables, Euclidian spaces, concept of functional of several variables, Linear transformations, continuous functions, Derivatives in an open subset of R^n , Chain rule, Partial derivatives, Interchange of the order differentiation, Inverse function theorem, Implicit Function theorem, Derivatives of higher order.

Text and Reference Books:

1. GF Simmons: Introduction to Topology and Modern Analysis, McGraw Hill, 1963.

2. JL Kelly: Topology, Von Nostrand Reinhold Co. New York, 1995.

3. Real Analysis by H.L. Royden, 4th edition, 2010.

4. Measure Theory and Integration, by G.de Barra, 2nd Edition, 2013.

Semester -I

Course Code: MMA-103 **Total Marks: 100, Credit: 4**

Course Name: Ordinary Differential Equations

Course out comes (CO): At the end of the course, the student will be able to:

CO1	Recognize differential equations that can be solved by each of the three methods – direct integration, separation of variables and integrating factor method – and use the appropriate method to solve them
CO2	Use an initial condition to find a particular solution of a differential equation, given a general solution
CO3	Check a solution of a differential equation in explicit or implicit form, by substituting it into the differential equation.
CO4	Understand the various terms used in of population models and radioactivity..
CO5	Solve a homogeneous linear system by the Eigen value method.

Course Details:

Unit- I: Existence and uniqueness of solution; Continuity and differentiability of solution w.r.t. initial condition and parameters; General theory of linear deferential equations; Methods of solving non homogeneous linear equations; Cauchy Euler equation; Linear equations with periodic co efficient; System of linear deferential equations; Stability theory for system of linear deferential equations.

Unit- II: System of first order equation: Nonlinear system, Volterra's prey & predator equation, Non Linear equation: Autonomous system. The phase plane & its phenomena, types of critical points & stability. Critical points & stability for linear system, stability by Liapunov's direct method simple critical points of non linear system &non linear mechanics.Conservative system, Periodic solution, Poincare – Bendixson Theorem.

Unit -III: Eigen Value Problem, Orthogonality of Eigen Function, Eigen function expansion in series of orthonormal function, Matrix method for linear system of homogenous and non homogenous equation.

Unit- IV: Second order differential equation Introduction, Preliminary results, Boundedness of solution, Oscillatory equation, number of zeroes, Pruffer's transformation, Strum Liouville boundary value problems Oscillation theory, Green's function.

Text and Reference Books:

1. E. A. Coddington and N. Levinson: Theory of Ordinary Differential Equations, McGraw Hill, 1955.
2. S. L. Ross: Differential Equations, John Wiley sons, New York, 3rd edition, 1984.
3. Shair Ahmad and M.R.M Rao: Theory of ordinary differential equations. Affiliated East-West Press Private Ltd. New Delhi, 1999.
4. G.F. Simmons: Differential Equations, McGraw Hill, 1991.
5. E. D. Renvilleand P. E. Bedient: Elementary Differential Equations, McGraw Hill, 1969.

Semester -I

Course Code: MMA-104 **Total Marks: 100, Credit: 4**

Course Name: Complex Analysis

Course out comes (CO): At the end of the course, the student will be able to:

CO1	Apply the concept and consequences of analyticity and the Cauchy-Riemann equations and

	of results on Harmonic and entire functions including the fundamental theorem of algebra, Analyze sequences and series of analytic functions and types of convergence,
CO2	Evaluate complex contour integrals directly and by the fundamental theorem, apply the Cauchy integral
CO3	Theorem in its various versions, and the Cauchy integral formula, and represent functions as Taylor, power and Laurent series, classify singularities and poles, find residues
CO4	Evaluate complex integrals using the residue theorem.
CO5	Understand range of analytic functions and concerned results.

Course Details:

Unit –I: Analytic Function, Cauchy- Riemann Equation, harmonic conjugates, Power series, Radius of Convergence of Power series, Power series representation of an analytic function, Cauchy hadamard's theorem.

Unit –II: Elementary function: Branch Point, Branch cut, branch of multivalued function, Analyticity of branches of Log z, z^a, Mobius transforms, Conformal mapping, Cauchy's theorem, Cauchy integral formula, Morera's theorem, Open mapping theorem, Cauchy's inequality, Liouville's theorem and applications, Taylor's and Laurent's series, Maximum modulus principle and Schwarz's Lemma.

Unit –III: Singularity: zeroes of an analytic function, Singular point, different types of singularities, limiting point of zeroes and poles, Weierstrass theorem.

Unit –IV: Calculus of Residue's: Residue at pole, Residue at infinity, Cauchy's residue theorem, Jordan's lemma, Evaluation of real definite integral, evaluation of improper integral, Meromorphic function, Argument principle and Rouche's theorem.

Text and Reference Books:

1. J.B. Conway : Functional of one complex variable, Narosa, 1987.

2. L. V. Ahlfors : Complex analysis, McGraw Hil, 1986

3. Churchill, J. W. and Brown, R.V., " Complex Analysis", McGraw Hill. 2009

Semester -I

Course Code: MMA-105 **Total Marks: 100, Credit: 4**

Course Name: Programming in Python

Course out comes (CO): At the end of the course, the student will be able to:

CO1	Understand syntax of python language.
CO2	Convert mathematical problem in programming code
CO3	Express proficiency in handling of strings and functions.
CO4	Develop programs on topics learnt in M.Sc. program, like Newton Raphson method, transportation problems etc.
CO5	Articulate the Object-Oriented Programming concepts such encapsulation and inheritance

Course Details:

Unit-I:
Inttroduction:TheProgrammingCycleforPython,PythonIDE,InteractingwithPythonPrograms, Elements python,TypeConversion.Expressions,AssignmentStatement,ArithmeticOperators,OperatorPrecedence,BooleanExpression.

Unit- II: Conditionals**:**ConditionalstatementinPython(if-elsestatement,itsworkingandexecution),Nested-ifstatement andElif statement python,ExpressionEvaluation&FloatRepresentation.Loops:Purposeandworkingofloops,Whileloopincludingitsworking,ForLoop,NestedLoops,Breakand Continue.

Unit -III: Function: Parts of A Function, Execution of A Function, Keyword and Def ault Arguments, Scope Rules.
Strings: Length of the string and perform Concatenation and Repeat operations init.Indexing and Slicing of Strings.
Python Data Structure: Tuples ,Unpacking Sequences ,Lists, Mutable Sequences, List Comprehension, Sets, Dictionaries
Higher Order Functions: Treat functions as first class Objects, Lambda Expressions.

