Master of Science (M. Sc.) Semester Scheme - CBCS
Subject: MATHEMATICS

Course Structure, Scheme of Teaching and Evaluation (2023-24& Onwards)

	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
SEMESTER - III	HARD CORE PAPERS							
	HCT 3.1	Measure Theory and Integration	4	80	20	100	4	3
	HCT 3.2	Complex Analysis - I	4	80	20	100	4	3
	HCT 3.3	Fluid Mechanics	4	80	20	100	4	3
	HCT 3.4	Numerical Methods - I	4	80	20	100	4	3
	SOFT CORE PAPER (ANY ONE)							
	SCT 3.1	Advanced Topology Number Theory	4	80	20	100	4	3
	OPEN ELECTIVE PAPER (ANY ONE)							
	OET 3.1	Statistical Techniques Elements of Applied Mathematics	2	40	10	50	2	2
	PRACTICAL PAPER							
	HCP 3.1	Programming Lab - III	4	40	10	50	2	3
	Mandatory Credits: Personality Development		2	---	---	---	2	---

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
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	HCT3.1	Measure Theory and Integration	4	80	20	100	4	3

Course Objective(s):

- To introduce the concepts of measure and integral with respect to a measure, to show their basic properties, and to provide a basis for further studies in Analysis, Probability, and Dynamical Systems.
- To gain understanding of the abstract measure theory and definition and main properties of the integral.
- To construct Lebesgue's measure on the real line and in n-dimensional Euclidean space.
- To explain the basic advanced directions of the theory.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- Derives the concepts of Borel sets, measurable functions, differentiation of monotone functions.
- Analyze about the integral of simple functions, a non-negative functions, functions of bounded variation.
- Construct a clear idea about differentiation of an integral, absolute continuity and convex functions.
- Apply the theory of the course to solve a variety of problems at an appropriate level of difficulty.

Syllabus

UNIT-1: Lebesgue Measure and measurablefunctions: Lebesgue Measure - Introduction, Outer measure, measurable sets and Lebesgue measure, translation invariant, algebra of measurable sets, countable subadditivity, countable additively and continuity of measure, Borel sets, a non- measurable set.Measurable Function -Examples: Characteristic function, constant function and continuous function, Sums, products and compositions, Sequential point wise limits, Simple functions.

UNIT-2: Lebesgue Integral of Bounded Functions: The Riemann integral, integral of simple functions, integral of bounded functions over a set of finite measure, bounded convergence theorem.

UNIT-3: The GeneralLebesgue Integral: Lebesgue integral of measurable nonnegative functions, Fatou’s lemma, Monotone convergence theorem, the general Lebesgue integral, integrable functions, linearity and monotonicity of integration, additivity over the domains of integration. Lebesgue dominated convergence theorem.

UNIT-4: Differentiation and Integration: Differentiation of monotone functions, Vitali covering lemma, Dini derivatives, Lebesgue differentiation theorem, functions of bounded variation, Jordan’s theorem, differentiation of an integral, indefinite integral, absolute continuity.

REFERENCES:

1. H. L. Royden: Real Analysis, 3d Edition, MacMillan, New York, 1963.
2. G. DeBarra: Measure and Integration, Wiley Eastern Ltd., UK, 1981.
3. C. Goffman: Real Functions, Holt, Rinehart and Winston Inc. New York, 1953.
4. P. K. Jain and V. P. Gupta: Lebesgue Measure and Integration, Wiley Eastern Ltd., 1986.
5. I. K. Rana: An introduction to Measure and Integration, Narosa Publishing House, 1997.
6. I. K. Rana : An Introduction to Measure and Integration, Narosa Publishing House, New Delhi, 1997.
7. P. R. Halmos: Measure Theory, Springer-Verlag, New York, 1974.
8. W. Rudin : Real & Complex Analysis, McGraw Hill, New York, 1987.

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	HCT 3.2	Complex Analysis - I	4	80	20	100	4	3

Course Objective(s):

- Students will learn complex plane and its algebra.
- Students will learn power series and radius of convergence.
- Students will learn complex integration.
- Students will learn series expansions (Taylor’s and Laurent’s series).