Unit-IV: Sieve of Eratosthenes: generate prime number switch the help of an algorithm given by the Greek Mathematician named Eratosthenes, whose algorithm is known as Sieve of Eratosthenes.

FileI/O: File input and output operations in Python Programming Exceptions and Assertions
Modules: Introduction, Importing Modules
Abstract Data Types: Abstract data types and ADT interface in Python Programming.
Classes: Class definition and other operations in the classes, Special Methods (suchas_init_,_str_,comparison methods and Arithmetic method set c.), Class Example,

Inheritance, Inheritance and O**OP.**

Unit -V: Iterators & Recursion: Recursive Fibonacci, Tower of Hanoi
Search: Simple earchand Estimating Search Time, Binary Search and Estimating Binary Search Time
Sorting &Merging: Selection Sort, Merge List, Merge Sort, Higher Order.

Text and Reference Books:

1. Allen B. Downey, "Think Python: How to Think Like a Computer Scientist", 2nd edition, Updated for Python 3,Shroff/O'ReillyPublishers,2016 (http://greenteapress.com/wp/thinkpython/)

2. Guido van Rossum and Fred L. Drake Jr, ―An Introduction to Python – Revised and updated for Python 3.2, NetworkTheoryLtd., 2011.

3. JohnVDuttag―IntroductiontoComputationandProgrammingUsingPython'',Revised and expanded Edition, MIT Press, 2013.

4.Robert Sedgewick, Kevin Wayne, Robert Dondero, ―Introduction to Programming in Python: An Inter-disciplinary Approach, Pearson India Education Services Pvt. Ltd.,2016.Timothy A. Budd, ―Exploring Python‖, Mc-Graw Hill Education (India) Private Ltd.

Semester -II

Course Code: MMA-201 **Total Marks: 100, Credit: 4**

Course Name: Abstract Algebra

Course out comes (CO): At the end of the course, the student will be able to:

CO1	. Students will be able to perform computations involving divisibility of integers.
CO2	Students will be asked to identify ring-theoretic and group-theoretic properties and identify these properties in familiar rings and groups.
CO3	Students will provide proofs to simple assertions of ring- and group-theoretic principles.
CO4	It will help them to get a better understanding of later course In algebra and number theory and thus should give students a better platform to study more advanced topics in algebra.
CO5	The student will be able to apply the basic concepts of field theory, including field extensions and finite fields.

Course Details:

Unit –I: Groups, Normal and subnormal series, Composition series, Jordan- Holder theorem, Solvable groups, Nilpotent groups, P- Sylow subgroup, Cauchy's theorem, Conjugacy relation, Class equation, Direct product, Sylow's theorems, structure theorem for finite abelian groups.

Unit –II: Integral domain, Imbedding theorem, prime and maximal ideals, Quotient rings, Euclidean rings, Polynomial rings, Gaussian ring, unique factorization theorem.

Unit –III: Field extension, algebraic and transcendental extensions, separable and inseparable extensions, Normal extensions, perfect field, Finite field, Primitive elements, Algebraically closed fields, Automorphisms of extensions, Galois extensions, fundamental theorem of Galois theory; solvability by radicals.

Unit –IV: Canonical Forms: Similarity of linear transformations, Invariant subspaces, Reduction to triangular forms, Nilpotent transformations, the primary decomposition theorem, Jordan blocks and Jordan forms.

Text and Reference Books:

1. Serge Lang: Algebra, Addison Wesley, 1965.

2. V. Sahai &V. Bist: Algebra, Second edition, Narosa, 2013.

3. I.N. Herstain, Topic in Algebra, Wiley Eastern limited, New delhi, 1975.

Semester -II

Course Code: MMA-202 **Total Marks: 100, Credit: 4**
Course Name: Numerical Method

Course out comes (CO): At the end of the course, the student will be able to:

CO1	Solve transcendental, non-linear equations and system of non-linear equations, error analysis and its importance.
CO2	Interpolate and extrapolate the data's using various interpolating methods, like, cubic spline, Newton's divided difference etc.
CO3	Integrate and differentiate functions using Newton's cotes and Gaussian quadrature formula.
CO4	Solve ODE and boundary value problems using numerical methods.

CO5	To learn numerical solution of differential equations

Course Details:

Unit I: Roots of transcendental equations and polynomial equations, Bisection method, Iteration based on first degree equations, Regula-Falsi methods, Rate of convergence, Generalized Newton- Raphson method.

Unit II: System of linear equation: Direct method-: Gauss Elimination method, Triangularization method, Iterative methods-: Jacobi's method, Gauss-Seidel method, SOR method, Givens power method for Eigen value and Eigen vectors.

Unit III: Interpolation and Approximation: Lagrange's and Newtons divided difference, Finite difference operators, Hermite interpolation, piecewise & cubic spline interpolation, Least square approximation, Min-Max polynomial approximation method, Chebyshev polynomial, Lanczos economization.

Unit -IV: Newton cotes methods, Method based on Undetermined coefficients, Gauss Legendre integration method.

Unit-V: Numerical Methods for ODE: Single step method- Euler's method, Taylor series method, Runge- Kutta method of 2^{nd} and 4^{th} order, Numerical methods for BVP, Multistep method, :predictor -corrector method, Adams Bashforth method, Adams Moulton method, Milne method, convergence and stability.

Text and Reference Books:

1. Gerald, C.F and Wheatly, P.O," Applied Numerical Analysis", 6^{th} edition, Wesley, 2002.

2. Jain, M.K, Iyengar, S.R.K and Jain,R.K, "Numerical methods for Scientific and Engineering computation", New Age Pvt.Pub,New-Delhi,2000.

3. Introduction to Numerical Analysis by S.S Sastry, Prentice Hall,Flied, 5^{th} edition, 2012.

4. Krishnamurthy, E.V &Sen, S.K , Applied Numerical analysis, East West Publication.

Semester -II

Course Code: MMA-203 **Total Marks: 100, Credit: 4**

Course Name: Partial Differential Equations

Course out comes (CO): At the end of the course, the student will be able to:

CO1	Use knowledge of partial differential equations (PDEs), modeling, the general structure of

	solutions, and analytic and numerical methods for solutions.
CO2	Formulate physical problems as PDEs using conservation laws.
CO3	Understand analogies between mathematical descriptions of different (wave) phenomena in physics and engineering.
CO4	Solve practical PDE problems with finite difference methods, implemented in code, and analyze the consistency, stability and convergence properties of such numerical methods.
CO5	Interpret solutions in a physical context, such as identifying travelling waves, standing waves, and shock waves.

Course Details:

Unit-I: Introduction, basic concept and definition, classification of second order linear equation and method of characteristics, canonical form, Equations with constant coefficients, Supper position principle. Method of separation of variables.

Unit- II: Boundary Value Problems, Maximum and Minimum Principles, Uniqueness and Stability theorem, Dirichlet problem for a Circle, Dirichlet Problem for a Circular annulus, Neumann problem for a Circle, Dirichlet problem for a Rectangular, Dirichlet problem involving Poisson equation.

Unit-III: The Cauchy problem: The Cauchy problem, Cauchy-Kowalewsky Theorem, Hadmard example, Cauchy problem for homogeneous wave equations, Initial value problem, The Cauchy problem for Non-homogenous wave equation., The vibration string problem, Existence and uniqueness solution of the vibrating problem.

Unit- IV: Fourier transform and Initial boundary value problems. Properties of Fourier Transform, Convolution (Fourier Transform), Step and impulse Function Fourier Transform, Semi infinite region, Green's functions and boundary value problem.

Text and Reference Books:

1. L. C. Evans, Partial Differential Equations, Graduate Studies in Mathematics, Vol. 19, AMS, 1999.

2. JurgenJost, Partial Differential Equations: Graduate Text in Mathematics, Springer Verlag Heidelberg, 1998.

3. Robert C Mcowen, Partial Differential Equations: Methods and Applications, Pearson Education Inc., 2003.

4. Fritz John, Partial Differential Equations, Springer-Verlag, 1986.

5. I.N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, 1988.

Semester -II

Course Code: MMA-204 **Total Marks: 100, Credit: 4**

Course Name: Integral Transform

Course out comes (CO): At the end of the course, the student will be able to:

CO1	Solve differential equations with initial conditions using Laplace transform
CO2	Evaluate the Fourier transform of a continuous function.
CO3	Axisymmetric problems in cylindrical polar coordinates are solved withHankel transform.
CO4	Analysing the behaviour of many functions with Mellintansform.
CO5	Students will gain a range of techniques employing the Laplace and Fourier Transforms in the solution of ordinary and partial differential equations. They will also have an appreciation of generalized functions, their calculus and applications.

Course Details:

Unit –I: Laplace Transform: Existence of Laplace Transform, Function of exponential order, a function of Class A, Laplace Transform of some elementary function, First and Second translation, change of scale property, Laplace transform of the derivative, Laplace transform of Integral, Multiplication, Division , Periodic function.

Unit-II: Inverse Laplace Transform: Null Function, Lerch's Theorem, first and second Translation, Change of scale, Derivatives, Integrals, Multiplication, Division, Convolution Theorem, Heviside's expansion, The complex inversion formula.

Applications: Solution of Ordinary Differential equations. Solution of Simultaneous Ordinary differential equations, Solution of Partial differential equation, Application to Electric circuits, Mechanics. Integral equations, Initial and Boundary value problem

Unit-III: Fourier Integral theorem, Fourier Transform, Convolution, Relation between Fourier and Laplace Transform, Parseval'sIndentity for Fourier Transform, Relationship between Fourier and Laplace Transforms, Fourier Transform of derivative of function, Finite Fourier Transform, Application of Fourier transform in Initial and Boundary value problems.

Unit-IV: HankelTransfrom, Inversion formula for the Hankel Transform, Some important results for Bessel function, Hankel Transform of derivative of Function, Parsevals Theorem, Finite Hankel Transform, Application of Hankel Transform in initial and Boundary value Problems.

Unit –V: Mellin Transform, The Mellininversion Theorem, Linear property, some elementary properties,, Mellin transform of derivative, Mellin transform of Integral, convolution Theorem.

Text and Reference Books:

1. Ian N Senddon: The Use of Integral Transform, McGraw Hill, 1972.
2. L. Dobanth and D. Bhatta: Integral Transforms and Their Applications, 2nd edition, Taylor and Francis Group, 2nd edition, 2006.
3. E. Kreyszig: Advanced Engineering Mathematics, John Wiley & Sons 2011

Semester -II

Course Code: MMA-205 **Total Marks: 100, Credit: 4**

Course Name: Probability and Statistics

Course out comes (CO): At the end of the course, the student will be able to:

CO1	Organize, manage and present data. Analyze statistical data using measures of central tendency, dispersion and location.
CO2	Translate real-world problems into probability models.
CO3	Derive the probability density function of transformation of random variables.
CO4	Calculate probabilities, and derive the marginal and conditional distributions of bivariate

	random variables.
CO5	Understand critically the problems that are faced in testing of a hypothesis with reference to the errors in decision making.

Course Details:

Unit- I: Probability: Axiomatic definition, Properties. Conditional probability, Bayes rule and independence of events, Random variables, Distribution function, Probability mass and density functions, Expectation, Moments, Moment generating function.

Unit-II: Probability distributions: Binomial, Geometric, Negative -Binomial, Poisson, Uniform, Exponential, Gamma, Normal distributions, Moments Independence of random variables, Covariance, Correlation, Functions of random variables.

Unit-III: Statistics: Population, Sample, Parameters. Method of moment, Unbiasedness, Confidence interval, estimation for mean, difference of means, variance, proportions, Sample size problem,

Unit- IV: Test of Hypotheses: Tests for means, variance, two sample problems, Test for proportions, Relation between confidence intervals and tests of hypotheses, Chi-square goodness of fit tests, Contingency tables.

Text and Reference Books:

1. S.C. Gupta and V.K. Kapoor: "Fundamentals of Mathematical Statistics" Sultan Chand & Sons New Delhi, 2014

2. V. K. Rohatgi and A. K. Md. EhsanesSaleh: An Introduction to Probability and Statistics", John Wiley and Sons, 2nd edition.2000.