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- know the definitions and some basics of Complex plane.
- do basic operations on complex numbers.
- find out radius of convergence.
- know how to read and write proofs in complex integration.

Syllabus

Unit - I: Complex plane its algebra and topology. Holomorphic maps. Analytic functions. Harmonic functions.Hormonic conjugate function; their relation to analytic functions.

Unit - II: Power series. Radius of convergence.Integration and differentiation of power series.Uniqueness of series representation. Relation between power series and analytic functions: trigonometric, exponential and logarithmic functions.

Unit - III: Review of complex integration. Basic properties of complex integration. winding number.Cauchy-Goursat theorem.Cauchy theorem for a disc, triangle and rectangle.Liouville theorem.Fundamental theorem of algebra.Morera's theorem.

Unit - IV: Taylor and Laurent's expansion. Singularities.Poles.Removable and Isolated singularities.Classification of singularities using Laurent's expansion.Behaviour of analytic function in the neighborhood of singularities.Principle of analytic continuation, Residue theorem and contour integrals.Argument principle, Rouche's theorem and its applications.

References:

1. J. B. Conway: *Functions of One Complex Variable*, 2nd edition, Graduate Texts in Mathematics, Springer-Verlag, New York–Berlin, 1978; first edition, 1973.
2. Ahlfors, L. V.: *Complex Analysis*, 3rd edition, New York, McGraw-Hill, 1979.
3. S. Ponnusamy: *Foundations of Complex Analysis*, 2nd Edition, Narosa Publishing House, India, 2005.
4. R. V. Churchil and J. W. Brown: *Complex Variables and Applications*, 4th Edition, McGraw Hill Book Company, New York, 1984.
5. Rudin, W.: *Real and Complex Analysis*, New York, McGraw-Hill, 1966.
6. S. L. Segal: *Nine Introductions in Complex Analysis*, revised edition, North-Holland Mathematics Studies, Elsevier, Amsterdam, 2008; first edition, 1981.
7. I. Stewart and D. Tall: *Complex Analysis*, Cambridge University Press, 1983.
8. H. S. Kasana: *Complex Variables- Theory and Applications*, 2nd edition, PHI Learning Pvt. Ltd., India, 2005.

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	HCT3.3	Fluid mechanics	4	80	20	100	4	3

Course Objective(s):

- To familiarize the students with basic concepts of fluid dynamics.
- To understand the applications in medical, astrophysical, geophysical, agricultural, aero dynamical and other related disciplines.
- To develop the problem-solving skills essential to fluid dynamics in practical applications.
- **To** understand the fundamental knowledge of fluids and its properties.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- describe the concepts and equations of fluid dynamics.
- apply thermodynamic control volume concepts in fluid dynamics for applications that include momentum, mass and energy balances.
- analyze the approximate solutions of the Navier-Stokes equation.
- appreciate the role of fluid dynamics in day-to-day life.

Syllabus

UNIT-1: Motion of Inviscid Fluids: Pressure at a point in a fluid at rest and that in motion, Euler's equation on motion, Barotropic flows, Bernoullis equations in standard forms, Illustrative examples thereon, Vortex motion, Circulation, Kelvin's circulation theorem, Helmhotz Vorticity equation, Performance in Vorticity and Circulation, Kelvin's Minimum Energy Theorem, Illustrative examples.

UNIT-2: Two Dimensional Flows of Inviscid Fluids: Meaning of two dimensional flows and Examples, Stream function, Complex potential, Line Sources and Line Sinks, Line Doublets and Line Vortices, Milne Thomson circle theorem and Applications, Blasius theorem and Applications.

UNIT-3: Motion of Viscous Fluids: Stress tensor of viscous fluid flow, Stoke's law, Navierstoke's equation, Simple exact solutions of the Navier-Stoke's equation, Standard applications, **i)** Plane Poiseuille and Hagen Poiscuileflows **ii)**Couette flow **iii)** Steady flow between concentric cylinders **iv)** Beltrami flows **v)** Unsteady flow near an oscillating plate **vi)** Slow and steady flow past a rigid sphere and cylinder. Diffusion of Vorticity, Energy dissipation due to Viscosity, Dimensional analysis (Brief discussion), Reynolds number, Laminar and Turbulent flows, Examples of flow at low and high Reynolds number, Brief discussion of boundary layer theory with illustrative examples.