3. R. V. Hogg and A. Craig: Introduction to Mathematical Statistics, Pearson Education, 6th Edition, 2005.

Semester -III

Course Code: MMA-301 **Total Marks: 100, Credit: 4**

Course Name: Discrete Mathematics

Course out comes (CO): At the end of the course, the student will be able to:

CO1	Have the knowledge of Fibonacci sequence, linear recurrence relations with constant coefficients.
CO2	Construct generating function and study its application to counting and in solving recurrence

	relations.
CO3	Simplify logic and Boolean circuits using K-maps.
CO4	Find principle disjunctive & conjunctive normal forms and application of inference theory.
CO5	Grasp the concepts of relations, posets and lattices and understand the relation between Lattices and Boolean algebra.

Course Details:

Unit- I: Logic: Introduction to logic, Rules of Inference, Validity of arguments, Normal forms, Direct and Indirect proofs, Proof by contradiction.

Unit -II: Recurrence relations with examples of Fibonacci numbers, the tower of Hanoi problem, Difference equation, Generating function, solution of recurrence relation using generating functions.

Unit -III: Definition and types of relations, representing relations using digraphs and matrices, closure of relations, paths in diagraph, Transitive closure using Warshall's algorithm, Posets, Hasse diagram, Lattices.

Unit- IV: Boolean algebra and Boolean functions, different representations of Boolean function, application to synthesis of circuits, circuit minimization and simplification, Karnaugh map.

Unit-V: Automata theory, Finite state automaton, Types of automaton, Deterministic finite state automaton, Non-deterministic finite state automaton, Non-deterministic finite state automaton, Equivalence of NFA and DFA, Finite state machines: Moore and Mealy machine and their conversion, Turning machine.

Text and Reference Books:

1.C.L Liu: Elements of Discrete Mathematics, Tata McGraw- Hill,2000

2. Kenneth Rosen, WCB McGraw-Hill, 6th edition, 2004

3. J.P Tremblay and R.P Manohar: Discrete Mathematical structures with Application

to Computer science, McGraw-Hill(1975).

Semester III

Course Code: MMA-302 **Total Marks: 100, Credit: 4**

Course Name: Number Theory

Course out comes (CO): At the end of the course, the student will be able to:

CO1	Utilize the congruence's, indices, residue classes, Linear congruence's Complete & reduced residue systems and the Euler – Fermate Theorem and Learn Chinese remainder theorem & its application and introduction of Cryptography
CO2	Learn more about prime numbers, primality test and analyze Fermat's little Theorem, Wilson theorem, Fermat-Kraitchik factorization method and solve various related problems.
CO3	Understand order of an integer modulo n, primitive roots of primes and composite numbers , theory of indices and implement of these concepts to cryptography.
CO4	Understand the concepts of quadratic residues , Legendre's symbol & Jacobi symbol ,reciprocity law and implement the concepts to Diophantine equations for Solving different types of problems,.
CO5	Work effectively as part of a group to solve challenging problems in Number Theory.

Course Details:

Unit- I: Introduction to Modular forms: Congruence Residue classes and complete residue system. Linear congruences. Reduced residue system and the Euler-Fermat theorem. polynomials congruences modulo p, Lagrange's theorem. Simultaneous linear congruences, The Chinese remainder theorem, Application of Chinese remainder theorem, introduction to cryptography.

Unit-II: Prime numbers, estimate of prime numbers, primality test, Polynomial congruences with prime power modulli, Fermat's little theorem and pseudoprime, Carmichael numbers, Wilson's theorem, Fermat-Kraitchik factorization method, Euler phi function and use of it in RSA cryptanalysis, Euler's generalization of Fermat's little theorem, modular exponentiation by repeated squaring method.

Unit-III: Order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots, theory of indices, application of primitive roots to cryptography.

Unit- IV: Quadratic residues, Euler's criterion, Legendre's Symbol and its properties Gauss Law, the quadratic reciprocity law, Applications of reciprocity law. The Jacobi symbol and reciprocity law for Jacobi symbols. Applications of reciprocity law to Diophantine equations.

Text and Reference Books:

1. A course in number theory and cryptography, Neal Koblitz, Springer-Verlag, 2nd edition, 1994.

2. An introduction to the theory of number, Ivan Niven, Zuckerman, Montgomery, willy India edition, 1991.

3. Elementary number theory, David M. Burton, , Tata McGraw Hill Edition, 7th edition, 2017.

4. Introduction to cryptography, Johannes A. Buchmann, Springer, 2012.

Semester III

Course Code: MMA-303 **Total Marks: 100, Credit: 4**

Course Name: Topology

Course out comes(CO): At the end of the course, the student will be able to:

CO1	Understand concepts of complete metric space , continuity, Uniform continuity, Isometry , homeomorphism and related some important theorems.
CO2	Understand axioms of choice , Zorn's lemma,Well ordering theorem and Cardinal number and its arithmetic.
CO3	Understand the concepts of topological spaces, concepts of Bases and sub bases and the basic definitions of open sets, neighbourhood, interior, exterior, closure and their axioms for defining topological space.
CO4	Understand the Characterization of topology in terms of Kuratowski closures perator, continuity, homomorphism, Separation axioms , regular and normal spaces and some important theorems in these spaces.
CO5	Apply theoretical concepts in topology to understand real world applications.

Course Details:

Unit –I: Completeness of a metric space, Cantor's intersection theorem, Dense sets, Bair category theorem, Separable spaces, Continuous function, Extension theorem, Uniform Continuity, Isometry and homeomorphism, equivalent matrics, Compactness, Sequential compactness, Totally bounded spaces, Finite intersection property, Continuous function and compact sets.

Unit –II: Axiom of choice, Zermelo's postulate, Zorn's lemma, Well ordering theorem, Cardinal number and its arithmetic, Schroeder- Bernstein theorem, Cantor's theorem and the continuous hypothesis

Unit –III: Topological spaces: Definitions and Examples, Basis and Sub basis for a Topology, limit points, closure, interior; Continuous functions, Homeomorphisms; Subspace Topology, Metric Topology, Product & Box Topology, Order Topology; Quotient spaces

Unit –IV: Characteristics of Topology in terms of Kuratowski closures operator and fundamental system in neighborhood, continuous map and homomorphism, first and second countable space, Lindel off theorem , separable spaces, second countability and separablity, Separation axioms, T_0, T_1, T_2, T_3, and T_4 spaces their characterization and basic property.

Text and Reference Books:

1. James R Munkres: Topology, A first course, Prentice Hall, New Delhi, 2000

2. GF Simmons: Introduction to Topology and Modern Analysis, McGraw Hill, 1963.

3. JL Kelly: Topology, Van Nostrand Reinhold Co. New York, 1995.

Semester -III

Course Code: MMA-304 Total Marks: 100, Credit: 4

Course Name: Integral Equations and Calculus of Variations

Course out comes (CO): At the end of the course, the student will be able to:

CO1	. Understand what functional are, and have some appreciation of their applications apply the formula that determines stationary paths of a functional to deduce the differential equations for stationary paths in simple cases.
CO2	Use the Euler-Lagrange equation or its first integral to find differential equations for stationary paths.
CO3	Solve differential equations for stationary paths, subject to boundary conditions, in straightforward cases.
CO4	Conversion of Volterra Equation to ODE, IVP and BVP to Integral Equation.
CO5	The concept of Fredholm's first, second and third theorem, Integral Equations with symmetric kernel, Eigen function expansion, Hilbert-Schmidt theorem.

Course Details:

Unit –I: Integral equation: Basic concept, solution of integral equation, conversion of differential equation to integral equation, Intial value problem and boundary value problem, solution of Fredlholm's integral equation, symmetric kernel, Hilbert's-Schmidt theory, Risz – Fischer theorem.

Unit –II: Solution of Fredhlom integral equation of second kind by successive substitution and successive approximation, Solution of Voltera integral equation of second kind by successive substitution and successive approximation, Reduction of Voltera integral equation into differential equation, reduction of Voltera integral equation of first kind to a Voltera integral equation of second kind, classical Fredhlom theory.

Unit –III: Variational problems with fixed boundary: Eulear's equation, the Brachistochorn problem, functional, Euler's poissioneqution, Isoperimetric problem, variational problem with moving boundary: transversality condition, variational problem with moving boundary with implicit from, one sided variation.

Unit –IV: Sufficient condition for an extremum: Jacobi condition, legendre condition, Lagrenges equation from hamilton's principle, direct method in variational problem: Ritz method, Galerkin's method, Collocation method and least square method.

Text and Reference Books:

1. Gupta A.S., "Calculus of Variations with Applications" Prentice hall of India, 1996.

2. Elsgolts L., Differential equations and calculus of variations", MIR publisher, 1980

Semester -III

Course Code: MMA-305 (A) Total Marks: 100, Credit: 4

Course Name: Mathematical Statistics

Course out comes (CO): At the end of the course, the student will be able to:

CO1	Organize, manage and present data. Analyze statistical data using measures of central tendency, dispersion and location.
CO2	Use the basic probability rules, including additive and multiplicative laws, using the terms, independent and mutually exclusive events.
CO3	Translate real-world problems into probability models.
CO4	Derive the probability density function of transformation of random variables and calculate probabilities, and derive the marginal and conditional distributions of variate random

	variables.
CO5	Determine properties of point estimators (efficiency, consistency, sufficiency); find minimum variance unbiased estimators; find method of moments and maximum likelihood estimators.

Course Details:

Unit-I: SAMPLING DISTRIBUTIONS AND ESTIMATION THEORY: Sampling distributions Characteristics of good estimators Method of Moments, Maximum Likelihood Estimation Interval estimates for mean variance and proportions.

Unit-II: TESTING OF HYPOTHESIS: Type I and Type II errors Tests based on Normal, t, Chi-square and F distributions for testing of mean, varianceand proportions-Tests for Independence of attributes and Goodness of fit.

Unit-III: CORRELATION AND REGRESSION: Method of Least Squares - Linear Regression - Normal Regression Analysis Normal Correlation AnalysisPartial and Multiple Correlation - Multiple Linear Regression.

Unit-IV: DESIGN OF EXPERIMENTS: Analysis of Variance - One-way and two-way Classifications - Completely Randomized Design - Randomized Block Design-Latin Square Design.

Unit-V: MULTIVARIATE ANALYSIS: Covariance matrix – Correlation Matrix - Normal density function -Principal components - Sample variation by principal components-Principal components by graphing.

Text and Reference Books:

1. J.E. Freund: Mathematical Statistica: Prentice Hall of India, 5th Edition, 2001.
2. R.A. Johnson and D.W. Wichern: Applied Multivariate Statistical Analysis, Pearson Education Asia, 5th Edition, 2002.
3. S. C. Gupta and V.K. Kapoor: Fundamentals of Mathematical Statistics, SultanChand& Sons, 11th Edition, 2003.

Semester -III

Course Code: MMA-305 (B) Total Marks: 100, Credit: 4

Course Name: Graph Theory

Course out comes (CO): At the end of the course, the student will be able to:

CO1	Students will achieve command of the fundamental definitions and concepts of graph theory
CO2	Students will understand and apply the core theorems and algorithms, generating examples

	as needed, and asking the next natural question.
CO3	Students will achieve proficiency in writing proofs, including those using basic graph theory proof techniques such as bijections, minimal counterexamples, and loaded induction.
CO4	Students will work on clearly expressing mathematical arguments, in discussions and in their writing
CO5	Students will become familiar with the major viewpoints and goals of graph theory: classification, extremality, optimization and sharpness, algorithms, and duality

Course Details:

Unit- I : Graph and its terminology, Directed and undirected graph, Multi graph, Simple graph, Complete graph, Weighted graph, Planar and non-planar graph, Regular graph, Graph isomorphism and homeomorphism, Euler's formula, Statement and applications of Kuratowski's theorem, Path factorization of a graph, representing graphs in computer system, Coloring of graph.

Unit- II: Graph connectivity, Konigsberg bridge problem, Euleria path and Elerian circuit, Hamiltonian path and Hamiltonian circuit, Shortest path, Dijkstra's algorithm, Paths between the vertices, Path matrix, Warshall's algorithm, Cut point, bridge, cut sets and connectivity, Menger's theorem

Unit-III: Tree and related terminology, spanning tree, Finding minimum spanning tree by Kruskal's algorithm and Prim's algorithm, inorder, preorder, and postorder tree traversals, Binary tree, Expression trees and reverse polish notation (RPN), RPN evaluation by stack.