UNIT-4: Gas Dynamics: Compressible fluid flows, Standard forms of equations of State,Speed of sound in a gas, Equations of motion of Non-Viscous and Viscous Compressible flows, Subsonic, Sonic and supersonic flows, Isentropic flows, Gas Dynamical Equations, Illustrative examples.

References:

1. G. K. Bachelor: An Introduction to Fluid Mechanics, Foundation Books, New Delhi, (1994).
2. R. K. Rathy: An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, (1976)
3. D. J. Tritton, Physical fluid dynamics, Oxford Science publication, second edition, 1987.
4. S.W. Yuan, foundations of fluid mechanics, Third edition, Prentice – Hall International Inc. London.
5. Schlichting H., Boundary layer theory, McGraw-Hill, 1979.
6. Nield D. A. and Bejan A., Convection in porous media, Springer, 2006.
7. F. Chorlton: Text Book of Fluid Dynamics, CBS Publishers, New Delhi, (1985).
8. L. D. Landav and E. M. Lipschil: Fluid Mechanics, Pragamon Press, London, (1985)

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	HCT 3.4	Numerical Methods-I	4	80	20	100	4	3

Course Objective(s):

- This introductory course presents students some classical and commonly used numerical methods in various disciplines involving computing and numerical approximation and solution of equations.
- The course teaches students how to choose an appropriate numerical method for a particular problem and to understand the advantages and limitations of the chosen numerical scheme for a given mathematical problem so that results from the computation can be properly interpreted.
- The course also highlights important theoretical considerations on Interpolation and approximation.
- To develop the mathematical skills of the students in the areas of numerical methods.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- Apply numerical methods to find our solution of algebraic equations using different methods under different conditions, and numerical solution of system of algebraic equations.
- Apply various interpolation methods and finite difference concepts.
- Work out Gauss Elimination method, Gauss-Jordan method, LU factorization, triangularization method, iteration methods: Gauss Jordan methods, Gauss-Seidel method, successive over relaxation method, convergence criteria.
- Work on the eigenvalues and eigenvectors of matrix by Jocobi's method, given's method, house holder's method, power method, inverse power method.

Syllabus

UNIT-1: Solutions of Linear System of Equations: Introduction to Direct Methods via.,Gauss Elimination method, Gauss-Jordan method, LU factorization, Triangularization method, Iteration Methods: Gauss Jordan methods, Gauss-Seidel method, successive over relaxation method, convergence criteria, and problems on each method.

UNIT-2: Solutions of Nonlinear/Transcendental Equations: Fixed point iteration, method of Falsi position, Newton Raphson method, secant method, Regula-Falsi method, Muller's method, Aitkin's δ^2 method, orders of convergence of each method. problems on each method. Sturm sequence for identifying the number of real roots of the polynomial functions. Extraction of quadratic polynomial by Bairstow's method.

UNIT-3: Eigenvalues and Eigenvectors of a Matrix: The characteristics of a polynomial, The eigenvalues and eigenvectors of matrix by Jocobi's method, given's method, house holder's method, power method, inverse power method, QR Algorithm.

UNIT-4: Interpolation and Approximation Theory: Polynomial interpolation theory, Gregory Newtons forward, back ward and central difference interpolation polynomial. Lagranges interpolation polynomial, truncation error. Hermite interpolation polynomial, inverse interpolation, piece wise polynomial interpolation, trigonometric interpolation, convergence analysis, Spline approximation, cubic splines, best approximation property, least square approximation for both discrete data and for continuous functions.

REFERENCES:

1. R. K. Jain, S. R. K. Iyengar and M. K. Jain: *Numerical methods for scientific and Engineeringcomputation*, Wiley Eastern, 2001.
2. S. D. Conte and Carl De Boor: *Elementary Numerical Analysis*, McGraw Hill, 2000.
3. C. E. Froberg: *Introduction to Numerical Analysis*, Addison Wesley, 1995.
4. M. K. Jain: Numerical Solution of Differential Equations, Wiley Eastern, 1990.
5. G. D. Smith:*Numerical Solution of PDE*. Oxford University Press, 1998.
6. A Iserles: *A first course in the numerical analysis of differential equations*,2nd edition, Cambridge texts inapplied mathematics, 2008.
7. D. Kincade and W Cheney: *Numerical analysis*,3rd edition American Mathematical Society, 2002.
8. R.L. Burden and J.D. Faires: *Numerical Analysis*,7th edition Thomson-Brooks/Cole, 1989.