Unit-IV: Flow network, Feasible flows, Multiple sources and multiple sinks, Cutsets in flow network, Relation between flows and cuts, Max flow problem, Max flow min-cut therem, Matching, Covering, Application of networks in Operations Research – CPM/PERT.

Text and Reference Books:

1. Graph Theory, Harary, Addison- Wesley, 1969

2. Introduction to Graph Theory, D. B. West, Prentice Hall, 1996.

3. Graph Theory and Its Applications, Jonathan Gross and Jay Yellan, CRC, 1998

Semester -III

Course Code: MMA-305 (C) **Total Number: 100, Credit:4**

Course Name: Mechanics

Course out comes (CO): At the end of the course, the student will be able to:

CO1	Newton's laws of motion and conservation principles.
CO2	Introduction to analytical mechanics as a systematic tool for problem solving.
CO3	Relative motion. Inertial and non-inertial reference frames.
CO4	Introduction to analytical mechanics as a systematic tool for problem solving.
CO5	Parameters defining the motion of mechanical systems and their degrees of freedom.

Course Details:

Unit-I: Lagrangian Formulation: Mechanics of a particle, mechanics of a system of particles, constraints, generalized coordinates, generalized velocity, generalized force and potential. D'Alembert's principle and Lagrange's equations, some applications of Lagrangian formulation.

Unit-II: Hamilton's principle, derivation of Lagrange's equations from Hamilton's principle, extension of Hamilton's principle to non-holonomic systems.

Unit-III: Hamiltonian formulation: Legendre transformations and the Hamilton equations of motion, cyclic coordinates and conservation theorems, derivation of Hamilton's equations from a variational principle, the principle of least action, the equation of canonical transformation.

Unit-IV: Poisson and Lagrange brackets and their invariance under canonical transformation. Jacobi's identity; Poisson's Theorem, Equations of motion infinitesimal canonical transformation in the Poisson bracket. Hamilton Jacobi Equations for Hamilton's principal function, the harmonic oscillator problem as an example of the Hamilton-Jacobi method.

Text and Reference Books:

1. H.Goldstein , Classical mechanics , 2nd edition, Narosa Publishing House, 2001.
2. W.Rindler , Relevant topics from Special relativity , Oliver & Boyd, 1960.

Semester -III

Course Code: MMA-305 (D) **Total Marks: 100, Credit: 4**

Course Name: Special Functions

Course out comes (CO): At the end of the course, the student will be able to:

CO1	Explain and Usefulness of this function
CO2	Classify and explain the functions of different types of differential equations
CO3	To determine types of PDE this may be solved by applications of Special functions.
CO4	To analyse properties of Special functions by their integral representation and symmetries
CO5	Identified the application of some basic mathematical methods via all these special functions.

Course Details:

Unit- I: Infinite products: Definition of infinite product, necessary condition for convergence, the associated series of logarithms, absolute convergence, uniform convergence. The gamma function, The beta function, Legendre's duplication formula, Gauss multiplication formula, summation formula due to Euler, behavior of log gamma z for log mod z. Asymptotic series, Watson's lemma.

Unit-II: Hypergeometric function, integral representation, contiguous function relation, hypergeometirc differential equation, logarithmic solution of the hypergeometric function, elementary series manipulation, simple transformation, generalized hypergeometric function, confluent hypergeometric function.

Unit-III: Bessel function: Definition of Bessel function, Bessel differential equation, recurrence relation, generating function, Bessel integral, modified Bessel functions, Neumann polynomial, Neumann series. Legendre Polynomial, Hermite polynomial Jacobi Polynomial : Generating function, differential equation, recurrence relation, Rodrigues formula, Hypergeometric form of Legendre polynomial, special properties, orthogonality, an expansion theorem, expansion of x^{n}.

Unit-IV: Elliptic function: Doubly periodic function, Elliptic function, elementary properties, order of an Elliptic function, The Weierstrass function P(z), other Elliptic function, A differential equation for P(z), connection with Elliptic integral. Theta function: Definition, Elementary properties, the basic properties table. Jacobain Elliptic Function: A differential equation, involving Theta function, The function sn(u), The function cn(u) and dn(u), relation involving square and derivatives.

Text and Reference Books:

1. E. D. Rainville: Special function, MacMillan Co., 1971.
2. .L. C. Andrews, Special function of Mathematics for Engineering, SPIE Publications, 1997.

Semester -IV

Course Code: MMA-401 **Total Marks: 100, Credit: 4**

Course Name: Fluid Dynamics

Course out comes (CO): At the end of the course, the student will be able to:

CO1	Describe the physical properties of a fluid.
CO2	Calculate the pressure distribution for incompressible fluids.
CO3	Describe the principles of motion for fluids.
CO4	Identify derivation of basic equations of fluid mechanics
CO5	Identify how to derive basic equations and know the related assumptions.

Course Details:

Unit –I: Introduction to fluid dynamics, Normal and Shearing stress, Different types of flows, Lagrangian and Eulerian method, local and individual time rate of change, vortricity vector, Beltrami flow, stream line and path line, vortricity equation, equation of continuity by Euler's method, equation of continuity in orthogonal curvilinear coordinates, cartisian coordinates and cylindrical coordinates, Euler's equation of motion in general vector form, Bernoulli's equation .

Unit-II: Viscous flow: Definition of viscosity, general theory of stress and rate of strain in fluid flow, stress analysis in fluid motion, nature of strain, relation between stress and rate of strain, Navier Stokes equation, dissipation of energy, Reynold's.number, study flow between parallel plates , Laminar flow between parallel plates.

Unit-III: Gas dynamics: speed of sound, equation of motion, subsonic, sonic and supersonic flow, isentropic gas flow, Reservoir discharge through a channel of varying cross-section, Shock waves, formation of shock waves, elementary analysis of normal shock waves

Unit-IV: Magneto Hydrodynamics: nature of magneto hydro dynamics, Maxwell electromagnetic field equation, equation of motion of conducting fluid, rate of flow of charge, magnetic Reynold's number, Alfven's theorem, Ferraro's law of isorotation.

Text and Reference Books:

1. Bachelor G.K: An introduction to fluid dynamics, Publisher, Cambridge University Press, 2000

2. Hermann Schilichting, Klaus Gersten, Krause E., Jr. Oertel H., Mayes C: "Boundary – Layer theory" , 8th edition springer, 2004.

3. Kundu, Pijush K., and Cohen Ira M., fluid mechanics. 3rd ed. Burlington, MA: Elsevier, 2004.

Semester -IV.

Course Code: MMA-402 **Total Marks: 100, Credit: 4**

Course Name: Cryptography

Course out comes (CO): At the end of the course, the student will be able to:

CO1	Understand fundamental concepts of cryptography.
CO2	Describe the difference among symmetric, asymmetric and public key Cryptography.
CO3	Define basic requirements of cryptography.
CO4	Apply concepts of Encryption & Decryption.
CO5	Describe the process for implementing cryptographic systems

Course Details:

Unit –I: Secure communication, cryptographic applications, Symmetric cipher model, Substitution technique: Ceasar cipher, Monoalphabatic cipher, Playfair cipher, Hillcipher, polyalphabatic cipher, one time pad, Transposition techniques, pseudorandom bit generator, linear feedback shift register sequences.

Unit-II: Stream cipher and block cipher, simplified DES, Feistel cipher, DES, AES, S-box design, Boolean functions, bent functions, construction of finite fields, modular polynomial arithmetic.

Unit-III: Public key cryptosystem, RSA cryptosystem, RAS and factoring, Rabin encryption , Key management, Diffie Hellman key exchange, discrete logarithm, ElGamal encryption, cryptographick hash function, message authentication codes, digital signature.

Unit-IV: Factoring: p-1 method, quadratic sieve, discrete logarithm: DL problem, Shanks Babystep Giant step algorithm, Pollard pho algorithm, Pohlig-Hellman algorithm, Elliptic curve cryptography

Text and Reference Books:

1. Introduction to crypogrphy, Johannes A. Buchmann, Springer, 1st Edition, 2012.

2. Cryptography and network security Principles and practices, William stallings, Pearson education, 7th Edition, 2017.

3. Handbook of applied cryptography, Alferd J. Menezes, Paul C. Van Oorschot, Scott A. Vanstone, CRC press, 1st Edition, 1996.

4. Introduction to cryptography and coding theory, Wade Trappe, Lawrance C. Washington, 2nd edition, 2005.

Semester -IV

Course Code: MMA-403 **Total Marks: 100, Credit: 4**

Course Name: Operation Research

Course out comes (CO): At the end of the course, the student will be able to:

CO1	Formulate and solve the LPP including those that lead to cycling and degeneracy.
CO2	Apply integer programming to the LPP's where integer solution is sought.
CO3	Solve transportation and assignment problems and their importance.
CO4	Apply the above concepts to real life problems.
CO5	Simulate different real life probabilistic situations using Monte Carlo simulation technique.

Course Details:

Unit I: Origin of OR and its definition, Phases of OR problem approach, Formulation of Linear Programming problems, Graphical solution of LPP.

Unit II: Solution of LPP by Simplex method, Two phase method, Big-M method, Methods to solve degeneracy in LPP, Revised Simplex Methods and applications.

Unit III: Concept of duality in LPP, Comparison of solutions of Dual and Primal, Dual Simplex method, Sensitivity Analysis, Integer Programming.

Unit IV: Mathematical formulation Of Transportation problem, Tabular representation, Methods to find initial basic feasible solution, Optimality test, Method of finding Optimal solution, Degeneracy in Transportation problem, Unbalanced Transportation problem, Mathematical formulation of Assignment problem, Hungarian Assignment method.

Text and Reference Books:

1. Rao,S.S , Optimization theory and applications, 3rd edition,Willey Eastern Ltd., New-Delhi, 1996.

2. Hiller,F.S and Liberman, Introduction to Operations Research, 6th Ed. McGraw-Hill, International Edition, Industrial Engg. Series, 1995.

3. Taha, H.A, Operations Research:An Introduction, 8th Ed, Prentice Hall Publishers, 2006.

4. Gupta, P.K,Hira,D.S, Operations Research, S.Chand& Company Pvt. Ltd, 5th Edition, 1996.

5. Sharma, S.D, Operations Research, Kedar Nath Ram Nath and Co. Meerut, 2002

Semester –IV

Course Code: MMA-404 (A) Total Marks: 100, Credit: 4

Course Name: Functional Analysis

Course out comes (CO): At the end of the course, the student will be able to:

CO1	Central concepts from functional analysis, including the Hahn-Banach theorem, the open mapping and closed graph theorems.
CO2	Banach-Steinhaus theorem, dual spaces, weak convergence, the BanachAnalogue theorem, and the spectral theorem for compact self-adjoint operators.
CO3	The student is able to apply his or her knowledge of functional analysis to solve mathematical problems.
CO4	Appreciate the role of Inner product space. Understand and apply ideas from the theory of Hilbert spaces to other areas.
CO5	Understand the fundamentals of spectral theory, and appreciate some of its power.

Course Details:

Unit-I: Banach Spaces- the definition and some examples, continuous linear transformations,The Hahn Banach theorem,

Unit-II: The natural imbedding of N in N**, the open mapping theorem, the conjugate of an operator.

Unit-III: Hilbert spaces- the definition and some simple properties, Orthogonal complements, orthogonal sets, the Conjugate space H*,

Unit-IV: The adjoint of an operator, Self adjoint operators, normal and unitary operators,Projections. Finite dimensional spectral theory – Spectrum of an operator, the spectral theorem.

Text and Reference Books:

1. G F Simmons: Introduction to Topology & Modern Analysis (McGraw Hill), 2017.

2. JL Kelly: Topology, Von Nostrand Reinhold Co. New York, 1995

3. Real Analysis by H.L. Royden, 4^{TH} edition, 2010.

Semester -IV

Course Code: MMA-404 (B) **Total Marks: 100, Credit: 4**

Course Name: Measure Theory

Course out comes (CO): At the end of the course, the student will be able to:

CO1	Students taking this course will develop an appreciation of the basic concepts of measure theory.
CO2	These methods will be useful for further study in a range of other fields, e.g. Stochastic calculus, Quantum Theory and Harmonic analysis.
CO3	The above outcomes are related to the development of the Science Faculty Graduate Attributes, in particular: 1.Research, inquiry and analytical thinking abilities, 4. Communication, 6. Information literacy
CO4	Integration and contribute to this classical field of knowledge by solving various problems.
CO5	Study the properties of Lebesgue integral and compare it with Riemann integral.