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
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	SCT3.1	Advanced Topology	4	80	20	100	4	3

Course Objective(s):

- Students will learn Countability axioms in topological spaces.
- Students will learn Metric spaces and metrizability of topological spaces.
- Students will learn Product spaces in topological spaces.
- Students will learn Algebraic topology.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- know the definitions and some basics of Countability of topological spaces.
- know how to read and write proofs in metric spaces and metrizability.
- distinguish Urysohn's lemma and the Tietze extension theorem.
- know a variety of examples and counterexamples in topology.

Syllabus

Unit-I:Countability Axioms: First and Second Axioms of countability. Lindelof spaces, separable spaces, countably compact spaces, Limit point compact spaces.

Unit-II: Metric Spaces and Metrizabilty: Separation and countability axioms in metric spaces, convergence in metric spaces, complete metric spaces, Urysohn'sMetrisation theorem, Bing's Metrisation theorem, Nagata-Smirnov Metrisation theorem.

Unit-III: ProductSpaces: Arbitrary product spaces, product invariance of separation and countability axioms. Tychonoff's theorem, product invariance of connectedness.

Unit-IV: Algebraic Topology: Homotopy of paths, covering spaces, fundamental group of circles, retractions and fixed points, fundamental theorem of algebra.

REFERENCES

1. James. Dugundji, Topology Allyn and Bacon (Reprinted by PHI and UBS)
2. J. R. Munkres, Topology – A first course PHI (2000)
3. S. Lipschutz, General Topology, Schaum's series, McGraw Hill Int (1981)
4. W. J. Pervin, Foundations of general topology, Academic Press (1964)
5. S. Willard, General Topology, Elsevier Pub. Co. (1970)
6. J. V. Deshpande, Introduction to topology, Tata McGraw Hill Co. (1988)
7. S. Nanda and S. Nanda, General Topology, MacMillan India (1990)
8. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill Book Co. (1963)
9. J. L. Kelley, General Topology, Van Nostrand Reinhold Co. (1995).
10. C. W. Baker, Introduction to topology, W. C. Brown Publisher (1991).

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
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	SCT 3.1	Number Theory	4	80	20	100	4	3

Course Objective(s):

- The course aims to give elementary ideas from number theory which will have applications in cryptology.
- Identify and apply various properties of and relating to the integers including the Well-Ordering Principle, primes, unique factorization, the division algorithm, understand the concept of a congruence,
- To impart the knowledge of encryption and decryption techniques and their applications in managing the security of data

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- Solve problems in elementary number theory.
- At the end of the course the student will be able to go for higher courses in number theory.
- They will be more logical and careful in finding proofs of mathematical results.

Syllabus

Unit I : Prime numbers, The Fundamental theorem of Arithmetic, The series of Reciprocals of primes, The Euclidean Algorithm. Fermat and Mersenne numbers. Farey series, Farey dissection of the continuum, Irrational numbers-Irrationality of mth root of N, e and π.

Unit II: Arithmetical Functions – The Mobius function, The Euler' function and Sigma function, The Dirichlet product of Arithmetical functions, Multiplicative functions. Averages of Arithmetical functions – Euler summation formula, Some elementary asymptotic formulas, The average orders of $d(n)$, $\sigma(n)$, $\varphi(n)$, $\mu(n)$. An application to the distribution of lattice points visible from the origin.

Unit III: Approximation Irrational numbers, Hurwitz's Theorem, Representation of a number by two or four squares, Definition $g(k)$ and $G(k)$, Proof of $g(4)>50$, Perfect numbers. The series of Fibonacci and Lucas.

Unit IV: Continued fractions - Finite continued fractions, Convergent of a continued fraction, Continued fractions with positive quotients. Simple continued fractions, The representation of an irreducible rational fraction by a simple continued fraction. The continued fraction algorithm and Euclid's algorithm. The difference between the fraction and its convergents, Infinite simple continued fractions, the representation of an irrational number by an infinite continued fraction, Equivalent numbers and periodic continued fractions, some special quadratic surds.