Course Details:

Unit –I: Outer measures, measures and measurable sets, Lebesgue measure on R, Borel measure

Unit –II: Measurable functions, simple functions, Egoroff's theorem, Lebesgue integral and its properties, monotone convergence theorem, Fatou's Lemma, Dominated convergence theorem various modes of convergence and their relations.

Unit-III: Signed measures, Hahn and Jordan decomposition theorems, Lebesgue-Radon-Nikodym theorem, Lebesgue decomposition theorem, the representation of positive linear functionals on $C_c(X)$

Unit –IV: Product measures, iterated integrals, Fubini's and Tonelli's theorems Lp spaces and their completeness, conjugate space of $L_p$for $1 < p<$ infinity, conjugate space of L_1 for sigma-finite measure space Differentiation of monotone functions, functions of bounded variation, differentiation of an integral, absolute continuity.

Text and Reference Books:

1. Rudin, Walter. Real and Complex Analysis. McGraw-Hill International Editions: Mathematics Series. McGraw-Hill Education - Europe, 1986.

2. Jones, Frank. Lebesgue Integration on Euclidean Space. Boston: Jones & Bartlett Publishers, February 1, 1993.

3. Evans, Lawrence C., and Ronald F. Gariepy. Measure Theory and Fine Properties of Function.Boca Raton, Florida: CRC Press, December 18, 1991

Semester -IV

Course Code: MMA-404 (C) **Total Marks: 100, Credit: 4**
Course Name: Optimization Technique

Course out comes (CO): At the end of the course, the student will be able to:

CO1	Operation research models using optimization techniques based upon the fundamentals of engineering mathematics (minimization and Maximization of objective function).
CO2	The problem formulation by using linear, dynamic programming, game theory and queuing models.
CO3	The stochastic models for discrete and continuous variables to control inventory and simulation of manufacturing models for the production decision making.
CO4	Formulation of mathematical models for quantitative analysis of managerial problems in industry.

CO5	Identify appropriate method for application of simulation to solve inventory and queuing problems for real world applications.

Course Details:

Unit I: Theory of Games: Introduction, Saddle point, Minimax-Maximin criteria for Optimal strategy, Minimax theorem, Solution of Games by LPP, Arithmetic methods, Principle of Dominance, Graphical methods, Matrix methods and Iterative methods.

Unit II: Network Analysis: Basic steps, Network diagram representation, Rules for drawing networks, Forward and Backward pass computations, Determination of critical path, Project evaluation and review techniques updating, Application areas of PERT/CPM techniques.

Unit III: Job Sequencing, Principle Assumption, Solution of Sequencing problem, n-jobs through 3- machines, 2-jobs through m-machines, n-jobs through m-machines.

Unit IV: Introduction function of inventory and its disadvantage, ABC analysis, Concept of inventory costs, Basics of Inventory policy(order, lead times, types), Fixed order-quantity models-EOQ, POQ and Quality discount models. EOQ models for discrete units, Special cases of EOQ models for safety stock with known/ unknown stock out situations.

Text and Reference Books:

1. Beale, E.M.L and Mackley,L: Introduction to Optimization, John Wiley, 1988.

2. Rao,S.S, Optimization theory and applications, 3rd edition,Willey Eastern Ltd., New-Delhi, 1996.

3. Hiller,F.S and Liberman, Introduction to Operations Research, 6th Ed. McGraw-Hill,

International Edition, Industrial Engg. Series, 1995.

4. Gupta, P.K,Hira,D.S, Operations Research, S. Chand& Company Pvt. Ltd, 2015.

Semester -IV

Course Code: MMA-404 (D) **Total Marks: 100, Credit: 4**

Course Name: Theory of Linear Operators

Course out comes (CO): At the end of the course, the student will be able to:

CO1	It will introduce the student to terms, concepts and results for bounded linear operators which are commonly used in this particular area of Mathematics.

CO2	It will also introduce the students which are relevant to current research and prepare the student to persue such a career..
CO3	To introduce fundamental ideas and aspects of approximation theory in normal and Hilbert spaces
CO4	To introduce fundamental ideas and aspects of approximation theory in normal and Hilbert spaces.
CO5	To study the compact linear operators, which play an important role in the theory of integral equations.

Course Details:

Unit I: Spectral theory in normed linear spaces, resolvent set and spectrum, spectral properties of bounded linear operators, properties of resolvent and spectrum, Spectral mapping theorem for polynomials, Spectral radius of bounded linear operator on complex Banach space, Elementary theory of Banach algebras.

Unit II: Spectral properties of bounded self-adjoint operators on a complex Hilbert space, Positive operators, monotone sequence theorem for bounded self-adjoint operators on a complex Hilbert space, square roots of positive operator, Projection operators, Spectral family of a bounded self-adjoint linear operatorand its properties, Spectral representation of bounded linear operators, Spectral theorem.

Unit III: Spectral measures, Spectral Integrals, Regular spectral measures, Real and complex Spectral measures, Complex, spectral integrals, Description of Spectral subspaces, Characterization of Spectral subspaces, The spectral theorem for bounded normal Operators.

Unit IV: Linear operators in Hilbert space, Hellinger-Toeplitz theorem, Hilbert adjoint operators, Symmetric and self-adjoint linear operators, closed linear operators and closures, Spectrum of self-adjoint linear operator, Spectral theorem for unitary and self-adjoint linear operators, Multiplication operator and Differentiation operator.

Text and ReferenceBooks:

1. P.R halmos , Introduction to Hilbert Spaces and the Theory of Spectral Multiplicity, Second edition, Chelsea Publishing Co,N.Y,1957.

2. N Dunford & J.T Schwartz, Linear Operators-3 Parts, Interscience/Wiley, New-York, 1958.

3. N.I Ahhiezer & I.M Glazman, Theory of Linear Operators in Hilbert Space, Frederick Ungar Pub. Co. N.Y., VolI(1961), Vol II(1963).

4. P. R Halmos, A Hilbert Space Problem Book, D. Van Nostrand Company Inc., 1967.

Semester -IV

Course Code: MMA-405 **Total Marks: 100, Credit: 4**

Course Name: Project and Seminar

*The student does a project on the one of the topics which he/she has learned in M.Sc. program.