Reference:

1. G. H. Hardy and E. M. Wright – An Introduction to Theory of Numbers, Oxford University Press, 1979, 5th Ed.,

2. I. Niven, H. S. Zuckerman and H. L. Montgomery – An Introduction to the Theory of Numbers, New York, John Wiley and Sons, Inc., 2004, 5th Ed.,

3. Bruce C. Berndt – Ramanujan's Note Books Volume-1 to 5, Springer.

4. G. E. Andrews – Number Theory, Dover Books, 1995.

5. T. M. Apostol – Introduction to Analytic Number Theory, Narosa Publishing House, New Delhi.

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
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	OET 3.1	STATISTICAL TECHNIQUES	2	40	10	50	2	2

Course Objective(s):

- To find the association between attributes.
- To find the correlation between two variables and form regression lines.
- To understand the concepts of sampling
- To estimate the parameters using various methods.
- To understand exact sampling distribution

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- Analyze the data pertaining to attributes and to interpret the results.
- To recognize and evaluate the relationship between two quantitative variables through simple linear correlation and regression.
- To understand the relationship between sample statistics and population parameters.

Syllabus

Unit I: Measure of Central Tendency: Arithmetic mean, Median, Mode, Geometric mean and Harmonic mean, Merits and demerits.

Unit II: Measure of Variation: Introduction, mean deviation, Standard deviation, merits and limitations.

Unit III:Correlation Analysis: Types of Correlation, methods of studying correlation, Karl Person's co-efficient of correlation, Rank correlation co-efficient, methods of least squares. **Regression Analysis:** Introduction, Regression lines, Regression equations of Y on X, Regression Co-efficient.

Unit IV: Probability: Random experiment, Sample space and events, Axioms of probability, Conditional probability and independence, Addition, Multiplication and Baye's theorem.

References:

1.S.P. Gupta and M.P. Gupta, Business Statistics

2. C.B. Gupta, An Introduction to Statistical methods

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
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	OET 3.1	Elements of Applied Mathematics	2	40	10	50	2	2

Course Objective(s):

- To find the association between attributes.
- Students should be able to explain basic concepts of matrix theory, numerical techniques, probability distributions and calculus of single variable
- Students should be able to apply basic concepts of differential calculus to solve problems related to extremum, approximations, curvature etc

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- Students should be able to apply basic numerical techniques to solve linear and nonlinear equations.
- Students should be able to do basic statistical inference, linear and nonlinear regression analysis and design of experiments.
- Students should be able to effectively choose appropriate mathematical and statistical concepts to solve various real world problems.

Unit I: Solutions of system of linear equations (Gauss-elimination, LU-decomposition etc.) Numerical methods for solving non-linear algebraic / transcendental etc.

Unit II: Newton's method, Secant, Regula Falsi, Jacobi

Unit III: Numerical solution set of linear algebraic equations: Jacobi, Gauss Siedel, and under / over relaxation methods

Unit IV: Interpolation and extrapolation for equal and non-equal spaced data (Newtons Forward, Newtons backward and Lagrange) Numerical integration (trapezoidal rule, Simpson's Rule)

Reference:

1. Erwin Kreyszig, John-Wiely , Advanced Engineering Mathematics.
2. S. R. K. Iyengar, R. K. Jain , Advanced Engineering Mathematics.
3. S. S. Sastry, Introductory Methods Of Numerical Analysis.

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
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	SCP 3.1	Programming Lab - III	4	40	10	50	2	3

Course Objective(s):

- It enables the student to explore mathematical concepts and verify mathematical facts through the use of software and also enhances the skills in programming.
- Show proficiency in using the software C-Programming.
- Students will learn to write the code for verifying vector spaces, subspaces and properties using FOSS.
- Students will learn to write the code for linear transformations and their representationas matrices.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- understand the use of various techniques of the software for effectively doing mathematics.
- obtain necessary skills in programming.
- understand the applications of mathematics.
- utilize the software knowledge for academic research.

Syllabus

Problems from HCT 3.4 (Theory) may be solved with the help of C-Programming.